Coasts 4

Status

- Population is increasing in coastal areas faster than in any other region of the country.
- More people and property are becoming exposed to coastal hazards daily.
- The costs of mitigating and recovering from disasters is steadily increasing.

Climate Change Problem

- Sea level rise.
- Possibility of more frequent and/or more intense coastal storms.
- Temperature and precipitation impacts.

What Is Most Vulnerable?

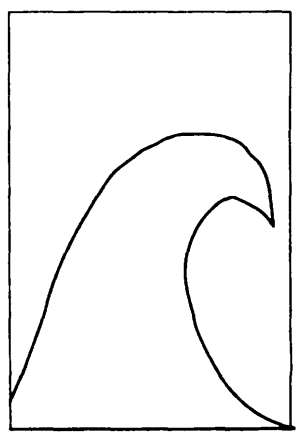
- Low-relief, easily eroded shorelines (e.g., Southeast and Gulf coasts).
- Subsiding areas (e.g., Mississippi River Delta).
- Structures immediately adjacent to the ocean.

Impediments to Better Management

- Popularity of coastal areas.
- Insufficient incentives to take adequate precautions.
- Perceived or actual cost.
- Private property concerns.
- Institutional fragmentation.

Types of Responses

- Revamp the National Flood Insurance Program
- Improve disaster-assistance policies.
- Revise the Coastal Barrier Resources Act and the Coastal Zone Management Act.
- Change beach-nourishment guidelines.
- Alter the U.S. Tax Code.



OVERVIEW

The subject of this chapter—the coastal zone-is somewhat distinct from that of the other chapters in this report because it focuses on a readily identifiable geographic area and on the built components of this area rather than on a specific natural resource. The coastal zone can be broadly characterized both as a popular place to live, work, and play and as an area where some unique, climate-related risks to people, property, and ecosystems occur. Population near the coast is growing faster than in any other region of the country, and the construction of buildings and infrastructure to serve this growing population is proceeding rapidly. As a result, protection against and recovery from hazards peculiar to the coastal zone, such as hurricanes and sea level rise, are becoming ever more costly. The combination of popularity and risk in coastal areas has important near-term consequences for the safety of coastal residents, protection of property, maintenance of local economies, and preservation of remaining natural areas.

Longer-term climate change impacts are likely to exacerbate existing problems associated with living in the coastal zone. Sea level rise is a potential climate change impact unique to coastal areas and one that could lead to increased flooding and erosion in areas already vulnerable to the dynamic forces of wind, waves, currents, and tides. Climate change could also lead to more frequent and/or severe hurricanes and other coastal storms. Scientists are less confident about this possibility than they are about sea level rise, but even if coastal storms are unaffected by climate change, their impact on the coast will increase as the sea rises.

Climate change in coastal areas would clearly be costly for Federal, State, and local governments. These costs are associated both with the inherent risks of living in the coastal zone and with how these risks are allocated among various public and private entities. The present system of risk allocation in the coastal zone does not promote an adequate appreciation of the current and potential hazards associated with living in this area. As a result, certain types of risky development are encouraged (or at least not discouraged) that could lead to greatly increased Federal outlays in the future. One need only look at the costs to the Federal Government for disaster assistance after Hurricanes Hugo (about $1.6 billion), Andrew (about $2.1 billion), and Iniki (about $400 million) to appreciate the potential magnitude of the outlays involved. Moreover, in each of these cases, total costs were considerably greater. Climate change will likely add to the risks and costs of living in the coastal zone, so it is essential that these risks be well-understood by all stakeholders and that coastal development and preservation are guided by this understanding. The sooner policies that encourage an adequate appreciation of risk are in place, the easier and less costly adaptation to a changing climate is likely to be.

Risk management is a Federal, as well as a State and local, responsibility. The Federal Government has an interest in promoting sound planning and public safety in an effective and efficient manner. Federal coastal zone policies can be improved in several ways to better guide the decisions of those living in coastal areas. Considered in this chapter are policies to improve the National Flood Insurance Program, disaster assistance, beach nourishment and shoreline protection, coastal zone and barrier-island management, and the U.S. Tax Code. In other chapters, we consider related water, wetlands, and preserves issues (ch. 5 and vol. 2, chs. 4 and 5).

VULNERABILITY OF COASTAL AREAS

Climate-related risks, from blizzards to tornadoes, are inherent to many parts of the United States. However, the coastal zone--that narrow boundary zone where ocean and dry land meet and most directly influence one another-is a dynamic area of larger-than-average risk. Hurricanes and other violent coastal storms cause hundreds of millions of dollars in damage every

year and are responsible for numerous deaths. For example, the two most destructive natural disasters of 1992, Hurricanes Andrew and Iniki did considerable damage in the coastal zone, and these two catastrophes accounted for almost 80 percent of the more than $21 billion of insurance-industry claims for the 10 most costly catastrophes in 1992.

Less dramatic than the destruction of homes and other structures by storms-but ultimately very costly-is coastal erosion. A significant proportion of the U.S. coastline is eroding. Although rates of erosion are highest during major storms, long-term erosion caused by the unremitting action of normal waves, wind, and tides adds much to the risks and costs of living in coastal areas. Structures in or near eroding areas are increasingly at risk as erosion progresses. Furthermore, erosion can be exacerbated by human activities, including the deepening of ports and harbors, maintenance of tidal inlets, damming of major rivers, and pumping of coastal groundwater and petroleum.

The remaining undeveloped parts of the coastal zone (e.g., wetlands and many barrier islands) are also at risk. They are vulnerable both to the effects of climate change and to human encroachment and thus may need special attention if society wishes to preserve them.

The coastal zone may be the region of the country most vulnerable to climate change. Like other areas, it would be affected by higher temperatures and changes in precipitation In addition, coastal regions would have to contend with the changing sea level and could be subject to more-frequent and/or more-intense hurricanes and other coastal storms. Such expressions of climate change would cause, among other things, increased coastal flooding and erosion, higher storm surges, increased wind damage, and increased saltwater intrusion into freshwater aquifers.

Demographic Trends

Increases in population and development in coastal areas have been dramatic in recent decades. Between 1%0 and 1990, the population of coastal counties grew from 80 million to roughly 112 million people. People living in coastal counties in 1990, about 44 percent of the total U.S. population, occupied an area that comprises just 11 percent of the United States outside Alaska.[1] Population density in coastal counties, roughly 350 people per square mile (135 people per square kilometer),[2] is more than four times the national average. Projections suggest that by the year 2010, coastal populations will grow to 127 million (15). Seventeen of the 20 States expected to grow by the greatest amount by 2010 are coastal. Florida alone is expected to add 11 million people to its population, a 230 percent change from 1960 (15).

With population growth has come development and a corresponding increase in the exposure of property to natural disasters. For example, the property-casualty insurance industry has estimated that its insured property exposure in residential and commercial coastal counties in the 18 Gulf and Atlantic Coast States increased from $1.13 to $1.86 trillion between 1980 and 1988 (l). This change is a result of increasing property values as well as of greater numbers of properties insured.[3] Insurance-industry liabilities in some States have grown much faster during this period than the coastal-State average-by 83 percent in South Carolina, a victim of Hurricane Hugo in 1989, for example (l). Many insurance compa-

[1] The coastal zone baa been defined *in* a variety of ways-for example, as the area encompassed by counties adjacent to the ocean, the area below a specified elevation, or the area within an arbitrary number of miles from the coast. About 53 percent of the U.S. *population lives in counties* entirely or substantially within 50 miles (80 kilometers) of the coast (89).

[2] To convert square miles to square kilometers, multiply by 2.590.

[3] These figures do not include amounts for the Pacific Coast, near-coastal cities, such as Houston and Philadelphia that could be (and have been) affected by coastal storms, or any uninsured property or self-insured government property.

NOAA

The concentration of people in coastal areas is steadily increasing. Densely populated Miami Beach, shown here, was spared the major losses suffered only a few miles to the south when Hurricane Andrew struck in 1992. The city may not always be so fortunate.

nies decided to pull out of Florida after Hurricane Andrew, and others are increasing premium rates significantly, perhaps an indication of future trends.

Sea Level Rise

Continuing sea level rise and associated long-term shoreline erosion could be a substantial problem for some U.S. coastal regions (see, for example, fig 4-l). Global sea level has risen by some 4 to 8 inches (10 to 20 centimeters)[4] in the past 100 years, largely as a result of melting of land-based ice sheets and glaciers (64).[5] Along the U.S. Gulf Coast, *relative sea level rise*[6] has been closer to 12 inches (67). According to the Intergovernmental Panel on Climate Change (WCC), sea level could rise another 10 inches or so in the next 50 years. Estimates of future sea level rise due to global warming vary greatly, but the change is likely to be between 12 and 43 inches by the year 2100, with a "best estimate" of 26 inches above levels that would otherwise exist (40). Future sea level rise in this range could expand areas where coastal flooding and inundation occur, and coastal erosion could increase. A 20-inch rise could inundate more than 5,000 square miles (mi^2, or about 13,000 square kilometers)[7] of dry land and an additional 4,000 mi^2 of wetlands in the United States if no actions are taken to protect threatened areas (63, 82). The Federal Emergency Management Agency (FEMA) suggests that the number of households subject to flooding would increase from about 2.7 million now to almost 6 million by 2100 as a result of a combination of a 12-inch sea level rise and coastal area population growth (21).

Sea level rise would especially be a problem along the low-lying barrier-island system of the Atlantic Coast from New York south to Florida and along the Gulf of Mexico Coast, where small, vertical rises in sea level would cause large, horizontal movements in the shoreline and where the full effects of storm surges, winds, waves, and tides are felt (fig. 4-2). High-risk shorelines are characterized by low-relief, easily eroded surfaces, retreating shorelines, evidence of subsidence, and high wave and tide energies. A coastal vulnerability index based on these factors has been used to identify areas most vulnerable to future sea level rise (35).

The most vulnerable shorelines in the conterminous United States are in the Gulf of Mexico, and include virtually all of the Louisiana shoreline and parts of the Texas coast. These areas have anomalously high relative sea level rise, and erosion there is coupled with low elevation and mobile sediments. Forty percent of the entire Gulf Coast is retreating at rates greater than 80 inches

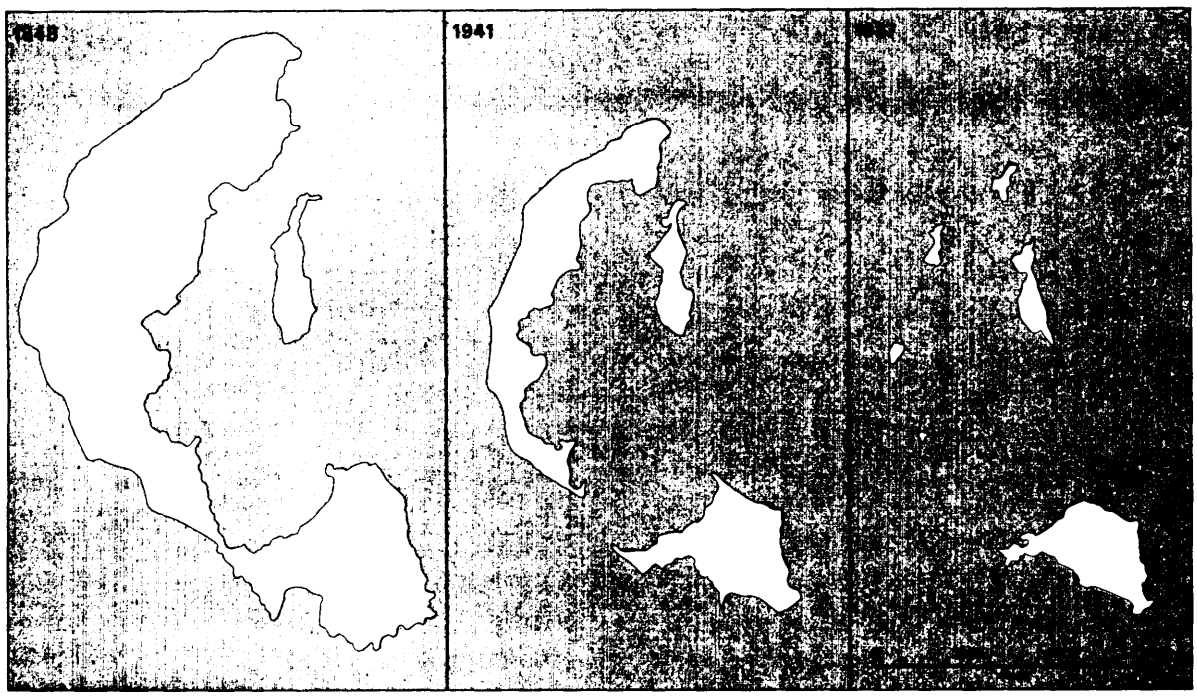
4 To convert inches to centimeters, multiply by 2.54,

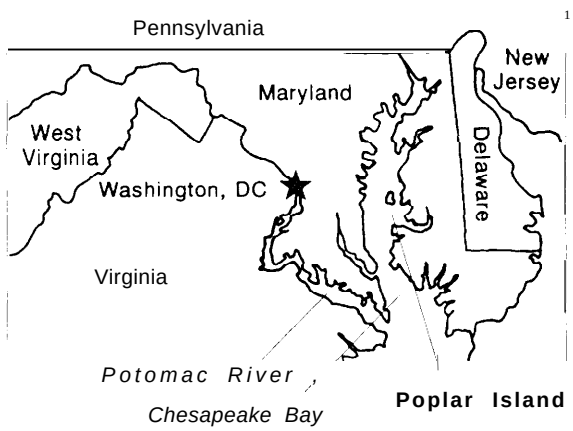
5 Other factors include thermal expansion of the oceans, the slow rebound of land after melting of glaciers (glacial isostatic adjustment), and local tectonic activity.

6 As the sea rises, adjacent land may be independently increasing or decreasing in elevation due to tectonic activity, compacting of sediments, or subsurface pumping of petroleum or water, for example. Relative sea level rise reflects the net effect of all these factors.

7 To convert square miles to square kilometers, multiply by 2.590.

Figure 4-1—Historical Land Loss of Poplar Island in Chesapeake Bay as a Result of Sea Level Rise and Erosion





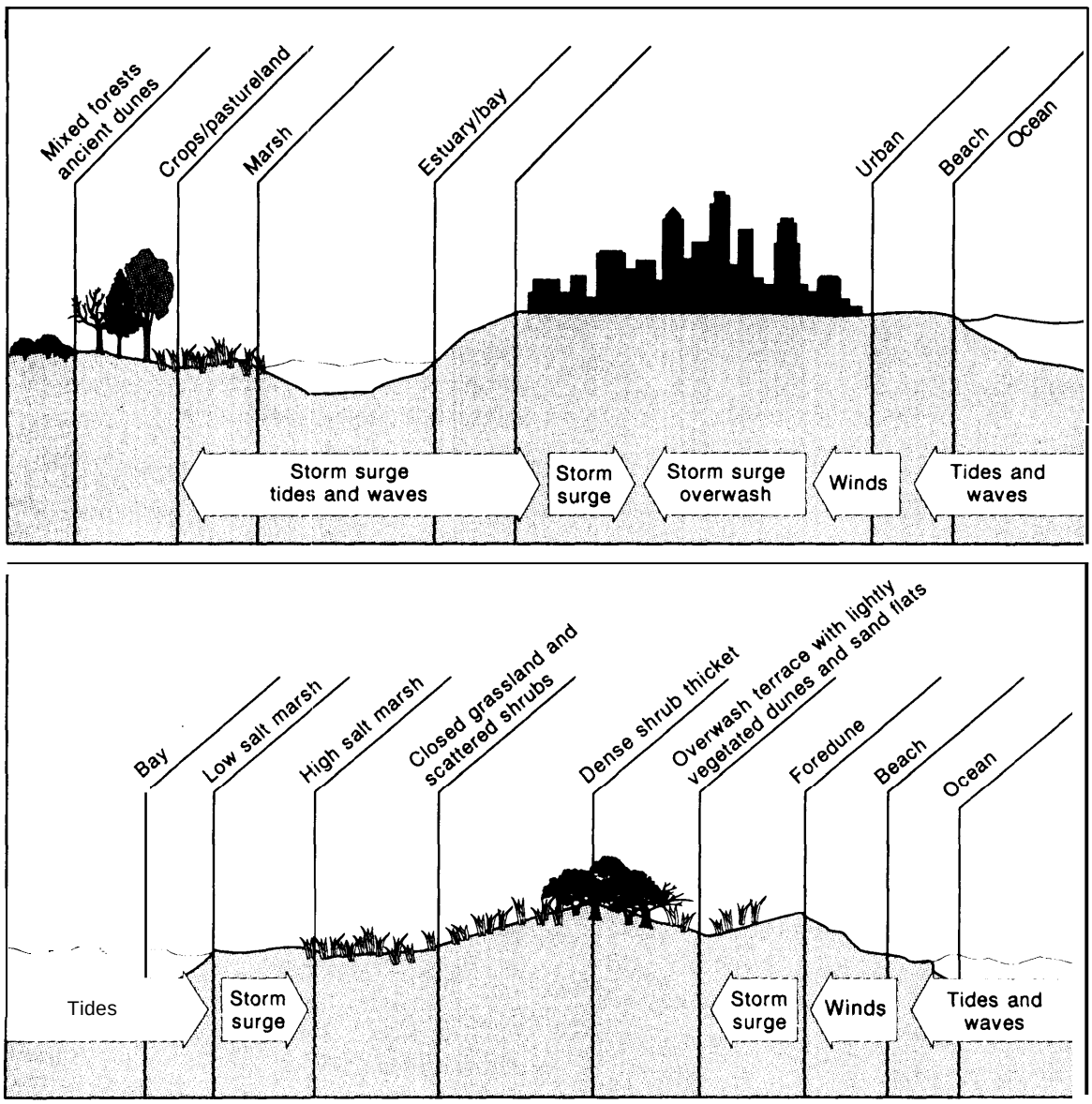
SOURCE: S. Weatherman, University of Maryland, College Park

per year. The highest rate of relative sea level rise in the United States occurs in Louisiana, where the average rate during the past 50 years has been more than 0.3 inches per year (35). About half of all land estimated to be inundated from sea level rise is in Louisiana. The Mississippi River Delta is especially at risk. In the absence of adequate protective measures, coastal cities such as Galveston, Texas, would frequently suffer intolerable flooding (16, 81, 83).

The highest-risk shorelines along the Atlantic Coast include the outer coast of the Delmarva Peninsula, northern Cape Hatteras, Long Island, and segments of New Jersey, Georgia, and South Carolina. Heavy damage from periodic flooding and some loss of land due to inundation can be expected in such coastal cities as Atlantic City, New Jersey; Ocean City, Maryland; Charleston, South Carolina; and Miami Beach, Florida, if the sea level rises as predicted and no steps are taken to protect against it (48). About 25 percent of the Atlantic Coast is eroding; 8 percent is accreting.

Most of the tectonically active West Coast of the United States is steeper than the Atlantic and Gulf Coasts. Thus, western coastal areas are generally less Vulnerable to sea level rise. How-

Figure 4-2-Schematics of a Developed and an Undeveloped Barrier Island



NOTE: General **locations of land-use and land-cover types are shown In relation to dominant shoreline process.**

SOURCE: R. Dolan, University of Virginla, Charlottesville.

ever, areas such as the low-lying San Joaquin-Sacramento Delta (adjacent to San Francisco Bay—see box 5-A), the barrier beaches of Washington and Oregon, and parts of the Puget Sound lowlands are all quite vulnerable to sea level rise (35). The Pacific Coast generally is less vulnerable to erosion, too, because erosion-resistant rocks prevail over unconsolidated sediments. Only about 6 percent is eroding.

Several studies have attempted to estimate the possible costs of protecting U.S. coastlines from a rising sea. On the basis of results of studies commissioned by the Environmental Protection Agency, the cumulative costs of coastal defensive measures in populated areas have been estimated to be from $100 to $350 billion for a 40-inch rise in sea level by 2100 (83).[8] More recently, the U.S. Army Corps of Engineers has used similar data to make the same calculation but with different assumptions (e.g., about the protection measures that would most likely be used). The Corps estimates maximum costs at less than $120 billion (in 1992 dollars) (86).

The large spread between the estimates suggests that attaching great significance to any dollar figure for protecting the coast against sea level rise should be done cautiously. Of necessity, all such studies are based on a large number of assumptions about an uncertain future—especially the degree to which sea level is likely to rise in the next 100 years-and on extrapolations from a few well-studied areas to all vulnerable coastlines. Defensive and mitigative strategies, however, are site-specific and cannot easily be generalized nationwide (60). Also, the current IPCC "best estimate" for sea level rise by 2100 is 26 inches, which, if realized, could mean that protection costs would be much lower than those reported above. Furthermore, the above cost estimates, accumulated over more than 100 years, have not been discounted to present worth. Using the Corps' high estimate of $120 billion and a discount rate of 3 percent, the present worth of investment during this period would be $25 billion, or, equivalently, an average annual cost of $700 million. The costs of protecting against a rising sea may be manageable, but they will not be trivial.

Substantial damage to the natural environment could also result from sea level rise, including inundation of large areas of coastal wetlands (63, 81) and loss of biodiversity (73) (see vol. 2, chs. 4 and 5). The value of lost land (wetlands and undeveloped dry land) as a result of sea level rise has been estimated to be from $50 to $250 billion by 2100 (83). Losses of wetlands will be largest where human development, such as construction of bulkheads and houses, impedes the natural landward migration of wetlands in response to sea level rise (82). (For more on wetlands, see vol. 2, ch. 4.) Also, some human activities outside the coastal zone, such as construction of upland dams (which trap sediments that would otherwise replenish beaches), can thwart natural processes that could otherwise mitigate the potential erosion and flooding caused by an accelerated sea level rise (40).

Hurricanes and Coastal Storms

Hurricanes and severe coastal storms are among the most destructive and costly of natural phenomena. Flooding, erosion, and wind damage caused by such storms result in many lost lives and hundreds of millions of dollars of property damage every year.

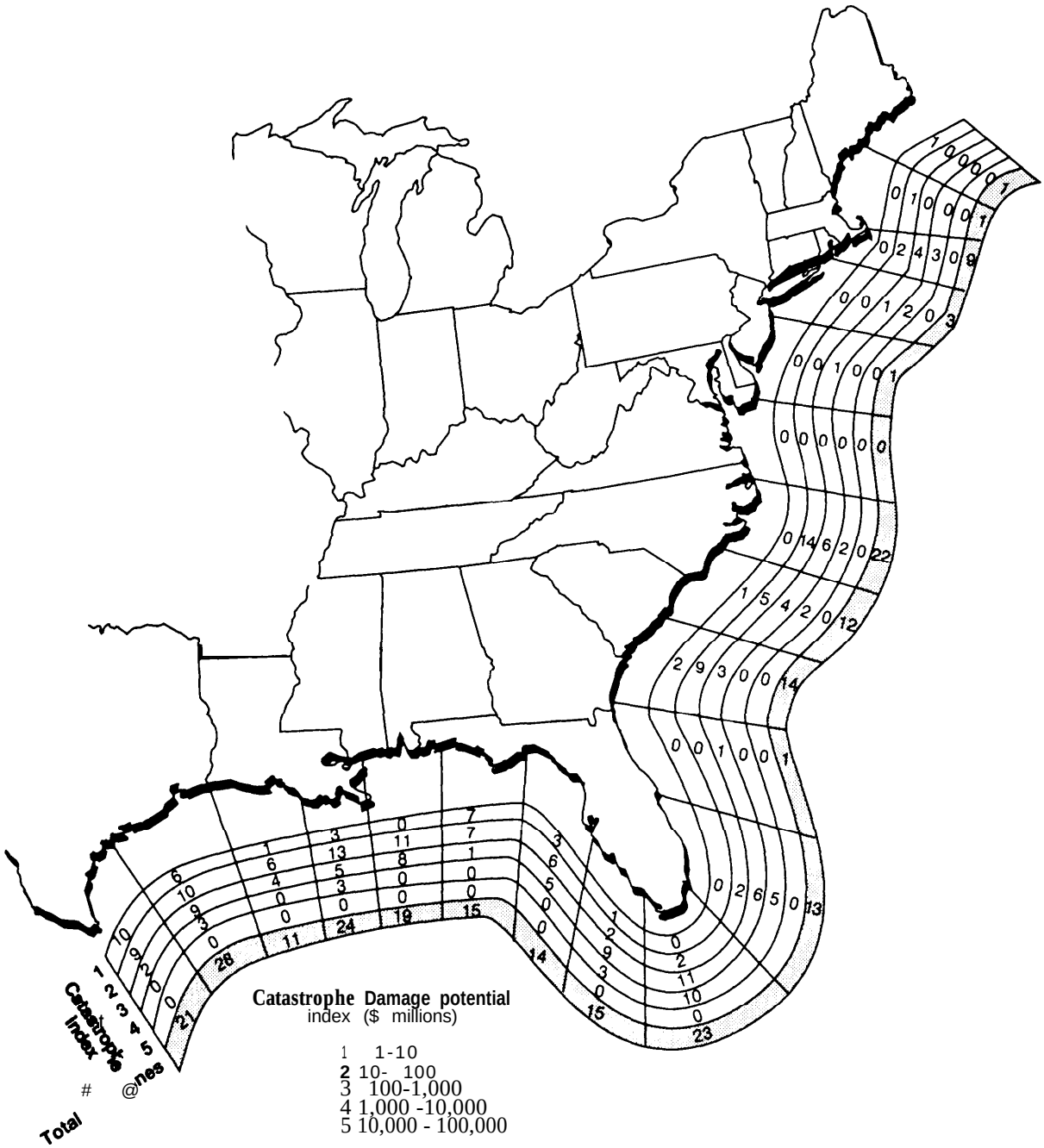
The East and Gulf Coasts of the United States are especially vulnerable to hurricanes. Since 1871, roughly 250 hurricanes of varying intensity have struck parts of the coast between Texas and Maine. Virtually no segment of this coast has been spared (fig. 4-3A) (28). The destructive potential of a hurricane is a function of both its intensity (see box 4-A) and the density of development in the area affected. As develop-

B The authors of reference 83 consider their estimates conservative because they do not take into account impacts not readily quantified or the costs of protecting future development.

Figure 4-3A--Intensity of Historic Hurricanes

NOTE: Estimate of the Saffir-Simpson intensity at landfall of tho 247coastal crossings by hurricanes that affected the Gulf or East Coast in the ll9-year period between 1871 and 1990. Total hurricanes striking each segment of coast plus **the number of hurricanes of each intensity** are **shown. For example, 23 hurricanes** struck the **southern tip of Florida during this period. Only one was a** category 5 **hurricane at landfall. Figure 4-3B shows that the present-day damage-producing potential of each of these 23 hurricanes was greater than $IO million but less than $IO billion (i.e., fell into categories** 2, 3, or 4).

Figure 4-3B--Damage-Producing Potential of Historic Hurricanes



NOTE: Estimate of the catastrophe index, which shows the present-daydamage-producing potential of the 247 land-falling hurricanes that occurred somatime in the past 119 years. Numbers of hurricanes In each damage category are shown. For example, 10 hurricanes that have struck the southern tip of Florida were strong enough to cause between $1 and $10 billion in damages if they occurred today (category A). Hurricane Andr- is not Included in the data, but It would be the first to fall into category 5.

SOURCE: D. Friedman, Natural Hazards Research Program, Travelers Insurance Co., "estimation of Damage-Producing Potentials of Future Natural Disasters in the United States Caused by Earthquakes and Storm%" paper presented at the International Conference on the Impact of Natural Disasters, Los Angeles, CA, 1991.

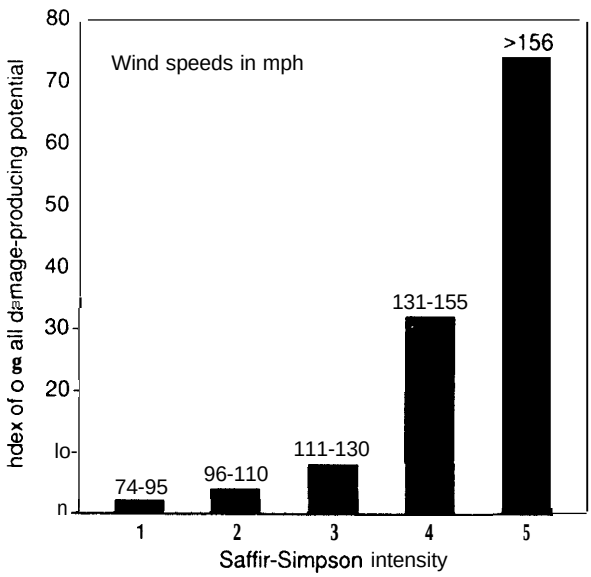
Box 4-A-Saffir-Simpson Hurricane-Intensity Scale

Category O

1. Winds less than 74 mph (119 km/h).[1]
2. Storm surge less than 4.0 feet (1.2 meters).[2]

Abroad coastal area may experience some damage to shrubbery, signs, and small structures and possibly some beach erosion, but the overall scope and impact of damage would not likely require relief action by the Federal Government.

Safflr-Simpson Hurricane-intensity Scale



NOTE: To convert miles per hour to kilometers par hour, multiply by 1 .s09.

SOURCE: Adapted from P. Hebert, J. Jarrell, and M. Mayfield, *The Deadliest, Costliest, and Most Intense United States Hurricanes of This Century (and Other Frequently Requested Hurricane Facts) (Coral Gables, FL:* National Hurricane Center, 19S2).

Category 1

1. Winds 74 to 95 mph; some damage to shrubbery, trees, and foliage; no real damage to building structures; some damage to poorly constructed signs, etc.
2. Storm surge 4 to 5 feet above normal; low-lying coastal roads inundated; minor pier damage; some small craft in exposed anchorages break moorings.

Category 2

1. Winds 96 to 110 mph; considerable damage to shrubbery and tree foliage; some trees blown down; no major damage to building structures.
2. Storm surge 6 to 8 feet above normal; coastal roads and low-lying escape routes inland cut by rising water 2 to 4 hours before arrival of the hurricane's center; considerable pier damage; marinas flooded; small craft in unprotected anchorages break moorings; evacuation of some shoreline residences and low-lying island areas required.

Category 3

1. Winds 111 to 130 mph; damage to shrubbery and trees; foliage off trees; large trees blown down; some structural damage to small residences and utility buildings.
2. Storm surge 9 to 12 feet above normal; serious flooding at coast, with many smaller structures near coast destroyed; larger structures damaged by battering offloading debris; low-lying escape routes inland cut3 to 5 hours before center arrives; terrain continuously lower than 5 feet maybe flooded inland 8 miles or more; evacuation of low-lying residences within several blocks of the shoreline may be required,

Category 4

1. Winds 131 to 155 mph; shrubs and trees down; all signs down; extensive roofing-material damage; extensive window and door damage; complete failure of roof structures on many small residences.

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[1] To convert miles per hour to kilometers per hour, multiply by 1.609. Speeds given here are at standard anemometer elevations. An anemometer is a device for measuring windspeed.

[2] To convert feet to meters, multiply by 0.305.

2. Storm surge 13 to 18 feet above normal; terrain continuously lower than 10 feet may be flooded inland as far as 6 miles; major darnage to lower floors of structures near the shore due to flooding and battering action; low-lying escape routes inland cut 3 to 5 hours before center arrives; major erosion of beach areas; massive evacuation of all *residences* within 1,500 feet of the shoreline and of single-story residences on low ground within 2 miles of the shoreline maybe required.

category 5

1. Winds greater than 155 mph; shrubs and trees down; roofing damage considerable; all signs down; severe and extensive window and door damage; complete failure of roof structures on many residences and industrial buildings; extensive glass failure; small buildings overturned and blown away.

2. Storm surge heights greater than 18 feet above normal; major damage to lower floors of all structures located less than 15 feet above sea level and within 1,500 feet of the shoreline; low-lying escape routes inland cut 3 to 5 hours before center arrives; massive evacuation of residential areas situated on low ground within 5 to 10 miles of the shoreline may be required.

SOURCE: P. Hebert, J. Jarell, and M. Mayfield, *The Deadliest, Costliest, and Most Intense United States Hurricanes of This Century (and Other Frequently Requested Hurricane Facts) (Coral* Gables, FL: National Hurricane Center, 19S2).

ment has expanded, exposure to coastal risks has increased dramatically. Table 4-1 compares damages from 49 hurricanes between 1949 and 1986 with damages those same hurricanes would have caused if they had occurred in 1987. Figure 4-3B shows the current damage-producing potential of the 247 hurricanes that struck the United States between 1871 and 1990. The different values, after adjusting for inflation, are due to increases in the size of the market (i.e., the amount of development) and the percentage of the market insured (27). For example, Hurricane Betsy, a category 3 storm, caused about $3.1 billion of insured losses in 1965 (adjusted to 1987 dollars). Had it struck in 1987, the insured losses would have been $6.3 billion.

Applied Insurance Research, Inc., in Boston, has developed estimates of total losses for major U.S. cities of a major hurricane strike. They estimate, for example, that a category 5 hurricane could generate $43 billion (in 1993 dollars) in losses in Galveston, Texas; $52 billion in Fort Lauderdale, Florida; and $34 billion in Hampton, Virginia (see table 4-2).

Hurricane Andrew was a category 4 hurricane when it struck South Florida in August 1992. The third most intense storm to strike the United States this century,[9] Andrew's total damages were more than 4 times greater than total damages from Hurricane Hugo, the former damage record holder. Andrew's estimated cost to property insurers as of February 1993 was at least $15.5 billion (72). However, this figure does not include losses involving uninsured property, such as damage to Government military facilities or other public property; utility equipment, such as power lines; economic losses, such as crop damage and lost tax revenue; and aircraft. It also does not include the cost of emergency services or property insured under the National Flood Insurance or Small Business Administration programs (72). The total losses from Andrew are likely to be greater than $30 billion. Moreover, if Andrew had struck 15 miles further north, in central Miami, damages could have been twice as much.

9 The two storms that hit land in the United States this century that were of greater intensity were Hurricane Camille, which struck the Mississippi coast in 1%9, killing 256 people, and the Labor Day hurricane that struck the Florida Keys in 1935, killing at least 600 (3). Hugo ranks 11th in intensity.

Table 4-l—Estimates of Insurance-Industry Potential Losses in 1987 Resulting from a Recurrence of Past Hurricanes

Year	Hurricane	Scenario 1 Damages in year-of-occurrence dollars ($ millions)	Scenario 2 Damages expressed in 1987 dollars ($ millions)	Scenario 3 Damages adjusted for inflation, market size, and insured share in 1987 dollars ($ millions)
1986	Charley	7	7	7
1986	Bonnie	21	22	22
1985	Kate	78	81	84
1985	Juan	44	46	47
1985	Gloria	419	436	440
1985	Elena	543	564	582
1985	Danny	37	39	40
1985	Bob	13	14	14
1984	Diana	36	40	41
1983	Alicia	675	790	893
1982	Iwa	137	170	192
1980	Allen	58	82	106
1979	Frederic	753	1,151	1,243
1979	David	122	187	217
1977	Babe	2	4	4
1976	Belle	23	45	53
1975	Eloise	119	259	352
1974	Carmen	12	28	36
1973	Delia[a]	3	8	11
1972	Agnes,[b]	8	22	36
1971	Ginger	2	6	8
1971	Edith	5	14	20
1971	Fern[a]	1	4	6
1971	Doria[a]	14	40	57
1970	Celia	310	1,007	1,602
1969	Camille	165	554	822
1986	Gladys	3	10	23
1967	Beulah	34	136	260
1966	Alma	5	22	59
1965	Betsy	715	3,096	6,300
1964	Isbell	2	9	23
1964	Hilda	23	104	204
1964	Dora	12	54	137
1964	Cleo	67	303	815
1961	Esther	4	20	54
1961	Carla	100	473	1,263
1960	Donna	91	430	1,313

a Tropical storm (maximum winds less than hurricane force).
b Wind damage only.

Note: Based on assumptions about changes in the cost of repair, size, and insured share of the affected property market since 1960.

Scenario l—Occurrence *of past hurrianes under original conditions.*

Scenario *2—Recurrence of past hurricanes with original market conditions, but using current value and cost-of-repair factor (inflation-adjusted only).*

Scenario *3--Recurrence of past hurricanes and their effect on current industry-insured properties, values, and costs of repair (combined market size, insured* share, *and inflation adjustment).*

SOURCE: D. Friedman, *Estimation of the Loss of Producing Potential of the Wind and Hail Perils to Insured Properties in the United States* (London, England: Insurance and Reinsurance Research Group, Ltd., 1987).

NOAA

Hurricane Andrew seen from space as it reached southeastern Florida on August 4, 1992. Andrew was one of the most destructive hurricanes in U.S. history. Estimated total losses of $30 billion would have been even higher had the eye of the hurricane struck heavily populated Miami a few miles to the north.

Table 4-2—Estimated Cost of a Major Hurricane Striking Densely Populated Areas (or Major Cities)

Saffir-Simpson category[a]	Landfall location	Estimated total loss ($ billions)[b]
5	Galveston, TX	43
5	New Orleans, LA	26
5	Miaml, FL	53
5	Ft. Lauderdale, FL	52
5	Hampton, VA	34
4	Ocean City, MD	20
4	Asbury Park, NJ	52
4	New York City, NY	45
4	Long Island, NY	41

[a]Severity of the hurricane (5 IS more severe than 4)
[b]1993 dollars

SOURCE Applied Insurance Research, Inc , Boston, MA

Neither Andrew nor Hugo hit major population centers.

On average, between 16 and 17 hurricanes per decade have occurred in the United States since 1900. About seven of these per decade have been major (37).[10] Much of the urban growth along the East and Gulf Coasts has occurred since 1%0, during which period hurricane and coastal-storm activity has been somewhat less than average (14 per decade between 1960 and 1990, of which about 5 per decade were major) (37). About 80 percent of people now living in hurricane-prone areas have never experienced a direct hit by a major storm (34). Prophetically, the National Committee on Property Insurance suggested in 1988 that the people of South Florida, who had not experienced a major hurricane since 1950, were living on borrowed time (58). Also, much coastal development since 1960 has been in the most vulnerable locations, including barrier islands,[11] beachfront areas, on or near coastal wetlands and estuarine shorelines, and in flood-hazard zones. Notably, many of the counties most susceptible to hurricanes (e.g., Monroe County, Florida, where the annual probability of a hurricane striking is 19 percent) are expected to grow at much faster rates than the Nation as a whole between now and 2000 (l).

Loss of life from hurricanes has declined over time, in large part due to improved weather forecasting and evacuation planning (34). For example, 35 deaths were caused by Andrew, whereas many hurricanes this century have caused many more than 100 deaths.[12] Although existing warning and prediction systems are likely to continue to improve, people continue to crowd into coastal areas, so the time required to evacuate them could increase. Aging infrastructure in some areas (see ch. 5) may also contribute to evacuation problems. Therefore, even without increased numbers or intensities of hurricanes (but more so with them), the potential exists for increased loss of life in the future.

10 Major storms are those classified as category 3 or greater.

11 Between 1955 and 1975, developed land on barrier islands increased by 153 percent (51).

12 & unnamed hurricane that struck Galveston, Texas, in 1900 caused more than 6,000 deaths.

Table 4-3--insured Losses Likely To Be Experienced Under Different Maximum-Wind-Speed Scenarios

storm	Class	Year	Estimated 1990 insured losses ($ billions)	Estimated 1980 insured losses if maximum wind speed increases ($ billion)		
				5 percent	10 percent	15 percent
Hugo	4	1969	4	5	7	9
Alicia	3	1963	2	3	4	6
Camille	5	1969	3	4	5	7

SOURCE: K. Clark, "Predicting Global Warming's Impact," Contingencies (newsletter of Applied Insurance Research, Inc., Boston, MA), May/June 1992.

Will the intensity or frequency of hurricanes and/or other storms increase in a warmer climate? General Circulation Models (GCMs) cannot simulate the occurrence of hurricanes in detail (40), but researchers have found that by modeling the doubling of carbon dioxide (CO_2, the number of simulated tropical disturbances-although not their intensity-increased (36) (see ch. 2 for a discussion of GCMS). There has also been some research on the relationship between rising sea-surface temperatures and hurricane severity and some suggestion that these may be positively correlated. However, no unambiguous correlation has yet been established. Some have suggested, for example, that hurricanes may be less intense in a warmer climate (13). Additional research is clearly needed to establish the relationship between global warming and hurricane intensity and frequency.

What is somewhat clearer is the nonlinear relationship between the maximum wind speeds of hurricanes and their damage-causing potential. Table 4-3 shows some examples of how insured losses would increase with maximum wind speed. If wind speeds for the three hurricanes shown had been 15 percent higher, insured wind losses would have more than doubled (13). Hence, if climate change leads to only marginally more-intense hurricanes, substantially greater damage can be expected.

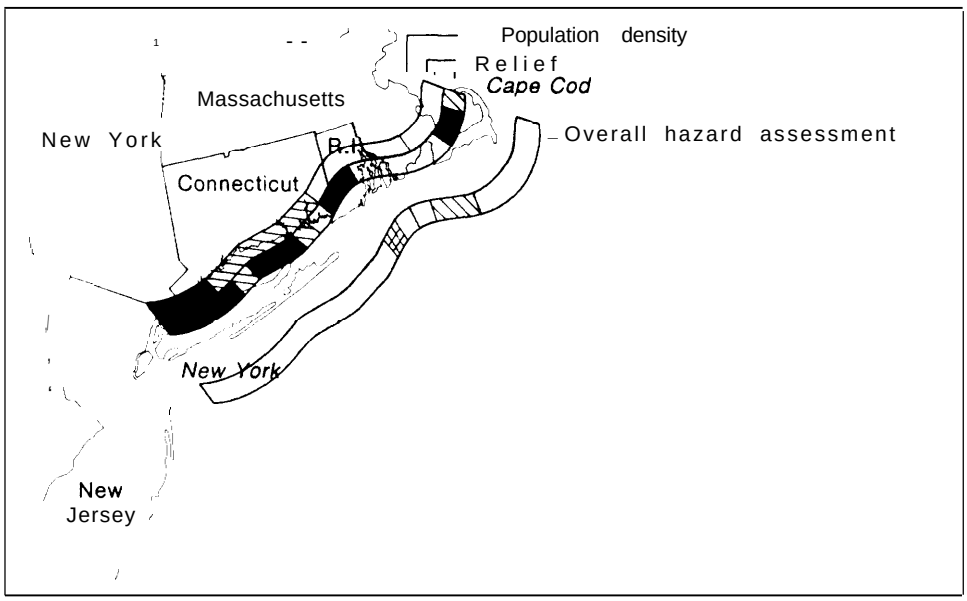
An Overall Coastal-Hazard Assessment

The U.S. Geological Survey (USGS) has combined information about a variety of natural processes and coastal characteristics with information about population density to develop an overall coastal-hazard map (90). Factors separately considered are coastal relief, shoreline change (a measure of sea level rise), storm surge, frequency of major storms, frequency of earthquakes and other earth movements, stabilization (a function of the density of structures), ice (important only in Alaska and the Great Lakes), and permafrost (perennially frozen ground, important in northern Alaska). Segments of the coast are rated from very high to very low risk in six categories. Figure 4-4 shows two simplified segments of the USGS map. The complete map, however, shows that Louisiana eastern Texas, parts of the Pacific Northwest, and much of Alaska and Hawaii are the most vulnerable segments of the U.S. coastal zone. USGS is currently in the process of producing more-detailed regional maps, which should be very helpful in assessing the vulnerability of U.S. coastal areas to climate change.

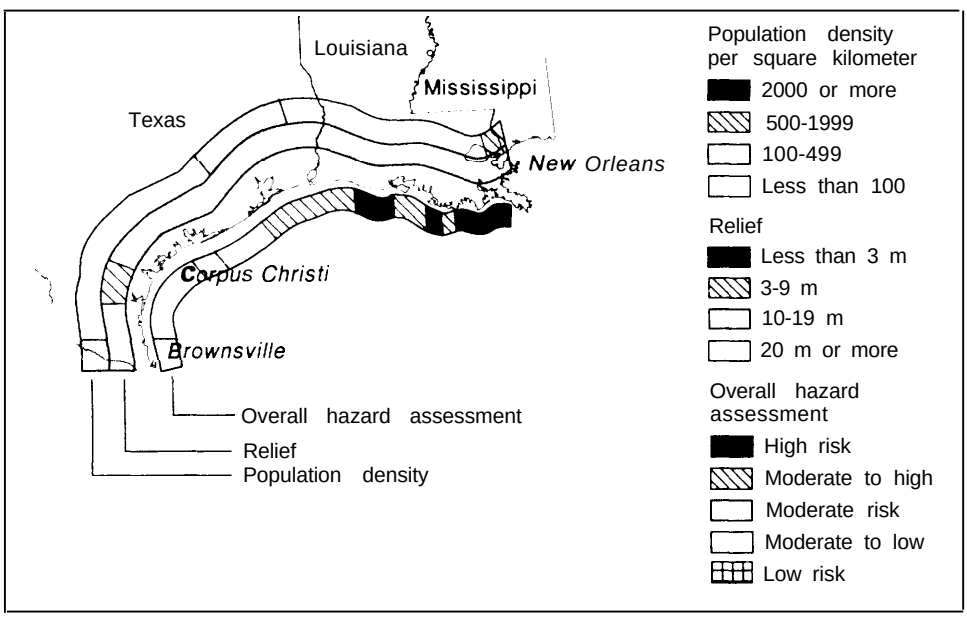
THE CHALLENGE FOR POLICY

Although development pressures in coastal areas are driven by many social and economic trends, government policies can influence the appropriateness, rate, quality, and location of development. Historically, government has subsidized coastal development, both directly and indirectly. In particular, four important programs and policies address the riskiness of living in the coastal zone: 1) the National Flood Insurance

Figure 4+-Coastal Hazard Assessment



New York to Massachusetts.



Texas to Louisiana.

SOURCE: U.S. Geological Survey (USGS), "Coastal Hazards," *National Atlas* **of the** *United States* of America(Reston, **VA: USGS, 1985).**

Program (NFIP), 2) Federal disaster assistance, 3) Federal beach-renourishment and shoreline-protection programs, and 4) the U.S. Tax Code. These programs and policies have clear benefits, but some of their elements have contributed to a distortion of the Nation's perception of the vulnerability of living in coastal areas and have lead to some inappropriate or ill-suited development. The goals of some coastal programs and policies are also often at cross-purposes with one another: improving coordination is as relevant in coastal areas as it is in other sectors discussed in this assessment.

National Flood Insurance Program

Congress made Federal flood insurance available in 1%8 through the creation of the National Flood Insurance Program (authorized under the National Flood Insurance Act, P.L. 90448). The NFIP was enacted to limit increasing flood-control and disaster-relief expenditures and to provide a pre-funded mechanism to more fully indemnify victims of flood-related disasters. It was also intended to limit unwise development in floodplains while at the same time providing affordable Federal insurance for structures located in special flood-hazard areas (14). Between 1978 and 1992, 430,000 flood-insurance claims were made, and total payments, including claims arising from Hurricanes Hugo, Andrew, and Iniki, have been nearly $4.0 billion (22).

The NFIP has been only partially successful. It has reduced somewhat the need for taxpayer-funded disaster assistance and has been a factor motivating local government mitigation efforts. Homes built in compliance with NFIP regulations are some 70 percent less likely to be damaged than those built before NFIP requirements went into effect. Before the program was created, affordable private flood insurance was generally not available. However, the program has also contributed to coastal development and has been criticized frequently for not adequately fostering prudent land use in hazardous areas.

The program is administered by the Federal Insurance Administration (FIA), a unit of FEMA. Under the NFIP, Federal flood insurance coverage is made available to owners of flood-prone property in communities that adopt and enforce a floodplain-management ordinance that meets the minimum program standards. Coverage is available both for the structure itself (up to $185,000 for a single-family structure) and for its contents (up to $60,000) (26). Participating communities must adopt certain minimum floodplain-management standards, including: 1) a requirement that new and substantially improved structures in the 100-year flood zone[13] be elevated to or above the 100-year flood level (generally known as *base flood elevation, or* BFE), *2)* restrictions on new development in designated floodways (e.g., development within a floodway is prohibited if it results in raising the flood levels), and 3) a requirement that subdivisions be designed to minimize exposure to flood hazards. Additional standards are imposed within high-hazard coastal zones ("velocity" zones, or "V" zones), including requirements that buildings be elevated on pilings, all new development be landward of the mean high water value, the BFE include wave heights greater than 3 feet (0.9 meters),[14] ad new development on dunes not increase potential flood damage.

NFIP participation by a community is voluntary, but there are now strong incentives to participate. Because of limited participation initially, the 1973 Flood Disaster Protection Act (P.L. 93-234) required flood insurance for all federally backed mortgages (e.g., for Department of Veteran Affairs (VA) and Federal Housing Administration (FHA) loans) and for all loans obtained through federally insured and regulated

13 'fbo area that would be inundated by a flood whose elevation has a 1 percent chance of being equaled or exceeded in any year, that is, that would occur on average only once every 100 years.

14 To convert feet to meters, multiply by 0.305.

financial institutions. Also, disaster-assistance grants to local governments for repair of public facilities are reduced for those governments not participating in the program (although individual property owners need not have flood insurance to be eligible for individual and family disaster-assistance grants). As a result, communit y participation has been high, and about 82 percent of the 22,000 flood-prone communities have adopted minimum floodplain-management standards (47). However, it is estimated that less than 25 percent of individual owners of flood-prone property currently purchase flood insurance.

The participation of individual property owners nevertheless amounts to a considerable Federal financial liability. There are currently about 2.6 million flood policies in effect. These represent nearly $230 billion of insurance (22). The probable maximum loss in any given year has been estimated to be about $3.5 billion. More than 70 percent of NFIP policy holders are located in coastal communities. Those located in the most hazardous V-zones (some 65,000 policy holders) represent about 2.5 percent of the policy base (55); but between 1978 and 1992, these areas accounted for approximately 6 percent of total losses and 5 percent of all premiums.

Properties that existed before community regulations went into effect (i.e., pre-FIRM properties)[15] are eligible for subsidized premium rates nationwide. In the 1978-92 period, these properties represented about 80 percent of the NFIP's exposure while accounting for about 90 percent of the losses. Currently, about 42 percent of the NFIP's policies are subsidized. Subsidized businesses pay premiums that are, on average, one-third what the full-risk premiums would be. Through the 1970s and early 1980s, Congress supported heavy premium subsidies on existing construction in order to encourage broad-based participation of flood-prone communities in the program. Subsequently, subsidies have been reduced but not eliminated. The amounts of insurance that can be subsidized per policy are limited. In the case of single-family-structure coverage, this amount is $35,000. Protection above this is purchased at full-risk rates. About 19 percent of the $230 billion of insurance is subsidized.[16]

Historically, the NFIP has suffered from several problems and has been the subject of considerable criticism. Between 1978 and 1987, the program ran an average annual operating deficit of about $65 million, generating a $657 million deficit over that lo-year period (55). Beginning with FY 1986, however, the NFIP has been self-supporting. Rating and coverage changes made by the NFIP through the mid-1980s have enabled the program to build up reserves in years when losses were less than the historical average in order to help fund the program in years when greater-than-average losses occurred. Post-FIRM construction in general and post-FIRM construction in V-zones in particular have generated surpluses whereas pre-FIRM subsidized insurance has continued to be a drain on the National Flood Insurance Fund (74).

As of early 1993, the flood-insurance fund contained less than $40 million in reserves. This amount seems low when compared with potential flood-damage liabilities. FIA's estimates suggest that the probability is high of exceeding the existing surplus amount in any given year. As table 4-4 indicates, the probability that total annual losses will exceed $800 million nationwide is a high 30 to 35 percent, and the probability that losses will exceed $300 million per year is 60 to 70 percent (23). The FEMA director can borrow up to $500 million from the Treasury without notifying Congress, and an additional $500 million if Congress is notified. Thus, FEMA's present $1 billion borrowing authority is much less than its $3.5 billion probable maximum loss in any given year (23). FEMA estimates that its combined borrowing authority and annual

15 That is, properties that existed before the development of flood-insurance-rate maps, or FIRMs. Most communities had FIRMs by 1975.

16 H. Leikin, Federal Insurance Administration, personal communication, June 29, 1993.

Table 44-Estimated Probabilities of Exceeding Given Levels of Flood-Insurance Losses

Total annual loss costs ($ millions)	Probability of exceeding total annual costs (percent)
300	60-70
800	30-35
1,400	10-15
1,800	2-7
3,500	0,05-0.50

SOURCE Federal Emergency Management Agency (FEMA), "Estimating Probabilities of Exceeding Given Levels of Flood Insurance Losses in a One Year Period " (Washington, DC FEMA, Aug. 4, 1992)

premium income are adequate 85 to 90 percent of the time.[17]

The average annual cost of flood insurance per structure, as reported by FIA, is $296.[18] For full-risk policies in coastal high-hazard zones, it is over $800. Many homeowners would not consider these costs modest. Compared with the magnitude of potential liabilities under the program and the meager size of the current surplus, however, the current cost of insurance to property owners may not be high enough. Moreover, 86 percent of insured property owners in coastal high-hazard areas receive insurance at subsidized rates and pay about $440 less per year than those without subsidies. Premiums are still set to cover the average historical-loss year. Other possibilities would be to set the premium rate high enough to cover a catastrophic-loss year or, perhaps, to cover the loss associated with a 1 percent chance of occurrence in any year.

Another problem is that although flood insurance is mandatory for new construction that uses loans from federally insured banks, many lenders are not ensuring that the requirement is satisfied.[19] It has been estimated that there are between 8 and 11 million structures in flood-hazard areas, but fewer than 2 million are actually covered by flood-insurance policies (47). In Maine and Texas, for example, 22 and 78 percent, respectively, of properties in special flood-hazard areas that requested disaster assistance did not have insurance (87). In some cases, properties were erroneously classified and in others, insurance policies were allowed to lapse (87). Many properties in flood-hazard areas simply are not required by law to have flood insurance because they have no mortgage or because they have a mortgage from an unregulated lender (i.e., from a non-federally insured lender).

Repetitively damaged properties represent another problem for the NFIP. Over 40 percent of all flood-insurance claims have been for properties damaged more than once (87), yet FIA does not have the authority to cut off or substantially restrict future coverage for such properties. lndividuals are permitted to rebuild and to continue to receive insurance, and the program allows for a potentially unlimited cycle of damage-rebuild-damage. Many believe that the premiums charged to repetitive-loss properties should be raised by FEMA to better reflect the risk of recurring flood damage (7).

Another significant concern about the way the NFIP functions in coastal areas is its failure to take into account long-term erosion. This amounts to a hidden subsidy of erosion risks because the flood program pays claims for erosion damage, although the risk is not a component of the rate structure for flood insurance.

Congress initiated changes to the definition of "flood" in 1973 to include collapse or subsidence along shorelines, and NFIP regulations were amended to allow creation of special erosion zones ("E" zones) and to mandate local land-management programs to take these hazards into account (59). Congress has not given FEMA the authority to map non-flood-related erosion zones (74), however, and property owners are generally opposed to erosion mapping. Also, FEMA has not

[17] Ibid.

[18] Ibid.

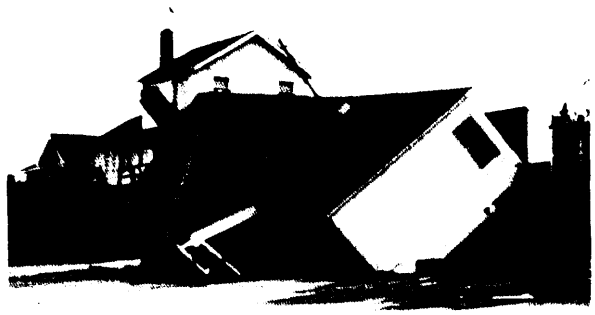
[19] Legislation being considered in the 103d Congress (e.g., H.R. 62) addresses this problem.

sought to require local land-management programs (e.g., housing setbacks) to address erosion hazards, and long-term erosion trends are generally not taken into account in FEMA's current floodplain mapping. V zones are the flood zones closest physically to shoreline-erosion zones, yet they are often narrowly drawn, and "frequently exclude adjoining areas with virtually indistinguishable hazard characteristics" (59).

The NFIP plays a role in regulating reconstruction following a flood event. When a building is "substantially" damaged (e.g., more than 50 percent destroyed), it must be rebuilt in compliance with the local floodplain standards currently in force. Replacement of older, unelevated structures with newer, elevated buildings after disasters like Hurricane Andrew, for example, can have important mitigation benefits. However, flood policies do not pay for the increased cost of bringing buildings into compliance with newer standards. Thus, for example, more than 3,000 buildings in South Florida damaged by Andrew need to be elevated, but there is no insurance money available to do so. In addition, local governments may choose to apply the ' 'substantially damaged" standard only if damages are greater than 50 percent of the replacement value of the structure. This has the effect of exempting more damaged structures from elevation and floodplain-management requirements when rebuilding.

FIA would like to provide "increased cost of construction coverage' but needs authority from Congress to do so (74). Such coverage, on average, would cost property owners an extra $34 annually. In coastal high-hazard zones, however, the additional premium would be substantially more, especially for subsidized property owners.

Finally, flood-insurance maps are infrequently revised and updated. FEMA is able to remap communities every 9 years, on average. However, many participating communities are growing rapidly, and development in the floodplain can substantially modify local flood hazards in less time than that.



STEPHEN LEATHERMAN

A house tumbles onto the beach at Fire Island, New York, as a result of erosion damage caused by the December 11, 1993, northeaster.

Federal Disaster Assistance

The Federal Government has been involved for many years in assisting State and local governments in responding to, and recovering from, national disasters. Its primary authority for providing disaster relief is the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 (P.L. 93-288, as amended by P.L. 100-707). Such assistance has, as it should, enabled communities to rebuild centers of commerce after disasters and to return (more or less) to pre-disaster conditions. However, although financial assistance to people who have suffered a major misfortune is often appropriate, it can also subsidize risky public and private actions and thus function as another form of incentive for hazardous coastal development.

Disaster assistance available through FEMA generally falls into two categories: individual and family assistance, and public assistance. Under FEMA's Individual and Family Grants (IFGs) program, grants upto$11,500 (adjusted *annually* for inflation) can be made to individuals and families to cover disaster-related expenses (e.g., home repairs not covered through insurance and

replacement of personal belongings) .20 Under FEMA's public-assistance program, States and communities can receive grants (usually at a 75 percent Federal cost share) to cover the cost of damages to public facilities. Eligible projects include repair of roads, bridges, sewer and water systems, recreational facilities, and public boardwalks, and, if certain beach-maintenance eligibility criteria are met, renourishment of beaches. Communities not participating in NFIP, however, receive reduced amounts of public assistance. Applicants under the IFG program need not be in a participating community nor have purchased Federal flood insurance, though they must agree to purchase flood insurance as a condition of receiving an IFG grant.

Precisely how much of an impact Federal disaster assistance has in encouraging (or failing to discourage) hazardous and damaging coastal development is uncertain Amounts of Federal disaster assistance in recent years have been substantial. Some $8.3 billion was spent between 1978 and 1988 on presidentially declared disasters. FEMA reports that approximately $89 million per year was spent as a result of hurricanes and coastal-storm events during this period (55). These disaster-assistance monies provide a significant subsidy for coastal communities, underwriting various potentially risky coastal public investments. In several recent disasters, including Hurricanes Andrew and Hugo, the Federal Government agreed to cover 100 percent of the costs of eligible public-sector damages. Where the 25 percent cost sharing has been required, the State frequently assumes half of that, leaving local governments to assume only 12.5 percent of the cost of such damages.

There are currently no provisions in this system for considering the magnitude of the damage to an individual community or the financial capability of the State or local government to cover these damages. High-risk communities would have stronger incentives to ensure that public facilities are placed in safe locations or designed in ways that minimize future vulnerability to hurricanes or other disasters if such factors were considered. In many cases, the Federal reconstruction subsidy is in addition to the original Federal subsidy used to construct the facility.

Disaster assistance has in many ways been seen by States and communities as an entitlement that is deserved regardless of the extent or cause of the damages, the ability of these jurisdictions to assume the costs, or participation in the NFIP. In theory, Presidential disaster declarations are only to be issued when the resources of affected State and local governments are clearly exceeded. Yet, Presidential declarations (which average 20 to 25 annually; 46 were proclaimed in 1992) are increasingly viewed as pro forma and have occurred even where damage levels are relatively modest and where State and local governments could clearly have assumed the cost with little burden. (A Presidential disaster declaration was made after Hurricane Diana struck the North Carolina coast in 1984, for example, even though the $79 million in damages was relatively small and the State could have handled the damages.) One survey of 481 communities found that local officials believe they can handle losses much larger than those defined by FEMA as constituting a disaster (1 1).

FEMA has sought to reform this system in the past, only to be criticized by representatives of State and local governments and owners of property in high-risk areas. In the mid-1980s, for example, FEMA proposed that the required State and local share of public-assistance grants be increased to 50 percent (i.e., 50 percent Federal, 50 percent State and local) and that a set of criteria be imposed to determine a legislative entity's ability to pay. These proposals met with considerable political opposition and were eventually dropped. Many commentators, however, have echoed the need for such reforms, which might

[20] IFG grants are available only to people who do not qualify for low-interest Small Business Administration disaster loans.

U.S. ARMY CORPS OF ENGINEERS

The San Francisco sea wall.

U.S. ARMY CORPS OF ENGINEERS

Beach-nourishment project at Rockaway, New York.

help to promote implementation of State mitigation measures (10, 25).

In addition to FEMA, several other Federal agencies provide some form of disaster assistance. These include loans, grants, and reconstruction monies from the independent Small Business Administration and Economic Development Administration, the Department of Transportation's Federal Highway Administration (for roads and bridges), the Department of Education (for school buildings), the Department of Agriculture's Farmers Home Administration., and the Army Corps of Engineers. In all, there are some 30 Federal disaster-relief programs (5).

One effort to coordinate the actions of the different Federal agencies was the Interagency Hazard-Mitigation agreement signed in 1980. Under this agreement, an interagency hazard-mitigation team is called into action immediately after a disaster declaration and is required to prepare a report within 15 days of the declaration. These reports typically identify hazard-mitigation opportunities and contain recommendations, many of which have been pursued by FEMA and other Federal agencies. These recommendations also typically are considered in the Section 409 hazard-mitigation plans prepared by States (see below). No systematic evaluation of how recommendations in these reports are implemented has yet been done.

Federal Beach Nourishment and Shoreline Protection

Shoreline protection, either in the form of "hard" devices, such as seawalls, revetments, groins, jetties, and breakwaters, or as "soft" buildup or replenishment of beaches and dunes, is often justified where storm surges and/or erosion threaten well-developed coastal communities and expensive facilities like harbors and resorts (59). The best protective measure for a given site will depend on the underlying physical conditions at the site and on economic, social, and environmental costs (see box 4-B).

The Federal Government, through the Army Corps of Engineers, has subsidized shore-protection projects for decades. Where the benefits of shoreline protection are associated with improving recreational opportunities or counteracting erosion, the Federal share of approved projects is currently 50 percent. Where the benefits include prevention of physical damage to property, the Federal share of construction costs increases to 65 percent. Most projects are now justified on the basis of prevention of physical damages, The periodic renourishment that maybe required on some beaches after a project has been

Box 4-B-Protect or Retreat?

There are essentially two types of responses to erosion and sea level rise: protect vulnerable areas or retreat from the coast. The most appropriate response for a specific area will depend on an array of socioeconomic and environmental factors, including the number and value of coastal structures at risk, the relative cost of protection and retreat options, aesthetic values, and the value of preserving undeveloped areas (49). The appropriate response will also depend on physical conditions at the site, including the availability and suitability of sand.

Protection can mean either building defenses that "harden" the shoreline against incursions of these% or replacing eroded beach sand, as necessary, through *beach nourishment* or *replenishment*. Since 1946, the U.S. Army Corps of Engineers has undertaken 121 shore protection projects encompassing a total shoreline distance of just over 300 miles (460 kilometers).' Another 52 projects that would protect about 230 miles of coast have been authorized (but not yet funded) by Congress (66). About 75 percent of all Corps projects involve beach nourishment as a basic feature, although beach nourishment is sometimes used in combination with hard structural protection measures (91).

The number of miles devoted to beach and dune nourishment in Corps projects reflects a general community preference for nonstructural approaches where feasible. Such approaches are especially preferable where beaches are primary assets for coastal communities, as, for example, in Miami Beach, Florida. Beach nourishment projects can also be expensive, but costs are site-specific and highly variable. In Miami Beach, nourishment of a 10.5-mile stretch of coast cost about $6 million per mile in the late 1970s. Beach nourishment can be an effective protective measure because beaches are efficient in absorbing wave energy. Usually, beach nourishments used where erosion of a natural beach is occurring. The ability of the nourished beach to absorb wave energy may, thus, come at the expense of its own erosion, so periodic renourishment maybe required. As an adaptation to sea level rise, beach nourishment has the advantage that it can be abruptly halted (e.g., in favor of retreat) without abandoning large investments when the costs of continued nourishment exceed benefits.

Some beach-nourishment projects have been criticized for having life spans that are shorter than anticipated and, more generally, for falling to perform as designed (66). Debate continues on the performance of specific beach-nourishment projects (e.g., see ref. 39). However, it seems clear that as understanding of fill and sediment dynamics has advanced, the performance of such projects has improved (39).

Hard structural protective measures are also appropriate in some circumstances. The most common are sea walls, breakwaters, and groins. Sea walls are concrete, steel, stone, or timber structures built parallel to and on the landward side of beaches. Their primary purpose is to protect upland areas. Like nourishment projects, they are normally built in areas that are eroding, and thus beaches in front of sea walls may eventually disappear. However, properly designed sea walls can protect the land behind them without causing adverse effects to beaches (59). Sea walls are initially more expensive than beach-nourishment projects, but the periodic costs required of beach-nourishment projects are not incurred. Some sea walls will likely have an adverse effect on the ability of wetlands to migrate in response to sea level rise. A 20-inch (0.5-meter)[2] rise in sea level could result in the loss of35 percent of coastal wetlands if standard measures are taken to protect currently developed lowlands; however, 30 percent of wetlands could be lost in any case if no protective measures are taken (62).

Breakwaters are linear structures placed in nearshore waters whose purpose is to shield the shoreline from incoming wave energy. Groins are wall-like structures constructed perpendicular to the shoreline and used to trap sand moving parallel to the shore. They are usually used in combination with beach nourishment. They have often been improperly used in the past, resulting in downdrift beach erosion.

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[1] To convert miles to kilometers, multiply by 1.609.

[2] To convert inches to meters, multiply by 0.025.

In coastal cities and seaside resort communities, the value of the land is usually great enough that decisions to install hard structures or replenish beach sand are often made. Retreat is usually not a practical alternative in these areas. In sparsely developed areas, the opposite is generally the case, and retreat maybe the only feasible option (83). Gradual retreat from the coast, limiting coastal uses to those that can be accommodated without protection, is favored by many insurance companies and environmentalists as the ultimate solution to coastal erosion and sea level rise. They argue that protection measures can only forestall inevitable destruction and, if risky development is allowed to continue, increase the costs of protection and retreat (54). Policies that promote retreat include setback provisions that some coastal States have adopted and the Federal Government's flooded-properties-purchase program and UptonJones relocation-assistance program (see main text).

A substantial amount of money has been invested in coastal areas. Owners of beachfront property are understandably upset when their homes or businesses are threatened by erosion, and retreat to a safer site may not be an option for many. The reality of erosion and sea level rise creates some difficult public-policy issues. Property owners naturally want to take steps to protect threatened iand. However, in some instances (e.g., in some quickly eroding areas), it will probably not be desirable or economically justified from a community or national perspective to do so, and gradual retreat will be preferred. Two issues with immense consequences for coastal development are likely to continue to be debated. First, is the extent to which private-property owners should be subsidized by taxpayers at large to maintain risky coastal development. Second, is how much property owners should be compensated when a State limits the economic use of seaside property. These issues will become more controversial as the amount of money invested in coastal development increases. The possibility of future sea level rise suggests that clear policies guiding the expectations of property owners need to be established.

SOURCE: Office of Technology Assessment, 1993.

completed (see box 4-B) has not to date been considered a "maintenance activity' (if it were, the Corps would not be involved), so these recurring costs are subsidized as well.[21] If the Corps uses sand dredged from navigation projects for beach nourishment, the Federal Government currently provides 50 percent of the increased costs that would be incurred to place this sand on beaches rather than to dispose of it in the least costly manner. Finally, the Federal Government shares the costs of feasibility studies with States. Federal aid is usually recommended to continue through the life of the project, normally 50 years for hard structures (91).

In recent years, the Corps has spent between $40 and $70 million annually for beach nourishment and structural-protection measures, the majority of which has been for beach nourishment.[22] Because the largest benefit of beach-protection projects is realized at the local or regional level, it may be desirable to shift more of the burden of paying for such projects from the Federal Government to the States. Responsibility for maintaining beach-nourishment projects, in particular, could be shifted to affected States, just as is maintenance of Corps-built flood-control projects.

States have also been active in assisting with and subsidizing shore-protection efforts. Several States now provide funding, often through the issuance of bonds, for local renourishment programs, and often in combination with Federal subsidies. In South Carolina, for instance, the State legislature created a $10 million Beach Renourishment Fund in 1988, most of which went to emergency renourishment and dune-rebuilding projects after Hurricane Hugo (43). Likewise, the

21 L. Vallianos, Institute of Water Resources, U.S. Army Corps of Engineers, personal communication, July 1993.

22 J. Housley, U.S. Army Corps of Engineers, personal communication, July 1993.

State of Maryland has provided about $60 million under its Shore Erosion Control Program (SECP) for beach renourishment in Ocean City. The State also provides interest-free loans and technical assistance for shorefront property owners experiencing erosion problems, and 50 percent matching funds to property owners who undertake nonstructural erosion-control measures such as planting grass (68). The State of New Jersey recently passed a bill to appropriate $15 million per year for shore projects, including beach nourishment.

U.S. Tax Code

Several major coastal-development subsidies are also available in the U.S. Tax Code. The casualty-loss deduction allows coastal property owners to deduct the cost of uninsured damages resulting from hurricanes and other natural disasters. Allowable deductions are determined by subtracting the post-storm value of property from its pre-storm value, less insurance received.[23] The deduction is only allowed where losses exceed 10 percent of adjusted gross income.

Other U.S. Tax Code subsidies include interest and property-tax deductions for second homes (which comprise much of coastal development) and accelerated depreciation for seasonal rental properties. These types of subsidies are largely hidden, and estimates of their aggregate cost are hard to come by. There is little doubt, however, that the extent of implicit public subsidy is substantial.

Other Development Subsidies

Coastal growth is subsidized by a variety of other Federal development programs and grants. The Farmers Home Administration, for example, provides subsidies in the form of community-facility loans, business and industry loans, and rural housing loans (88). The Department of Housing and Urban Development provides guaranteed home loans, as does the Department of Veterans Affairs. The Rural Electrification Administration provides loans for development of electrical systems, and the Environmental Protection Agency has provided considerable funding for water systems and for wastewater treatment. Extensive funding for the construction of highways, roads, bridges, and other improvements that make many otherwise remote coastal areas readily accessible has been provided by the Department of Transportation and is one of the more significant factors affecting the development of barrier islands. Most of these development-related grants and subsidies are not limited to coastal areas, and estimates of their magnitude and of their impacts in coastal regions are not available.

OBSTACLES TO BETTER MANAGEMENT

Improvements in the Federal and State programs that affect development in the coastal zone are possible and, considering the potential for increasing vulnerability in coastal areas as a result of global climate change, desirable. However, several impediments to reducing risk exist. Among these are the fact that people continue to be attracted to coastal areas, the notion of subsidies as social entitlements, private-property concerns, the cost of change, and institutional fragmentation and regulatory obstacles.

The Attraction of Coastal Areas

The economic and personal attraction Americans have to coasts can be seen as an obstacle to many coastal-management reforms. Recent surveys of coastal-property owners suggest that many have a solid appreciation for the danger and riskiness of building and living in coastal areas, but see hurricanes and coastal storms as simply a necessary part of the tradeoff for the benefits of coastal living (6). Table 4-5 shows the results of a questionnaire mailed to owners of beachfront

[23] See note 455 on Stem, hurricanes, and floods in 26 U.S. Code ('U. S. C.) 165.

Table 4&Results of a Mail Survey of 132 Owners of Beachfront Property in South Carolina After Hurricane Hugo That Asked the Question:

"Now that you *have experienced* the effects *of a hurricane, has this had any influence on your feelings about owning beachfront property?"*

	Percent
1. Yes, would not buy beachfront property again	6
2 Yes, would like to sell my property and buy property in a safer location	7
3. No, hurricanes are just a normal risk in beachfront areas	39
4. No, the benefits and enjoyments of beachfront living outweigh the potential risks	42
5. Other	6

SOURCE: T. Beatley, *Hurricane Hugo and Shoreline Retreat: Evacuating the Effectiveness of the South Carolina Beachfront Management Act,* final report to the National Science Foundation, September 1992

property in South Carolina heavily damaged by Hurricane Hugo. Even those who were devastated by such events did not generally have regrets or plan to move to safer locations. A related obstacle is the economic advantage of beachfront locations. Owners of beachfront property maybe reluctant to relocate structures at risk until they have nearly collapsed into the surf because the income from renting these units on the beach is substantially higher than it would be on sites farther inland. Also, equivalent beachfront property is often unavailable or too expensive.

Coastal Subsidies as Social Entitlements

Some coastal subsidies have, over time, acquired a constituency and set of beneficiaries who tend to view them as social entitlements, in much the same way that people view social security. Similar views exist about disaster assistance. Almost regardless of the magnitude of the damages or the ability of States, localities, and property owners to assume the damages, many people perceive that a disaster declaration and disaster assistance are deserved. Taking away or Curtailing programs such as Federal flood insurance would be opposed by communities and coastal property owners who fear that property values, salability, and economic attractiveness of coastal areas would be reduced.

Private Property and the Takings Issue

A major impediment to more-effective and more-sensible coastal management is concern about impacts on private property. Specifically, property owners who are restricted as a result of coastal-management programs (e.g., Ocean-front setback requirements or restrictions on filling wetlands) may claim that these restrictions represent unconstitutional *takings* **of private property under the fifth amendment to the U.S. Constitution (as well as under similar provisions in State constitutions). If land-use regulations are so restrictive that they deny all reasonable economic use of a coastal property, the courts may well conclude that a taking has occurred.**

A recent case in South Carolina, *Lucas v. South Carolina Coastal Council,* **illustrates the potential dimensions of this obstacle.[24] David Lucas, a South Carolina developer and property owner who had acquired two small lots on Isle of Palms (a barrier-island community east of Charleston), was prevented from building on them as a result of the 1988 South Carolina Beachfront Management Act (both lots were seaward of the so-called "baseline") (69). Arguing that the setback restrictions deprived him of all reasonable economic use of his property, he challenged the restrictions as an unconstitutional taking. The lower court found in his favor and awarded him**

[24] 112 S. Ct. 2886, 1992. See also reference 69.

$1.2 million. The South Carolina Supreme Court overruled this decision, upholding the Coastal Council's actions as merely preventing a public harm and thus not requiring compensation. Lucas appealed to the U.S. Supreme Court, where the majority determined that some compensation should be paid when the value of property is essentially destroyed by regulation. The court reiterated the position that when land-use regulations that preclude all economic use of property go into effect, a taking might occur (unless the regulation serves only to enforce a preexisting common-law doctrine, such as nuisance law). The case was then returned to the South Carolina Supreme Court, which, in reconsidering, found that a temporary taking had occurred. In July 1993, a settlement was finally reached, and the State agreed to pay Lucas $1.5 million.[25] The full implications of the Lucas decision remain to be seen, but it will likely be cited by opponents of more-stringent coastal land-use regulations.

Takings law is still developing, and considerable disagreement exists about when a regulatory taking actually occurs. What constitutes a reasonable economic use, for example, remains a debatable question. The South Carolina law did not prevent the erection of a temporary structure on the Lucas property, or prohibit the sale of the lots to adjoining property owners. The use restrictions in the NFIP generally are not considered a taking because participation by communities is voluntary and because protecting people from the threat of harm is part of community authority under police powers.

Irrespective of the specific constitutional challenge of a taking, additional restrictions on the use of land have in recent years met with serious political opposition. Several property-rights-protection groups, such as supporters of the wise use movement in the West., have been established and have been vocal in opposing additional government restrictions (see vol. 2, ch. 5).

Cost of Change: Perceived and Actual

Potential cost—actual and perceived-represents an obstacle to many proposed program changes. Coastal-land acquisition, for example, may entail major expenditures, given the high price of coastal property. Public subsidies for relocation of vulnerable structures could also involve substantial public expense. On the other hand, some alternatives are relatively inexpensive, and their perceived costs may be much higher than their actual costs. Adoption of coastal building standards, for instance, actually involves a relatively small increase in the cost of home construction (l).

In addition, attention is frequently focused on the initial costs of programs without considering the resulting long-term cost reductions. Although relocation subsidies (e.g., the Upton-Jones relocation assistance, discussed below) may involve substantial upfront costs, they serve to curtail future-loss expenditures, sometimes on properties that would likely be damaged again. Similarly, public acquisition of wetlands, floodplains, and other sensitive coastal lands, although expensive initially, can serve to prevent future public costs that could be many times higher (e.g., costs of disaster relief and ecological damages).

Institutional Fragmentation and Regulatory Obstacles

An important obstacle to better management, especially at the Federal level, is institutional (or organizational) fragmentation. No single Federal agency or department has responsibility for coastal management and coastal-damage risk reduction. For example, the Coastal Zone Management program is administered within the National Oceanic and Atmospheric Administration (NOAA); responsibility for wetland management is shared by the Environmental Protection Agency (EPA), the Corps of Engineers, and many others (see vol. 2, ch. 4); FEMA has responsibility for flood

25 South Carolina intends to recoup its money by selling the lots for development. However, the new build.@ permit will stipulate that the owner must remove structures that ever flood or become seaward of the dunes because of beach erosion (50).

insurance; and several agencies and offices are involved in disaster assistance. These different Federal programs and initiatives are not well-coordinated and there is no unified, comprehensive strategy for reducing the risks of living on the coast or for addressing specific issues such as climate-related sea level rise. Moreover, the perceived missions of these different agencies vary considerably, and can result in actions and programs that work at cross-purposes. FEMA has historically seen its mission not in terms of coastal management, but in terms of helping families and communities respond to, and cope with, natural disasters.

Hazardous coastal development is caused, in part, by an inadequate regulatory and enforcement framework. Many coastal States and localities have minimal controls on the location and quality of development. Although some States have adopted fairly stringent coastal setback requirements, for example, many others frequently permit new development close to the ocean front and in locations subject to erosion threats. North Carolina requires major coastal structures to be set back 60 times the average annual erosion rate (61). Yet, South Carolina effectively has no fixed shoreline setback, and through a special permit procedure, allows development very close to the ocean.

Few coastal States or localities prohibit development within floodplains, although structures in these areas may be subject to certain design requirements, such as being elevated to or above the 100-year flood level. To the uninformed coastal resident or buyer of coastal property, securing a State or local permit maybe falsely perceived as a "certification' of the safety of a coastal site or location. Moreover, ensuring full community compliance with existing floodplain-management regulations is difficult because FEMA's enforcement and monitoring staff is small.

The extensive wind damage from Hurricane Andrew illustrates the looseness with which many development codes have been implemented and enforced. The South Florida Building Code (with a wind-design standard of 120 miles (190 kilometers)[26] per hour) was generally viewed as one of the most stringent performance-based building codes in use anywhere. Yet, problems with enforcement and implementation (and with the provisions of the code itself) have raised questions about the stringency and effectiveness of coastal regulations. A grand jury in Dade County recently issued a report extremely critical of the "shoddy" building practices evident in South Florida (8). Among the problems cited by the grand jury were inadequate and lax building inspection, inability to control untrained and unlicensed building contractors, and corruption, apathy, and high turnover in the Florida Building and Zoning Department. Strengthening the code (including changing the ways roof systems are constructed) and increasing Federal wind standards for mobile homes (most of which were destroyed in the hurricane) were recommended.

In many coastal areas, building codes are simply not required. In 12 coastal States, adoption of building codes is left entirely up to local officials (53). In South Carolina, for instance, local governments are under no requirement to adopt a building code (although if they choose to do so, it must be the State's standard building code). In Texas, no State building code is mandated, and counties do not even have the authority to adopt building codes if they wanted to-leaving many rural and unincorporated areas without any construction standards.

ENCOURAGING LESS-DAMAGING COASTAL-DEVELOPMENT PATTERNS

The existing policy framework does include several major programs and policies that seek to reduce the risks of living on the coast and that could serve as the foundation for policy changes in the future. As mentioned earlier, the NFIP has

[26] To convert miles per hour to kilometers per hour, multiply by 1.609.

mandated, from its beginning, the adoption of certain minimum standards for floodplain management. In recent years, the program has been giving much greater attention to risk reduction and hazard mitigation. Some relatively recent changes to the NFIP, discussed below, include the Section 1362 Flooded Properties Purchase Program, the Upton-Jones relocation-assistance program, and the Community Rating System. Recently, several bills introduced in Congress have proposed further reforms, and these initiatives are described here as well. Other programs that have positively encouraged mitigation and risk reduction (or have the potential to do so) include the Federal Hazard Mitigation Grants program (Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act), State hazard-mitigation plans (required by Section 409 of the Stafford Act), the Coastal Barrier Resources Act (COBRA; P.L. 97-348), the Federal Coastal Zone Management Act (CZMA; P.L. 92-583), and the State coastal-management programs through which the Federal CZMA is implemented.

Section 1362 Flooded Properties Purchase Program

The NFIP, despite some limitations, has improved gradually over the years, and certain programs and provisions have been developed that move it in the direction of greater hazard mitigation and loss reduction. One of these is the Section 1362 Flooded Properties Purchase Program. Authorized in 1968 by a section of the National Flood Insurance Act, the program allows FEMA to break the damage-rebuild-damage cycle that accounts for many damage claims.

Under the program, FEMA can offer to buy out owners of damaged property, paying the difference between the fair market value of the structure and the allowable insurance claim, plus the value of the land on which the structure is or was located. The community must agree to participate, must be willing to accept the land, and must prepare a plan for its use that ensures that it will never be developed in the future. Eligible properties must have had Federal flood insurance and must meet one of several damage criteria (e.g., be damaged substantially beyond repair).

The Section 1362 Program has been used sparingly: since first funded in 1980, FEMA has acquired only about 100 properties per year. Modest amounts of funds are set aside for Section 1362 purchases, and there seems to be a bias against using those funds in coastal areas; because land in coastal communities is often very expensive, it is usually possible to get a greater "bang for the buck" when these limited funds are used along rivers. Since 1980, Congress has appropriated less than $5 million per year for Section 1362 funds, and in some years, FEMA has not spent it all.

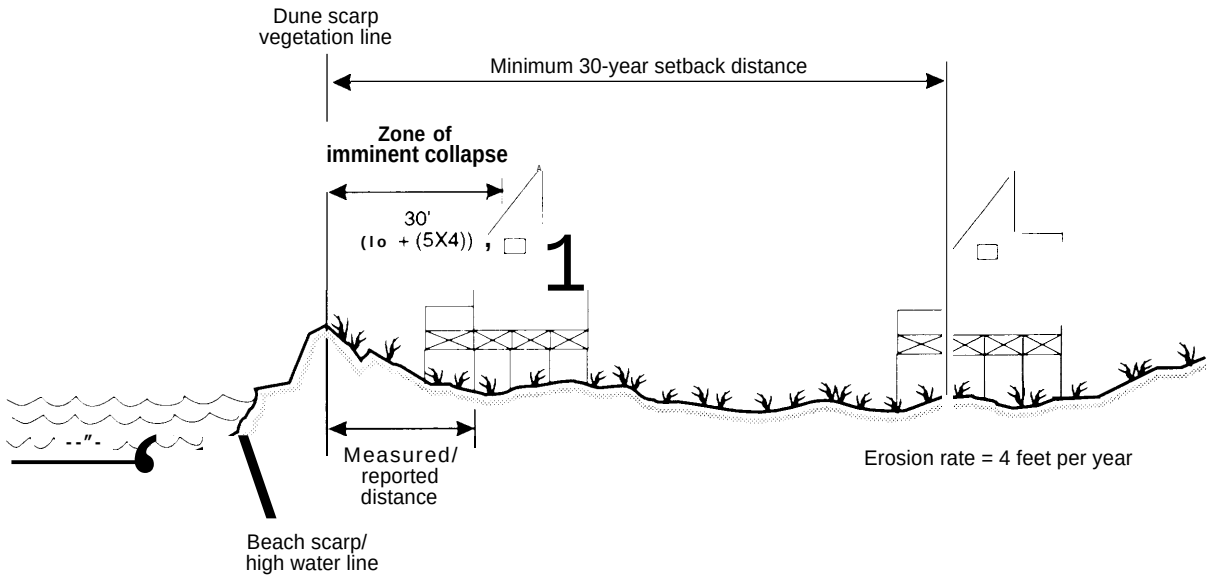
Upton-Jones Relocation Assistance

Another major change in the flood-insurance program was passage of the so-called Upton-Jones Amendment. An amendment to the Housing and Community Development Act of 1987 (P.L. 100-242), this provision sought to make available funds for subsidizing the demolition or relocation of shoreline structures that are subject to fairly immediate erosion hazards. Under the NFIP prior to Upton-Jones, a property owner could not receive any flood-insurance payment until the structure was actually damaged.

Under Upton-Jones, owners of shorefront property with Federal flood insurance are eligible for sizable demolition or relocation subsidies. Specifically, the amendment provides up to 40 percent of the insured value of a building for relocation (or 40 percent of the cost of relocation, if less) and up to 110 percent of the insured value of a structure for demolition. Relocation funds can be used for, among other things, new site preparation, construction of a new foundation, and utility hook-ups.

To qua.ii@, structures must be within a zone *of imminent collapse. FEMA* defines this area as

Figure 4-5--FEMA's Criteria **for Imminent-Collapse and Setback Determinations Under the Upton-Jones Amendment**



NOTE: To convert feet to meters, multiply by 0.305.

SOURCE: National Research Council, *Managing Coastal Erosion* (Washington, DC: National Academy Press, 1990).

seaward of a line 10 feet plus 5 times the average annual rate of erosion, as measured from a reference feature such as the normal high-water line (fig. 4-5). The provisions also require the State or local government to condemn structures or certify that they are in danger of collapse. Once FEMA declares a structure subject to imminent collapse, the owner has a certain reasonable time to relocate or demolish it, after which only 40 percent of losses can be recovered in the next storm or flooding event.

Once demolition or relocation occurs, certain restrictions are placed on the availability of new insurance. Specifically, to receive flood insurance, any future development on the property must be located landward of the 30-year erosion line for structures with one to four dwelling units or landward of the 60-year line for larger structures. Structures moved to a different site must also meet these and whatever other floodplain-management restrictions are in effect in the new location.

To date, use of the Upton-Jones Amendment has been limited. As of April 1992, only 494 claims had been filed. Of these, 283 were approved, 217 for demolition and 66 for relocation. The average value of demolition claims has been more than twice that of relocation claims (79). Low participation can be explained in part by a general lack of awareness about the program, a reluctance to remove or interrupt income from rental properties, a lack of suitable or affordable relocation sites, and problems encountered in condemning structures (e.g., many States do not allow condemnation unless there is actual structural damage (59)).

Despite considerable support for the concept, the Upton-Jones Amendment has not decreased NFIP expenditures or induced voluntary, anticipatory action by owners and has been insufficient to overcome individual and market incentives for

ocean-front owners to remain on the coastline (17, 18, 56). The National Research Council has recommended that relocation be encouraged over demolition, relocation behind the 30-year erosion line be mandated, easements or some other form of legal restriction preventing use of vacated shorefront areas be required, and insurance be terminated or premiums raised for structures within the zone of imminent collapse that are not relocated or demolished after a certain time (59).

The Upton-Jones program could be criticized as underwriting private risks because it encourages risky coastal development if property owners expect relocation assistance in the future (7). Also, the program applies only to individual properties: Upton-Jones provisions can be used to relocate one structure even as another one is being built on an adjacent, eroding site. The suggested changes mentioned above, in addition to coupling program benefits to more stringent erosion management for new construction (e.g., coastal setbacks), would serve to substantially eliminate such incentives.

Community Rating System

FEMA has recently initiated a program, the Community Rating System (CRS), to reward communities for the additional activities and programs they undertake to minimize flood damages beyond the minimum requirements of the NFIP. Specifically, the insurance premiums of property owners within communities that undertake flood-damage-reduction activities are reduced based on the extent of eligible activities undertaken. CRS gives credit for 18 mitigation activities, grouped into four categories: public information, mapping and regulations, flood-damage reduction, and flood preparedness (see table 4-6). Points are assigned to activities depending on the extent of their implementation within the community and their likely effectiveness at achieving CRS objectives (24).

Points allocated to individual measures are added to produce the community's total points, which are then used to determine the extent of premium reduction for property owners. As table 4-7 indicates, premium reductions range from 5 to 45 percent for property within Special Flood Hazard Areas (i.e., A and V zones). A maximum 5 percent reduction is allowed for property outside Special Flood Hazard Areas, largely because premiums are already low in these areas and because the measures for which credits are given are directed at the 100-year-flood zones.

The numbers of communities participating in the CRS program have so far been modest. In FY 1993, only 565 communities took part (3 percent of those participating in the NFIP). This small percentage, however, does represent about 45 percent of the flood-insurance-policy base. The level of mitigation effort for most participating communities has been relatively low, with the vast majority of communities (about 78 percent) eligible for only a 5 percent reduction in policyholder premiums. Another 15 percent of communities are eligible for 10 percent reductions. Twelve communities were given reductions of 15 percent, and one qualified for a 25 percent reduction.[27]

Questions nevertheless remain about the CRS strategy. It is not clear whether the most active local governments would not be undertaking these kinds of mitigation actions, anyway. Some of the measures for which local governments are given credit, such as hazard disclosure, may not lead to clear hazard or damage reduction. Conversely, credits are not now given for some measures, such as erosion management, that might be desirable. The CRS approach could also be criticized for further reducing premiums paid in hazardous areas. As an alternative, several of the measures for which localities are given credit (e.g., erosion setbacks) could simply be made mandatory as conditions for participating in the NFIP.

27 Data on the Community Rating System provided by C. Keegan, Federal Emergency Management Agency, Jan. 3, 1993.

Table 4-6--Community Rating System Designed by the Federal Emergency Management Agency to Encourage Communities to Minimize Flood Damage

Activity	Maximum points allowed	Average points earned	Percent of applicants requesting credit
Public information			
Elevation certificates	1 37[a]	73	100
Map determinations	140	140	92
Outreach projects	175	59	53
Hazard disclosure	81a	39	40
Flood-protection library	25	20	77
Flood-protection assistance	66	51	45
Mapping and regulations			
Additional flood data	360[a]	60	20
Open-space preservation	450[a]	1 15b	42
Higher regulatory standards	785'	101 [a]	59
Flood-data maintenance	12oa	41	41
Storm-water management	380[a]	121	37
Flood-damage reduction			
Repetitive-loss projects	441 [a]	41	11
Acquisition and relocation	1,600	97	13
Retrofitting	1,400	23	3
Drainage-system maintenance	330'	226	82
Flood preparedness			
Flood-warning program	200[a]	173	5
Levee safety	900[a]	0	0
Dam safety	120[a]	64	45

a Maximum Points revised since the 1990 community Rating System schedule.
b 1990 credits revised to reflect the 1992 Community Rating System schedule.

SOURCE. Federal Emergency Management Agency (FEMA), Interagency *Hazard Mitigation Survey Team Report on the Northeaster Storm,* **FEMA 973-NJ-DR** (Washington, DC: FEMA, January 1993)

Hazard-Mitigation Programs and Requirements Under the Stafford Act

There **have also been some reforms in the Federal disaster-assistance framework in recent years. The 1988 amendments to the Stafford Act created a Hazard Mitigation Grant Program (HMGP) (Section 404), which provides Federal matching funds for 50 percent of individual State and local mitigation projects. The grant funds are tied to disaster declarations and are limited to 10 percent of the total Federal share of the public-assistance monies made available for permanent restorative work.**

FEMA had approved 206 applications for hazard-mitigation grants through 1992, obligating approximately $43 million. As table 4-8 indicates, these funds have been used to finance various types of mitigation, including improving public-private facilities (e.g., floodproofing sewage treatment systems), constructing drainage systems, purchasing equipment, relocating structures, developing planning programs, promoting education and training activities, and improving land. Nearly 60 percent of the funds were used for improvements to public-private facilities. Only about 11 percent of these grants were used for relocation or acquisition, and only about 3 percent

Table 4-7—Premium Reductions for Special Flood Hazard Areas (SFHAs) and Non-SFHAs in the Federal Emergency Management Agency's Community Rating System

Points earned	Class	SFHA premium reduction (percent)	NonSFHA premium reduction (percent)
4,500+	1	45	5
4,000-4,499	2	40	5
3,500-3,999	3	35	5
3,000-3,499	4	30	5
2,500-2,999	5	25	5
2,000-2,499	6	20	5
1,500-1 ,999	7	15	5
1,000-1 ,499	8	10	5
500-999	9	5	5
0-499	10	0	0

SOURCE Federal Emergency Management Agency (FEMA), National *Flood Insurance Program Community Rating System Coordinators Manual* (Washington,DC: FEMA, July 1992.

Table 4&—Rank of Project Categories by Dollar Amount and Percent of Estimated Obligations in the Hazard Mitigation Grant Program (January 1989 to August 1992)

Type of project	$ Millions[a]	Percent
Public-private facilities	**25**	**58**
Drainage projects	6	14
Equipment purchases	5	12
Relocation of structures	5	11
Planning products	1	3
Education and training	<1	1
Land Improvements	<1	1
Total	43	100

[a] 1992 dollars

SOURCE. Joint Task Force on the Hazard Mitigation Grant Program, The Hazard Mitigation Grant *Program." An Evaluation Report,* prepared by National Emergency Management Association, the Association of State Floodplain Managers, and the Federal Emergency Management Agency, September 1992

for planning programs, such as development of beach-management plans, hazard-mitigation plans, and zoning- and building-code ordinances (41).

A joint task force of the National Emergency Management Association and the Association of State Floodplain Managers was formed to evaluate HMGP. Among the concerns identified were the slow pace of implementing the program, the lack of "hazard mitigation principles and guidance, ' difficult.ies in State-level coordination, and the failure of States and localities to identify mitigation opportunities before a disaster occurs. The specific recommendations of the joint task force include: creating State teams to respond to disaster declarations; developing and endorsing a Federal-State hazard-mitigation strategy after each disaster declaration to identify mitigation opportunities; updating and refining State hazard-mitigation plans through the Federal-State agreement; strengthening technical-assistance activities (e.g., through training and publication of handbooks); and improving guidance on project eligibility (41). Of special importance are the task force's conclusions that FEMA should better enforce State hazard-mitigation-plan requirements and seek to elevate the priority and importance given to these plans. Land use, relocation, and nonstructural programs are perhaps underrepresented in the HMGP. The overall level of funding seems modest, but not all available funds have been obligated because too few eligible projects have been proposed.

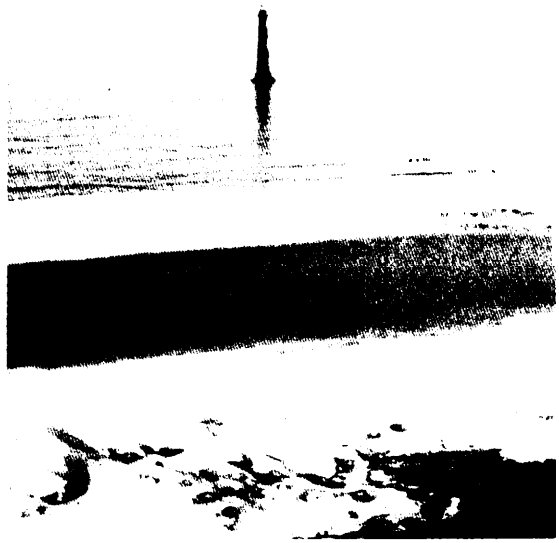
The Stafford Act also made mitigation an eligible expense under the FEMA public-assistance program (Section 406), and thus allows the Federal Government to contribute 75 percent of the funds for reconstruction improvements to the infrastructure (e.g., roads, bridges, and utility lines) to make them less vulnerable to future damage. Before these changes were made, mitigation expenditures were not eligible for public assistance, and if State and local governments wanted to rebuild damaged infrastructure to higher standards, they had to bear the entire expense. Section 406 could be more useful to States than the Hazard Mitigation Grant Program because opportunities for mitigation can be identified and taken advantage of quickly during the damage survey process, the mitigation can be incorporated into reconstruction without having to go through a grant-review process and compete with other projects, and the amount of money

available is not limited by the 10 percent cap of the Federal share of public-assistance monies.

The existing Federal disaster-assistance framework does have some significant "teeth' for promoting and requiring hazard mitigation. Section 409, although rarely used, states that the President may make disaster assistance conditional on State or local actions to mitigate hazards ("including safe land use and construction practices"). In addition, States receiving disaster assistance are required to prepare a State hazard-mitigation plan-a so-called Section 409 plan. These plans are intended to require States (and local communities) to confront the natural hazards they are subject to and identify programs and policies that can be implemented to reduce those hazards. In theory, FEMA can withhold disaster-assistance funds if the programs and policies contained in the plan have not been implemented. Politically, however, this is quite difficult to do, and FEMA has chosen not to adopt such a stringent approach. Most States required to prepare Section 409 plans have done so. However, FEMA lacks a clear system for monitoring State progress and compliance with Section 409 plans. Furthermore, once a disaster is over, States are relieved of much of the pressure to undertake planning and mitigation activities.

Coastal Barrier Resource Act

CoBRA, enacted by Congress in 1982, represents an attempt to move away from some of the ill effects of Federal subsidies such as flood insurance and disaster assistance. COBRA'S stated objectives are to reduce growth pressures on undeveloped barrier islands; to reduce threats to people and property of disasters and minimize the public expenditures that typically accompany such disasters; and to reduce damage to fish, wildlife, and other sensitive environmental resources.



STEPHEN LEATHERMAN

Morris Island lighthouse, once on solid ground, now sits in the Atlantic Ocean off Charleston, South Carolina.

The act designated the Coastal Barrier Resources System (CBRS), originally comprising 186 undeveloped barrier-island units, including 453,000 acres (183,500 hectares)[28] and 666 miles of shoreline. After a certain date, several Federal subsidies would no longer be permitted in these designated areas, including new flood-insurance policies, monies for infrastructure construction, and nonemergency forms of disaster relief. The Department of the Interior is responsible for implementing the program.

Barrier islands were defined in the act as including sand deposits, such as barrier islands and spits, and 'associated aquatic habitats," such as adjacent marshes and estuaries. A barrier island was deemed to be undeveloped, and thus eligible for inclusion in the system, if it had less than one walled and roofed building per 5 acres of land; there was an absence of urban infrastructure on it (e.g., vehicle access, water supply, wastewater disposal, and electrical service to each lot); and

[28] To convert acres to hectares, multiply by 0.405.

it was not part of a development of 100 or more lots (32).

CBRS was expanded in 1990 under the Coastal Barrier Improvement Act (P.L. 101-591) to include 560 units comprising 1.3 million acres and 1200 shoreline miles (88). In addition, under the 1990 act, the Department of the Interior was directed to map all undeveloped coastal barriers along the Pacific Coast (for eventual inclusion by Congress in CBRS).

Several studies have sought to evaluate the effectiveness of CoBRA at discouraging barrier-island development (31, 32,42, 88). These studies suggested that COBRA has not stopped development pressures on undeveloped coastal barriers, although the withdrawal of Federal subsidies has had some effect on discouraging new development there. The General Accounting Office (GAO) noted that the "availability of accessible coastal land is limited [and] populations of coastal areas are expected to increase by tens of millions by the year 2010. This population increase will further spur market demand, providing an incentive for developers, owners, and investors to assume the risks associated with owning and building in these storm-prone areas" (88).

The study results suggest several policy directions, including the acquisition of undeveloped barrier lands despite the high cost of such a strategy .29 Some studies in the past have argued that despite the high cost of acquisition, the public savings in the long term still justify such purchases (e.g., see ref. 55). One study (42) recommended removal of the remaining forms of Federal subsidy allowable under the current U.S. Tax Code (e.g., casualty-loss deductions); prohibition of all loans made by federally insured banks and lending institutions (originally waived under Section 11 of CoBRA); prohibition of Federal block grants; and prohibition of federally funded projects occurring outside, yet affecting, designated units.

The Coastal Zone Management Act and State Management Programs

The 1972 enactment of the Federal CZMA has served as a major catalyst for improved coastal planning and management. Under Section 305 of the act, the Federal Government-through the Office of Ocean and Coastal Resource Management within NOAA-provides grants for the development of State coastal-management programs. These programs must contain certain elements, and once approved, Section 306 of the act provides funding for State implementation. Funds are provided on a Federal-State cost-share basis. The Federal share was initially as high as 80 percent, but shares are now equal. In addition to the financial incentive for participation, States were also encouraged to participate as a way of exercising some degree of control over Federal actions and projects in their coastal zones. Thus, once a State's plan is approved, subsequent Federal actions must be consistent with it (per Section 307) to the extent practicable.

Although the program is voluntary, participation has been very high. Of the 35 coastal States and Territories eligible for funding, 29 now have federally approved plans (notable exceptions have been Texas and Georgia, but each is now working toward developing a program). Illinois is the only eligible State not developing a program (note that States along the Great Lakes are also considered "coastal"). Moreover, CZMA has clearly served as a major catalyst for the development of more-extensive and more-effective coastal-management programs. Compared with the State-only management frame work that existed before CZMA, there is little doubt that current coastal-development patterns and practices are more protective of sensitive

29 Reference *88* discusses the *fee-simple and less-than-fee-simple approaches.* Fee-simple acquisition involves purchasing full ownership, or the entire ' 'bundle of rights.' Less-than-fee-simple acquisition involves purchasing less than full ownership, or a partial interest in the land, typically the right to build *or* develop on all or a portion of the land.

coastal resources and have reduced the exposure of people and property to coastal risks (9, 33).

States have considerable freedom under CZMA to craft a coastal program to fit their individual needs and circumstances. It must include certain basic components, however, including identification of the boundaries of the coastal zone, definition of permissible land and water uses within the zone, creation of an inventory and designation of areas of particular concern, and identification of the means by which the State will exert control over activities in the coastal zone. Some States-Florida and New Jersey, for example--have taken a networking approach, pulling together into their coastal programs several already-existing management provisions. Other States, such as North Carolina, have created entirely new management and regulatory frameworks and new State decision-making bodies to implement the program (9).

There is considerable variation in the specific provisions and management tools used in State coastal programs and in their stringency and extent of coverage. Some State programs clearly have made major strides in reducing the riskiness of coastal development. At least 13 States now impose some form of coastal setback, requiring new development to locate a certain distance landward of the ocean (table 4-9) (38, 59,71, 89).

Increasingly, these setback requirements are calculated according to local erosion rates. North Carolina, for example, uses one of the toughest erosion-based setbacks. Specifically, for small-scale development in beachfront areas, new development must be set back a distance of at least 30 times the average annual rate of erosion for that particular stretch of coastline, measured from the first stable line of vegetation (61, 71). Development must also be landward of the crest of the "primary dune" and of the landward toe of the "frontal dune." For larger structures, the setback is doubled to 60 times the annual rate of erosion.

Other types of restrictions are also imposed. Under New York's Coastal Erosion Hazard Areas

Table 4-9--Status of U.S. Setback Authorities

State or Territory	Setback legislation	New policies for sea level rise
Alabama	Yes	No
Alaska	No	No
American Samoa	No	—
California	No	No
Connecticut	No	No
Delaware	Yes	No
Florida	Yes	No
Georgia	No	No
Guam	No	—
Hawaii	Yes	No
Illinois	No	No
Louisiana	No	No
Maine	Yes[a]	Yes
Maryland	No	No
Massachusetts	No	No
Michigan	Yes	No
Minnesota	No	No
Mississippi	No	No
New Hampshire	No	No
New Jersey	Yes[b]	No
New York	Yes	No
North Carolina	Yes	No
Northern Marianas	Yes[a]	—
Ohio	No	No
Oregon	No	No
Pennsylvania	Yes	No
Puerto Rico	Yes[a]	—
Rhode Island	Yes	No
South Carolina	Yes	Yes
Texas	No	No
Virgin Islands	Yes[a]	—
Virginia	No	No
Washington	No	No
Wisconsin	No	No

a State has a construction setback, but It is not primarily for coastal-erosion-hazard purposes.

b The State setback currently applies only to projects requiring a State coastal Area Facility Review Act (CAFRA) permit (i.e., projects of greater than 24 residential units). A proposed bill would revamp CAFRA and give the State greater control over oceanfront areas. Local municipalities have authority for "sub-CAFRA" projects through dune- and beach-protection ordnances.

SOURCES: J. Houlahan, "Comparison of State Coastal Setbacks to Manage Development In Coastal Hazard Areas," *Coastal Management, vol.* 17, 1989; P. Klarin and M. Hershman, "Response of Coastal Zone Management Programs to Sea Level Rise in the United States," Coastal Management, vol. 18, 1990.

Act,[30] for example, in certain erosion zones (i.e., so-called 'structural hazard zones' '), only 'movable' structures are permitted (71). Specific density limitations are imposed by some States in certain high-risk locations. Under North Carolina's program, for instance, development in inlet hazard zones is restricted to structures less than 5,000 square feet (450 square meters)[31] in size, and generally must not exceed a density of more than one unit per 15,000 square feet of developable land (61).

Some coastal States have also imposed significant restrictions on the building of erosion-control structures (e.g., seawalls, revetments, and groins). North Carolina, South Carolina, and Maine have banned the construction of new, permanent shore-hardening structures altogether. Such actions serve in the long run to reduce destruction of beaches, and put property owners on notice that should a beachfront structure become subject to erosion hazards, it will not be permissible to allow the construction of such protective (yet damaging) structures. States like North Carolina have managed to resist recent political challenges to such controls.

Most coastal States have also imposed restrictions on development in tidal, or saltwater, wetlands, and a smaller number apply restrictions to nontidal, or freshwater, wetlands. States typically require a permit before certain activities can take place in wetland areas, and usually include a more expansive list of potentially damaging activities than those regulated under the Federal Section 404 program (see below and vol. 2, ch. 4). Regulated activities typically include discharging dredge material, draining wetlands, cutting trees, and destroying vegetation. These regulations often extend to adjacent buffer areas as well. State wetland standards often incorporate many of the key concepts contained in the EPA-developed Section 404(b) guidelines, including restricting development activities to water-dependent uses and forbidding such activities where practicable alternatives exist.

Most state wetland programs also require mitigation when natural wetlands are destroyed or damaged. Imposed mitigation ratios-the amount of created, restored, or enhanced acreage required for each acre of natural wetland destroyed or damaged--can be two-to-one or greater (77).

Many State coastal programs also seek to manage rebuilding and reconstruction after hurricanes or other major flooding events. Most State programs require development permits for rebuilding substantially damaged structures. Hurricanes and coastal-storm events, while exacting substantial human and economic cost, often represent opportunities to rebuild in ways that minimize exposure to future risks (e.g., through relocation and through elevating structures and setting them further back from the water).

The South Carolina Beachfront Management Act (BMA), originally created in 1988, contained some of the most stringent reconstruction provisions in the country when Hurricane Hugo hit the coast a year later (see box 4-C). In enacting the BMA, the State sought to explicitly implement a long-term shoreline-retreat policy. Under the original act, habitable structures that were found to be "damaged beyond repair' (i.e., damaged by more than $66^2/_3$ percent) could only be rebuilt landward of a no-construction zone (the so-called "dead zone"). All structures rebuilt within a larger 40-year erosion zone were also required to move as far landward as possible (see fig. 4-6). The rebuilding of pools and recreational amenities damaged more than 50 percent was also prevented, and restrictions were placed on rebuilding erosion-control structures if damage was greater than 50 percent. Vertical seawalls could be replaced with sloping barriers, but only under certain conditions (6, 70).

Opposition to the rebuilding restrictions after Hurricane Hugo was intense, especially by beach-

M Article 34, New York Environmental Conservation Law.

31 To convert square feet to square meters, multiply by 0.093.

Box 4-C-South Carolina, Hurricane Hugo, and Coastal Development

No natural event illustrates the vulnerability of coastal areas to erosion, flooding, and wind damage more convincingly than the onslaught of a major hurricane. Hurricane Hugo, which hit the coast of South Carolina in 1989, was an unusually powerful storm. Classified as a category 4 hurricane (see box 4-A), Hugo was one of the most powerful storms ever to strike the East Coast of the United States. The storm surge accompanying Hugo exceeded 20 feet (6 meters)[1] above mean sea level in some locations (84). This high water level, plus strong winds and heavy rains, destroyed coastal real estate and affected farms, forests, and coastal habitats along much of the 181-mile (290-kilometer)[2] South Carolina coastline. Such intense storms are rare, but hurricanes of lower intensity and strong storms are a recurring, year-round phenomenon along the eastern seaboard. Each year, millions of dollars of damage to public and private infrastructure and property occurs along the East Coast as a result of these storms. In addition, significant, though usually less well-publicized, damage occurs to the natural environment.

Each year, as well, population in coastal areas increases more rapidly than population in other parts of the country. As a consequence, the exposure of people and property to coastal hazards is steadily increasing. Development pressures in South Carolina and throughout the Southeast are Intense. Between 1980 and 1990, for example, South Carolina's population increased by 13 percent. In coastal counties, however, population increased by 22 percent, and in the popular Myrtle Beach resort, it increased by over 40 percent (15).

Damage to South Carolina from Hurricane Hugo was extensive and was a result of both the intensity of the storm and the density and type of development in the area it struck. The following catalog of losses caused by Hugo illustrates the variety of ways that human lives and ecosystems can be disrupted and suggests the necessity of implementing strong coastal-zone-management policies and of educating the public about the risks of living in hazardous areas.

Homes and buildings—Hurricane Hugo caused about $7 billion in property damages in North and South Carolina, Puerto Rico, and the Virgin Islands, the four principal areas affected. Charleston County, South Carolina, was one of the hardest hit areas, suffering more than $1.9 billion in damages, about 30 percent of the assessed property value of the area According to the American Red Cross, Hugo destroyed 3,307 single-family homes in the major impact area. An additional 18,171 homes sustained major damage, and 56,580 sustained minor damage. More than 12,600 mobile homes were destroyed, and approximately 18,000 units of multifamily dwellings were either destroyed or damaged (1 9). Despite the large number of homes destroyed, many homeowners rebuilt in the same location. Over 90 percent of homes destroyed in the hard hit and affluent communities of Sullivan's Island and Isle of Palms, for example, were rebuilt in approximately the same place, a pattern that was repeated in many beachfront communities.

Tourism-South Carolina's tourist industry depends heavily on coastal attractions and generates more than $8 billion annually. The tourist industry suffered a major blow from Hurricane Hugo. In the Charleston Metropolitan Area, for example, attendance at local attractions during the 3 months following the storm was down 72 percent compared with attendance during the same period the previous year. Attendance finally returned to normal levels 3 years after the storm.

Forests and the forest Industry-About half the land in South Carolina's coastal counties is devoted to either forestry or agriculture. Over 1.8 million acres (0.7 million hectares)[3] of the State's coastal forests were damaged by wind and waterr. Losses on timberlands caused by Hurricane Hugo amounted to about $1 billion.

[1] To convert feet to meters, multiply by 0.305.

[2] To convert miles to kilometers, multiply by 1.609

[3] To convert acres to hectares, multiply by 0.405.

(Continued on next page)

Box 4-C-South Carolina, Hurricane Hugo, and Coastal Development-(Continued)

Seventy percent of saw timber in Francis Marion National Forest northeast of Charleston was downed, and over 6 billion board feet (12 million cubic meters)[4] of pine and hardwood saw timber were damaged. The amount of dead and downed wood amounted to 3 times the annual harvest in the State, enough to house virtually all the people of West Virginia. The damaged trees are now more susceptible to fire and insect attack.

Agriculture-The agriculture industry suffered over $320million in damages from salt contamination and high winds. immediately after the hurricane, sodium concentrations on some agricultural lands near the coast were 120 times the average annual concentration, and signs of salt stress can still be found on vegetation in coastal and tidal areas (30). Further inland, vegetables and orchards were heavily damaged by the high winds, and many farm structures also sustained damage.

Seafood industry-Of the 316 commercial fishingvessels licensed in South Carolina, 58 (18 percent) were damaged or destroyed. The total damage to vessels amounted to about $3 million (85).

Tax receipts-The effects of Hurricane Hugo on South Carolina's tax base were mixed. Because a large number of properties were destroyed, short-term reductions in tax collections did occur, but this impact was not severe. The property tax rate and other fees were temporarily increased in some hard-hit areas after the storm to maintain services and compensate for loss of some dwellings from the tax rolls.[5] However, many homes destroyed by Hugo were increased in size when rebuilt, and thus assessed at higher rates than before the storm. About haif of the property loss attributed to Hugo was uninsured, so State income tax collections were negatively affected as a result of income write-offs from casualty losses.

Ironically, because of increased demand on lodging, accommodation tax collections increased following the storm. The area also experienced a significant increase in personal income, in part because of a dramatic increase in coastal construction jobs. By the Spring of 1990, nearly 8,000 construction jobs had been added to the State's economy, more than offsetting the 6,800 jobs temporarily lost in the tourist industry. As a result, income and sales tax collections increased, and the net affect on State tax collections was considered a "wash." One estimate set the impact on State tax collection at only $12 million, a figure too small to conclusively attribute to Hugo (80).

Shoreline impacts and beach **renourishment**—Extensive shoreline erosion was caused by Hurricane Hugo. Some of the most noticeable effects included the erosion of the primary dune ridge system and the reduction in width and slope of beaches. To repair eroded beaches, the State and several coastal communities spent over $1.5 million on emergency dune scraping, over $7 million for the placement of 1.2 million cubic yards (0.9 million cubic meters)[6] of sand on Grand Strand beaches, and about $1.2 million for sand fencing and revegetation between North Myrtle Beach and Folly Beach (44).

Coastal wetlands—Salt marshes escaped significant damage from Hurricane Hugo. Primary productivity in these coastal marshes was virtually unaffected. The high tide during Hugo's landfall may have spared marshes from potential wave damage. During the months after the storm, some marshes advanced into adjacent forests suffering from salt damage, lending support to the hypothesis that sizable storms are capable of altering the boundaries between salt marshes and upland ecosystems (29).

Marine and **coastal wildlife**—Immediately after the storm, a reduction of salt and oxygen in coastal waters led to extensive mortality of sea life in some areas. Repopulation of most areas occurred within 2 months after the storm, however, as water quality improved (46). Heavy erosion of nesting areas on barrier islands during the storm affected some bird populations, including brown pelicans and royal terns. Inland, wit h the exception of a few areas

4 To convert board feet to cubic meters, multiply by 0.002.

5 Some taxes are still at the raised levels.

6 To convert cubic yards to cubic meters, multiply by 0.765.

affected by the highest storm surges, heavy wildlife mortality was not noted. Some wildlife in forested areas damaged by Hugo, however, maybe suppressed for a considerable period because damaged forests will require decades to recover. Forest species likely to be affected include gray squirrels, the red-cockaded woodpecker, and some forest songbirds (12). Overall, except for coastal forests, the natural environment weathered the storm with little long-term damage.

Personal losses—During the first weeks after Hurricane Hugo, some disaster victims experienced anxiety and mental disorientation (4). Eight in 10 reported experiencing more than normal depression (57). Although these emotional effects of Hugo decreased with time, other personal losses could not be restored. These include items destroyed in the hurricane that, although of little intrinsic value, had great personal significance to individuals.

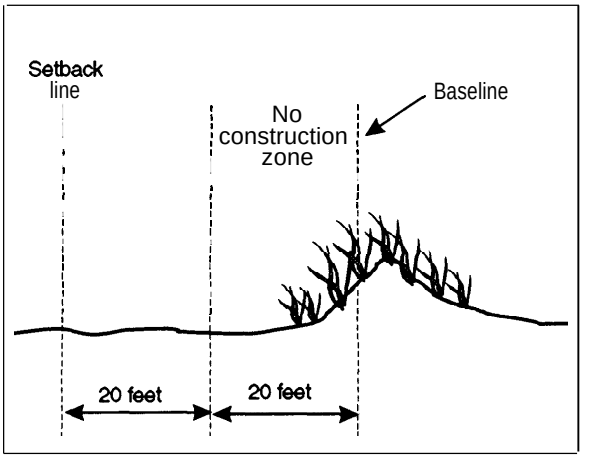
Coastal development is a double-edged sword in South Carolina, as it is in other States. Living near the coast has a strong attraction for many, and as communities grow, local revenues increase and public services improve. However, as people move to coastal areas, they expose themselves not only to occasional intense events like Hurricane Hugo but to more mundane, but still potentially costly, risks such as erosion and sea level rise. Hugo-strength storms are rare, but category 2 and 3 hurricanes strike the South Carolina coast about once every 7 or 8 years, on average.

SOURCE: MA. Davidson, Executive Director, South Carolina Sea Grant Consortium, K.H. Duffy, Duffy and Associates, DJ. Smith, Southeast Regional Climate Center, and A. Felts, University of Charleston, personal communication, May 14, 1993.

front-property owners.[32] Moreover, several * ings decisions (e.g., *Lucas v. South Carolina Coastal Council)* suggested that the State's financial liability in cases where the dead-zone restrictions prevented all reasonable use of a parcel could exceed $100 million. In 1990, the South Carolina legislature amended the law, completely eliminating the dead zone and creating a special variance procedure allowing development to occur even further seaward than the dead zone under certain conditions. Despite creating somewhat stronger rebuilding restrictions for erosion-control devices, the 1990 revisions in many ways represent apolitical "retreat from retreat" (6).

Increasingly, State coastal programs are requiring that local governments prepare hurricane and coastal-storm recovery and reconstruction plans. North Carolina was the fiist State to impose such requirements, but other States have followed suit (e.g., Florida and South Carolina) (34). Some States have begun to explicitly incorporate consideration of sea level rise into their programs. Seventeen coastal States have officially recognized the problem of sea level rise and have undertaken assessments of the issue (45). Eleven of these have initiated new public and intergovernmental processes (e.g., forming a sea level rise task force), and 13 States have existing regulations that are adaptable (or partially adaptable) to

Figure 4-8-New Zones Established by Beachfront Legislation



SOURCE: T. Beatley, "Risk Allocation Policy in the Coastal Zone: The Current Framework and Future Directions," contractor report prepared for the Office of Technology Assessment, February 1993. . .

[32] Some 159 beachfront structures located in the no-construction zone were found to be damaged beyond repair by Hugo.

Box 4-D-The "Maine Approach"

One response to sea level rise that may allow room for wetlands to migrate (see vol. 2, ch. 4), as well as maximize the human use of the coastal zone at minimum cost, has been implemented by the State of Maine. This State has adopted a policy of allowing development in the coastal zone to continue subject to the constraint that structures will have to be abandoned if and when sea level rises enough to t hreaten them (52). Ail new structures, therefore are presumed movable. This so-called "Maine approach" will likely be less expensive than preventing development because coastal land would remain in use until the sea rises a given amount, whereas restricting development prevents the property from being used in the interim even though its inundation maybe decades away. The presumption of movability is more flexible than restricting development because it does not require a specific estimate of how fast the sea will rise or the shore will retreat, or how far into the future one should plan. It also enables private real estate markets to discount iand prices according to information on the risk of sea level rise.

The Maine approach can be implemented in several ways. Maine has explicitly adopted this policy along its sand dune and wetland shores, with regulations that: 1) prohibit bulkhead construction, 2) explicitly put property owners on notice that structures are presumed to be movable, and 3) require property owners to affirmatively demonstrate their intention to abandon the property before being granted a permit to erect a structure in any area that would support wetland vegetation if sea level rises 3 feet (0.9 meters). Although implemented in 1989, the Maine approach has not yet been tested, so it is uncertain how well the approach will work if sea level rise actually becomes a problem. States' abilities to require or induce private property owners to allow coastal wetlands to migrate with arising sea will hinge on the balance between t he rights of private property owners and public trust doctrines. if the Federal Government wishes to promote this type of adaptation, it might do so through changes in the Coastal Zone Management Act (P.L. 92-583) when it is reauthorized in 1995.

several other States—including North Carolina—have implicitly adopted the Maine approach along the ocean coast by prohibiting the construction of sea walls while continuing to allow construction of bulkheads along wetland shores. In some States, a strict interpretation of the common iaw "public trust doctrine" would hold that as the shoreline migrates inland, so do the public rights to use tidelands for access and environmental purposes, including wetlands. Finally, private conservancies can implement this approach by purchasing coastal lands and then reselling them at a slight discount in return for deed restrictions prohibiting bulkheads or requiring that the property revert to the conservancy whenever the sea reaches a threshold.

SOURCE: Office of Technology Assessment, 1993.

future sea level rise (e.g., coastal setbacks, such as those discussed above). Only three, however, have adopted new policies specifically to respond to sea level rise (45).

Under Maine's Natural Resources Protection Act, wetland buffer zones are established to anticipate migration in response to sea level rise. As this zone moves in the future, development within it must also move (specifically, development must be relocated or abandoned if water encroaches on the development for more than a 6-month period or if it is damaged 50 percent or more)(45) (see box 4-D). Also, in certain frontal-dune areas (where some development is permitted), developers are required to build structures exceeding a certain minimum size to take into account a predicted 3-foot rise in sea levels over the next 100 years (45).

Some State programs have sought to facilitate and promote landward relocation of structures. In response to rising Great Lake levels, the State of Michigan created the Emergency Home Moving Program (EHMP). Under this emergency program, the State provided loan-interest subsidies to

property owners wishing to relocate lakefront structures threatened by erosion (71, 76). Property owners had a choice of either a 3 percent interest subsidy on the frost $25,000 of relocation costs or a one-time grant of $3,500. As a condition of this assistance, property owners had to move their structures at least 45 feet landward. The State also implemented an Emergency Home Flood Protection Program, which provided similar subsidies for the elevation of threatened structures (71).

Another strategy some States are using is the acquisition of coastal-hazard areas and sensitive lands. State programs, such as Florida's Preservation 2000 program and California's Coastal Conservancy program, have been very effective at protecting wetlands, beaches, and other sensitive coastal lands through outright purchases.[33]

Many State coastal programs also impose some form of real estate disclosure requirement, which may be useful in discouraging hazardous development. Under North Carolina's program, for example, an applicant must sign an Areas of Environmental Concern Hazard Notice to acknowledge that "he or she is aware of the risks associated with development in the ocean-hazard area and of the area's limited suitability for permanent structures" (61). Under South Carolina's modified beachfront-management program, similar disclosure provisions are required when a special beachfront variance is issued (6).

Building codes and construction standards represent another important component of many State and local risk-reduction strategies (although not necessarily an explicit component of a State's coastal program). Coastal structures can be designed to better withstand hurricane winds, waves, and storm surges. Building codes may be State-mandated (as in North Carolina) or locally mandated (as in South Carolina) and can vary substantially in stringency. The Federal CZMA does not mandate that States impose building codes, and, in some 12 coastal States, adoption of building codes is left as a local option. It is not uncommon for rural areas especially to have no construction standards (53).

The stringency of the wind-design standard to which coastal structures must be built is one variable in State programs. Under the N.C. Building Code, for instance, construction on the Outer Banks must be designed to withstand wind speeds of 120 miles per hour (mph). Structures there must also adhere to fairly stringent piling and foundation standards (34). The benefits of North Carolina's standards are illustrated by comparing damages from Hurricanes Alicia and Diana in Texas and North Carolina, respectively (75). Though the storms were comparable in strength and wind speeds, resulting damages were much less in North Carolina. The lower damages appear to be due in part to North Carolina's mandatory construction standards and to the lack of any control over building in unincorporated areas of Texas (see ref. 58).

The South Florida Building Code (SFBC) is considered one of the strongest prescriptive codes anywhere and similarly mandates a 120-mph wind-speed standard. However, inspections of damage from Hurricane Andrew identified several potential deficiencies in the code, including poor performance of roof coverings, poor connection between the roof system and the building, inadequate use of staples to attach plywood sheathing, and problems with windows and wall siding (65). Local enforcement and builder-compliance problems were also identified. Although a relatively strong code, some have argued for even tougher standards given the location, frequency, and potential magnitude of future storm events; density of development; and consequent greater threat that projectiles torn from one home will hit other homes. Others argue that tougher enforcement, not stronger standards, is needed.

[33] Preservation 2000 is a 10-year program established in 1990 with the intent of acquiring $3 billion of environmentally sensitive lands over 10 years.

The Federal CZMA, then, has stimulated considerable coastal planning and management that may not otherwise have occurred or would have occurred more slowly. Participation has been high, and even the two nonparticipating oceanfront States, Texas and Georgia, have been developing programs (Section 305 funds are now available again under the 1990 reauthorization of CZMA).

CZMA has suffered from certain implementation problems, however. First, funding levels have not changed much since the early 1980s, with annual implementation monies (Section 306) staying at about $33 million (89). Given the magnitude of the management tasks, individual State allocations seem modest. Provision of additional CZMA monies to States specifically for the development, strengthening, and enforcement of strong shorefront and hazard-area-management provisions could return benefits many fold. Second, the Federal coastal-management program has also historically suffered from a lack of clear and uniform performance standards. Some States have aggressively managed and controlled coastal development whereas others have done little. Third, NOAA has not applied sanctions to States that do not implement their adopted and approved programs. Although programs can be "disapproved," this action has never been taken. (On the other hand, the 1990 CZMA amendments now provide for "interim sanctions" if a State is not performing adequately.)

POLICY OPTIONS FOR THE FEDERAL GOVERNMENT

Although some important improvements in managing coastal development have been made in recent years, additional improvements are likely to be needed to forestall unwise development and to decrease existing vulnerability. The potential for sea level rise and more frequent and/or intense storms as a result of climate change adds to the already significant vulnerability of both developed and natural areas in the coastal zone. The following options for readjusting the existing incentive structure in coastal areas should be viewed as a starting point for additional discussion about appropriate changes. These possible changes are summarized in table 4-10.

Revamping the National Flood Insurance Program

The NFIP still provides subsidies to a substantial number of buildings in high-risk coastal areas. Current NFIP policy has been established by Congress, and Congress could make program and policy changes to the NFIP to reduce these subsidies and otherwise improve flood-mitigation activities and reduce damages from coastal hazards. Several bills suggesting such changes have been introduced into the 103d Congress, including S. 1405, the National Flood Insurance Reform Act of 1993, and H.R. 62, the National Flood Insurance, Compliance, Mitigation, and Erosion Management Act of 1993. Several options discussed below could be incorporated into these bills as they evolve.

Option 4-1: *Raise premium rates for the policyholders who receive subsidized flood insurance.* Despite the gradual increase in rates over the years, the average yearly premium paid by coastal property owners remains modest relative to the risk. The potential for catastrophic future storms and sea level rise associated with climate change suggests that the risks of living near the coast will be greater in the future. If the availability of flood insurance is to be maintained, rates may need to be raised to reflect these factors. Currently, rates reflect only average annual losses; occasional catastrophic losses can be much higher than average. Rates might be raised to incorporate an 'increased cost of reconstruction' benefit into policies.

Option 4-2: *Mandate erosion-management standards. The* current NFIP does not adequately address long-term erosion trends. One way it could do so would be to require minimum erosion-management standards. For example,

Table 4-10--Federal Programs and Laws Influencing Coastal Development: Status and Potential Changes

Federal program	Key provisions	Legislative basis	Existing mitigation provisions	Potential changes and policy options
National Flood Insurance Program (NFIP)	Provides Federal flood insurance to property owners in participating communities Communities must adopt minimum floodplain management provisions (e g., elevation to 100-year-flood level, restrictions to building in floodway	National Flood Insurance Act Flood Disaster Protection Act	Minimum floodplain-management standards, Upton-Jones relocation assistance Community Rating System 1362 flooded properties purchase program	Adjust premium rates Mandate erosion-management standards. Curtail insurance for high-risk, repetitive-loss properties, Prohibit new insurance in risky locations. Incorporate sea level rise in mapping and rate structure Expand relocation assistance
Disaster assistance	Individual and family grants program Public-assistance grants on 75-25 cost share	Stafford Disaster Relief and Emergency Assistance Act	Mitigation grants program Section 409 State mitigation plan required.	Reduce Federal share for public assistance Require more stringent mitigation Impose ability-to-pay standard Eliminate public-assistance funds altogether, Review criteria for declaring disasters.
Coastal-barrier management	Withdraws Federal subsidies for new development in designated Coastal Barrier Resources System (C BRS); prohibits issuance of new flood insurance, post-disaster assistance, and other development funds,	Coastal Barrier Resources Act (COBRA)		Further limit subsidies. Expand coverage to other sensitive lands. Promote State coastal barrier resource acts. Acquire undeveloped areas
Federal tax benefits	Casualty-loss deduction, Interest and property tax deductions for second homes. Accelerated depreciation for seasonal rental properties.	U S Tax Code		Eliminate or reduce tax benefits for coastal development Create tax deductions to support mitigation.
Coastal zone management	Federal funds and technical assistance for developing and implementing State coastal-management plans (cost-share basis).	Coastal Zone Management Act (CZMA)	State coastal-management plans (e.g., ocean-front setbacks, land acquisition, construction standards, post-storm reconstruction standards).	Mandate stronger development controls. Expand resources available to coastal States.

Table 4-10--Federal Programs and Laws Influencing Coastal Development: Status and Potential Changes--(Continued)

Federal program	Key provisions	Legislative basis	Existing mitigation provisions	Potential changes and policy options
Beach renourishment and shore protection	Provision of funding and technical assistance for beach-renourishment and shore-protection projects. Federal cost share from 55 to 90 percent	Federal Flood Control Acts (of 1917, 1936, 1945, 1955, 1968; for a detailed review of these, see ref. 71)		Discourage permanent shoreline stabilization. Increase State and local contribution. Phase out Federal funding of beach renourishment. Condition funding on minimum State and local coastal management.
Federal wetland protection	Restricts discharge of dredge and fill materials into U.S. waters.	Section 404 of the Clean Water Act	Section 404 (b)(l) guidelines, and U.S. Army Corps of Engineers public-interest review.	Tighten regulatory control in Section 404 permit review, Incorporate sea level rise into wetland management decisions. Explore use of transferable development rights.

SOURCE Office of Technology Assessment, 1993

minimum **State** or **local erosion setbacks could be required as a condition of participation in the NFIP (see also option 4.18, below). Alternatively, communities could be penalized for failure to adopt minimum setbacks-for example, by making them ineligible for mitigation and relocation assistance, by raising insurance premiums,** or by **reducing future claims in 10-year** erosion zones. Erosion-based setbacks, such as these in North Carolina, represent models, although the time frames used for calculating the setback could be expanded. Where lot depths or project designs allow, more extensive setbacks could be encouraged or required, for example. Another option for addressing erosion would be to factor long-term erosion trends into the premium rate structure for existing and future policyholders.

A precursor for improved erosion management is identifying and mapping erosion risks. Property owners are not anxious to have such risks identified due to potential adverse effects on **housing** values, **but** construction in erosion zones is risky and potentially costly to the Federal Government as well as to both present and future property owners. The Federa1 Insurance Administration is currently working, on guidelines and **standards for mapping erosion zones, but Congress needs to give the agency the authority to begin mapping.**

Option 4-3: *Prohibit new insurance policies in risky locations. NFIP* **could take several actions to reduce** its **long-term insurance liability and to bring the program more in line with the risk-averse philosophy of private-sector insurers. It could acknowledge that development in certain locations** is **extremely risky and prohibit all new insurance policies in these locations. In particular, the program could be changed so that no new insurance would be issued in V zones or in high-risk** erosion zones (e.g., within a 10-year erosion zone). H.R. 1236, introduced in the 102d Congress, contained language prohibiting all new flood-insurance policies for development seaward of the 30-year erosion line. Eventually eliminating new insurance within the 50-year erosion zone might also be considered.

A downside of this option is that it would limit the number of people paying into the fund. Also, those who insisted on building without flood insurance might still be helped by disaster relief after a major disaster but would have contributed nothing in the way of insurance premiums.

Option 4-4: *Increase insurance premiums after each claim on properties subject to multiple-flooding claims.* Current NFIP regulations do not substantially restrict how often a homeowner may rebuild after a loss, even if a future loss can be reasonably foreseen. By tying insurance premiums in high-risk areas to the number of losses a property has sustained, homeowners will have more incentive to consider coastal hazards in rebuilding decisions. Congress could also consider establishing a limit on the number of claims permissible before insurance is terminated (e.g., just as an automobile-insurance company might terminate a policy in the event of multiple accidents).

Option 4-5: *Incorporate sea level rise into the NFIP mapping and rate structure.* As discussed in earlier sections, future sea level rise may serve to substantially increase the size of the coastal zone subject to inundation and flooding in the future. The current NFIP mapping and rate structure does not take this into account, in part because FEMA contends that a 12-inch rise in sea level would not significantly affect the ability of the rating system to respond (21). Incorporation of even conservative estimates of sea level rise into FEMA maps might serve to discourage future development in these areas and put coastal communities and property owners on notice about such future risks. Development that does occur in these areas would be subject to certain minimum flood-management standards (e.g., elevation requirements). A means of accomplishing essentially the same goal may be to update floodplain maps more frequently. More-frequent updates would reflect changes related to sea level rise as well as those related to recent development. FIA maps are currently updated, on average, only once every 9 years. FIA's own goal for revisions is once every 5 years. More frequent updates would require more staff and additional funds.

Option 4-6: *Expand relocation assistance.* FEMA and NFIP could substantially expand the emphasis given to relocation assistance. The existing Section 1362 and Upton-Jones programs represent good strategies but are underused and underfunded. Section 1362, or something like it, could be expanded and funding could be increased. Efforts could be made to expand the use of Upton-Jones, as well, and to promote relocation as an alternative over demolition. Among possible improvements to Upton-Jones that could be considered are: 1) requiring relocation outside high-risk locations (e.g., landward of the 30-year erosion line), not simply making future insurance conditional on such relocation, and 2) expanding eligibility beyond the currently narrow definition of imminent collapse.

Incentives to relocate could be made stronger by modifying the ways in which NFIP treats structures that are at risk because of erosion. Requiring higher premiums for structures seaward of certain erosion zones (e.g., the 30-year erosion line) would create financial incentives to relocate. Cutting off insurance to structures within a zone of imminent collapse (e.g., within the 10- or 5-year erosion line) after a certain period of time (e.g., 2 years after a chosen date) may have a similar effect, but property owners whose homes were subsequently destroyed could still claim casualty-loss deductions, thus offsetting other Federal tax liabilities.

The Federal Government may also wish to help States develop their own more-extensive relocation-assistance programs. Just as the Federal Government has helped States establish revolving funds to finance improvements in local sewage-treatment plants (see ch. 5), so also could the Federal Government help States establish coastal-relocation revolving funds.

Under the Clean Water Act P.L. 92-500), the Federal Government has encouraged creation of State wastewater revolving funds through the provision of start-up capitalization grants. Once established, States then allow local governments to borrow funds for the construction of new wastewater treatment facilities or the improvement and upgrading of existing facilities. Loans are provided at interest rates at or below fair market (depending on factors such as a commu-

nity's financial circumstances and the severity of the water-quality problem). In the case of Virginia's Water Facilities Loan Fund, annual payments back to the fund are required, and full repayment of loans must occur within 20 years (e.g., see ref. 92). Thus, annual repayment by borrowers ensures a steady pool of funds available for new loans.

Such revolving funds could be similarly useful in providing grants to assist private property owners in locating and purchasing alternative coastal or noncoastal sites. State revolving funds might be used to purchase relocation sites in advance, later making them available to beachfront-property owners needing to relocate. Property owners could then be asked to repay the fund for these acquisition costs, perhaps at below-market rates.

Such a fund could also be useful in purchasing damaged properties after a hurricane or major storm event, in turn selling or relinquishing these lands to local governments for needed beach-access points and public recreational areas. In rare cases, land swaps may be possible, allowing a beachfront-property owner to trade for a State-acquired relocation lot further inland.

States could also be required to consider and incorporate relocation strategies and programs in the hazard-mitigation plans required by Section 409 of the Stafford Act (71). Relocation programs could be a minimum-requirement component of State 409 plans.

Revamping Disaster Assistance

The existing disaster-assistance framework could be modified in several ways to reduce incentives for hazardous and costly coastal development patterns, including the following.

option 4-7: *Reduce the Federal share of public assistance.* Typically, the Federal Government share of disaster-assistance funds for States and communities has been 75 percent. In some recent cases, the Federal Government has provided 100 percent of the disaster-assistance monies. Although it is difficult to specify what the Federal share of such assistance ought to be, very high levels of assistance are probably a disincentive to improving State and local disaster mitigation. Unsuccessful efforts have been made in the past to reduce the Federal share to no more than 50 percent. Cost-sharing proportions have changed in other areas, however. For example, the Federal share of water-resources-development studies has been reduced from 100 to 50 percent in recent years in a successful effort to motivate more thoughtful State consideration of water projects (see ch. 5).

Option 4-8: *Tie disaster assistance more strongly to State and local hazard-reduction programs. The* mitigation provisions and requirements currently included under the Stafford Act are already strong. However, a shortcoming may be that FEMA does not force States and localities to adopt mitigation (e.g., a dune-protection ordinance) as a condition of disaster assistance. FEMA rarely withholds disaster-assistance funds from States that fail to adopt or implement mitigation measures. Most States prepare Section 409 mitigation plans, but there is generally no mechanism for requiring or ensuring that States implement the plans. Thus, FEMA could adopt a more stringent view of mitigation, more clearly and aggressively tying disaster-assistance funds to tangible, long-term hazard-reduction policies, programs, and actions.

It may also be useful to establish some clearer system for judging State accountability for Section 409 progress. States could be required to more clearly indicate the mitigation actions they agree to adopt and implement within a specified time frame (e.g., adopting a shoreline setback requirement). Although politically difficult in the face of a disaster, the Federal Government could specify that subsequent Federal disaster assistance would not be provided where the plan has not been implemented. Alternatively, subsequent assistance could be limited, for example, to no more than 50 percent of otherwise eligible funding, or States could be required to repay disaster

assistance if mitigation measures are not adopted within a specified period.

FEMA could try to establish a system for certifying that State 409 plans meet a minimum mitigation threshold, that is, that they contain actions and policies sufficient to bring about a substantial degree of long-term risk reduction. For example, coastal States could be required to adopt a building code (or mandate local adoption) and to ensure that an adequate system of implementation and enforcement will exist. Such minimum construction standards (perhaps one of several standard codes) could be made a condition of participation in the NFIP, or of receiving funding under CZMA. The Federal Government could also consider raising national wind standards for mobile homes.

Option *4-9: Consider ability to pay and extent of damages. The existing* disaster-assistance framework fails to explicitly consider the ability of affected localities and States to assume disaster losses, or the extent of damage actually incurred. Once a disaster area is designated, all localities are eligible for disaster assistance regardless of the extent or size of damage incurred. Much Federal disaster assistance is provided in small amounts to numerous localities--damage levels that could clearly be covered by local governments. Furthermore, certain localities (and States) are wealthier and have a greater capacity to pay for and assume the costs of hurricanes and other disasters. FEMA has proposed a $2.50 per capita threshold for costs per disaster to determine when local resources are adequate and when Federal funds are not necessary or appropriate. Survey data indicate that most local governments could easily cope with this level of loss and that a sizable proportion of governments could cope locally with per capita losses of $14 or more (11). A threshold provision would act as a kind of disaster "deductible," and Federal resources would kick in only after it is reached. Such a system would further contribute to greater accountability of local and State governments for their decisions and to greater equity in the disaster-assistance system overall.

Option 4-10: *Eliminate public-assistance funds.* Although not very feasible politically, certain categories of disaster assistance could be eliminated. Although the public generally supports the role of the Federal Government in assisting individuals and families in recovery and rebuilding, this "helping" sentiment may not be as strong when it comes to helping States and localities rebuild boardwalks or local streets. One possibility would be to develop alternatives to outright grants, including creating a Federal public-assistance-loan program. If local governments need to borrow funds to rebuild sewer systems, roads, and recreational amenities, this kind of program would make such funds available but subject to repayment with interest. Loans could be offered at below-market interest rates. Such an arrangement may result in more cautious local and State investment policies. Another possibility might be to develop some type of insurance fund for local governments.

Option 4-11: *Through oversight hearings, Congress could review the criteria used by the President to declare disasters. One* question that could be investigated is whether existing criteria are too generous in situations that are not major disasters.

Extending and Expanding the Coastal Barrier Resources Act (COBRA)

Although withdrawal of Federal subsidies from barrier-island development clearly will not stop such development, it has been shown to slow it. Moreover, this approach is sensible from the perspective of taxpayer equity: if developers and coastal property owners choose to build in high-risk locations, at least the general public would not have to pay for it. The COBRA experience is positive, but efforts could be made to expand its coverage and strengthen its provisions.

option 4-12: *Further limit subsidies.* As noted earlier, COBRA does not eliminate all Federal

subsidies. Important remaining subsidies include the casualty-loss deduction under the U.S. Tax Code, Federal block grants., and grants and loans from federally insured banks. COBRA could be strengthened, and coastal development on designated units further discouraged, by eliminating these remaining subsidies. CoBRA could also be modified to prohibit Federal subsidy of projects and expenditures that, although technically outside the Coastal Barrier Resources System, serve to directly encourage or facilitate development (e.g., construction of a bridge).

Option 4-13: *Expand coverage to other sensitive lands.* Consideration should also be given to expanding the kinds of lands to which Federal subsidies are limited, including other sensitive coastal areas besides barrier islands. These could include coastal wetlands (and wetland buffer zones), estuarine shorelines, critical wildlife habitat, and Other areas (see vol. 2, ch. 4). Substantial resource-management benefits could result from the "CoBRA-cizing" of other sensitive lands. Also, efforts to expand the CBRS to the Pacific Coast, although currently meeting some resistance, could be continued.

Option 4-14: *Encourage the development of State COBRAS.* Florida is one State that has imposed certain limitations on future State investments in high-risk coastal areas, but few other States have such restrictions. One way the Federal Government could encourage development of CoBRAS in other States and reinforce the effects of Federal limitations is to require as an element of State coastal-zone-management plans that States consider the circumstances under which restrictions on State investments in coastal areas might be appropriate. Restrictions on expenditures for State roads and bridges might be considered, for example. This change could be implemented when CZMA is reauthorized in 1995.

Option 4-15: *Acquire undeveloped areas.* Although COBRA has been able to slow development of barrier islands, studies by the U.S. General Accounting Office and others illustrate that development will likely continue in many places despite withdrawal of Federal subsidies (88). Consequently, consideration should be given, as suggested by GAO and others, to acquiring many of the remaining undeveloped barrier-island units.

Acquisition now, though costly, may be cost-effective in the long run. Acquisition is especially warranted for barrier-island units of special ecological importance (e.g., those that contain endangered species habitat) and in areas that could provide important public-recreation benefits. Acquisition could be encouraged at Federal, State, and local levels, and in concert with private conservation groups and land trusts. At the Federal level, the U.S. Fish and Wildlife Service is the logical agency to spearhead such acquisition (see also vol. 2, chs. 4 and 5).

Revamping the U.S. Tax Code

As discussed in earlier sections, the U.S. Tax Code offers several major subsidies for coastal development, including casualty-loss deductions for damage from hurricanes and storms, depreciation tax shelters for seasonal rental properties, and deductibility of mortgage interest and property taxes for second homes. The actual effect of these tax benefits is difficult to determine. They do represent another major category of public subsidy of coastal development.

Option 4-16: *Eliminate or reduce tax benefits for coastal development.* For example, the casualty-loss deduction (that is, the deduction for losses in excess of insurance coverage) could be eliminated altogether for risks peculiar to the coastal zone, or restricted only to damages that occur to a principal residence (see ref. 71).

Option 4-17: *Modify the Tax Code to support and encourage mitigation. This* could be accomplished, for instance, by providing a tax deduction for home improvements intended to mitigate storm damages or for expenses associated with relocation (including purchase of a relocation lot).

Strengthening State and Local Coastal Management

Generally, coastal States and localities are in the best position to manage and control coastal development. Also, efforts to impose land-use planning or land-use controls at the Federal level have met with great skepticism and political opposition at the State level. On the other hand, the Federal CZMA has been successful in motivating improvements in coastal planning and management since it was passed more than two decades ago. Significantly, the 1990 amendments to the CZMA recognized for the first time the potential importance of climate change and sea level rise and called for coastal States *to* anticipate and plan for these possibilities. CZMA could be further modified and reinforced, when reauthorized in 1995, to promote greater risk reduction and more sensible land-development patterns.

Option 4-18: *Mandate certain specific--and stronger+ minimum development controls. These* could include, for instance, an erosion-setback program (already adopted by several States), restrictions on construction of immovable buildings, a relocation-assistance program and restrictions on rebuilding damaged or destroyed structures in high-risk locations, and adoption of minimum coastal-construction standards. Major Federal financial subsidies could be accompanied by the adoption of certain minimum risk-reduction measures. Minimum measures could also include wetland protection (possibly including protection of buffer and migration areas-see vol. 2, ch. 4) and minimum consideration of sea level rise in coastal programs.

The CZMA program could also be adjusted to create financial incentives to undertake additional risk-reduction measures. The current coastal-zone-enhancement grants program (Section 309) represents a movement in this direction and does include, as areas eligible for funding, management and protection of coastal wetlands and management of natural hazards (including sea level rise). More comprehensively, a "coastal-hazards-management program' could be required as a component of State CZM programs. Such a program might be modeled after the non-point-source-pollution-management program that participating coastal States were required to develop under the 1990 CZMA amendments. EPA and NOAA together oversee this program and jointly approve the State programs. A similar arrangement could be created with NOAA and FEMA.

Option 4-19: *Expand available resources. The* current level of funding provided to coastal States is meager at best. Annual appropriations for State program implementation (Section 306 funds) have remained around $33 million, despite the fact that the magnitude of coastal-management problems is increasing. Also, since the number of States participating in the CZM program has increased, funding available per State has decreased. Adequate funding is needed to implement State regulatory and development provisions (e.g., setback requirements) and to facilitate local coastal planning. Additional funding earmarked for State actions and programs that reduce coastal risks could also be provided. Funding for such coastal-planning activities could be a cost-effective expenditure that can serve to reduce long-term risks, as well as to better protect coastal environmental resources.

The Federal Government could also, to the extent possible, help to facilitate the development and implementation of State land-acquisition programs. Programs such as Florida's Conservation and Recreation Lands (CARL) program and California's Coastal Conservancy represent some of the most effective and sensible strategies for protecting wetlands, barriers, and other sensitive coastal lands and for preventing future exposure of people and property to coastal risks. The Federal Government could facilitate such programs by providing technical assistance and seed monies for State acquisition funds.

Shoreline Protection and Beach-Nourishment Programs

Significant subsidies to coastal development have also occurred through the programs and activities of the U.S. Army Corps of Engineers, including construction of shoreline-stabilization structures and funding of beach-nourishment projects.

Option 4-20: *Discourage permanent shoreline stabilization where feasible.* Several States have taken the lead in banning permanent shore-hardening structures such as sea walls and groins. Such Projects are costly and may actually increase development pressures. The Corps (or Congress) could develop a long-term coastal-management strategy that explicitly discourages the use of such hard shoreline techniques, except where absolutely necessary. Priority could be given to beach renourishment and approaches that are less environmentally damaging.

Option 4-21: *Increase State and local contributions and phase out Federal finding of beach-renourishment projects.* Concurrently, States could be encouraged to ensure that a substantial portion of renourishment costs are borne by beach-front communities and property owners. Ideally, the property owners and businesses directly benefiting from these investments would bear the lion's share of their costs. Renourishment can legitimately be considered a maintenance cost and, therefore, not eligible for Federal funding. Earmarking local revenue sources, such as special tax (renourishment) districts, a dedicated sales tax, or a tourist tax, could be encouraged.

As an alternative, Federal funding could be eliminated entirely (or phased out over time), and perhaps replaced with Federal seed monies for States to establish revolving-fund renourishment programs. An approach could be taken similar to that used for Federal funding of sewage treatment plants under the Clean Water Act (see ch. 5).

Option 4-22: *Make the Federal proportion of funding for renourishment projects conditional on adoption of certain State and local coastal-management initiatives. These* could include, for example, setback requirements, post-disaster restrictions, and relocation assistance.

Strengthening Wetland Protection

The Federal Government currently exercises substantial regulatory and management control over coastal wetlands. The existing programs, principally Section 404 of the Clean Water Act, jointly implemented by the Army Corps of Engineers and EPA, could be further strengthened to take into account future sea level rise and to better guard against destruction by coastal-development pressures. OTA'S options for improving wetland protection are discussed m volume 2, chapter 4.

FIRST STEPS

With or without climate change, average annual property damage in the coastal zone is expected to continue increasing (78). People will continue to move into and develop hazard-prone areas. As previously noted, for example, the damage-causing potential of hurricanes is much greater now in many coastal areas than it was several decades ago. This greater threat is attributable mostly to the fact that the coastal zone has become more intensively developed. Moreover, this development trend shows no sign of abating. Thus, coastal hazards are not just the result of uncontrollable natural phenomena. Rather, the growing coastal population both contributes to and modifies such hazards.

We suggest in this chapter that improvements can be made in allocating and managing risk in coastal areas. However, given current demographic trends, the longer the Nation waits to address the shortcomings of current policies, the more difficult and expensive coping with future disasters will be. There is no need to wait for unequivocal information about the nature of climate change; acting now to mitigate coastal hazards through implementation of prudent policies is likely to save both the public and private

sectors substantial sums in the coming decades, as well as save lives and natural areas and improve the quality of coastal living. When climate change is considered, however, with its potential for accelerated sea level rise and the possibility of more-intense or more-frequent storms, the case for strengthening existing policies is even more compelling.

Implementation of some or all of the options considered in this chapter could help send clearer signals to residents, potential residents, businesses, and visitors of coastal areas about the nature of coastal risks and the costs associated with those risks. Many of the options suggested in this chapter would also promote the flexibility and efficiency needed for adapting to a changing climate. Several bills now before the 103d Congress and some upcoming reauthorizations of existing laws could provide excellent "targets of opportunity" for implementing some of these options.

- Revamp the National Flood Insurance Program. Congress has been considering revamping the National Flood Insurance Program for several years, and bills to do this have been introduced in both the House and Senate. S. 1405, the National Flood Insurance Reform Act of 1993, and H.R. 62, the National Flood Insurance Compliance, Mitigation, and Erosion Management Act of 1993, contain provisions that partially address some of the NFIP options presented in this chapter (e.g., erosion management, relocation assistance, repetitive losses, and insurance for risky locations). As these bills evolve, other options in this chapter could be incorporated.
- Improve disaster assistance. Several bills have also been introduced in the 103d Congress to revise disaster-assistance policies and regulations. OTA'S disaster-assistance options could be incorporated into these evolving bills. H.R. 935, the Earthquake, Volcanic Eruption, and Hurricane Hazards Insurance Act of 1993, for example, would establish minimum criteria for reducing losses, recommends such measures as fiscal incentives to reduce losses, provides for low-interest loans or grants to retrofit facilities vulnerable to hurricanes, and provides guidelines for establishing actuarial premium rates for disaster insurance. S. 995, the Federal Disaster Preparedness and Response Act of 1993, would establish, among other things, a grant program and accompanying performance standards to help States prepare for, respond to, and recover from major disasters.
- Strengthen coastal zone management. The Coastal Zone Management Act will be up for reauthorization in 1995. OTA's coastal-zone-management options could be included in reauthorization legislation at that time. In particular, mandating that States adopt cost-effective risk-reduction measures as part of their CZM programs would help reduce future vulnerability to climate change. Also, the reauthorization process would be an appropriate time to consider whether a coastal-hazards-management program should be required as a component of State CZM programs. With oversight by NOAA and FEMA, such a program could help improve coordination among government agencies as well as help reduce the risk of living in the coastal zone.
- Promote public education. The public generally is not well-informed about the risks associated with living in coastal areas, and this lack of awareness has led and will lead to large and unnecessary public and private expenditures. Timely public education about erosion, sea level rise, flooding risks, and building codes, for example, could be a cost-effective means of reducing future risk as well as future expenditures. This "first step" does not appear in any of the options presented earlier in this chapter; however, education is equal in importance to all of the programs discussed here. H.R. 935,