

The Potential Economic Impact of Hurricanes on Hampton Roads



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THE POTENTIAL ECONOMIC IMPACT OF HURRICANES ON HAMPTON ROADS

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INTRODUCTION

Hampton Roads is situated along the nation's eastern seaboard. This location has conferred a number of benefits upon its economy. Principal among these is a natural harbor that has enabled the region to develop a large naval presence, a shipbuilding and ship repair industry, and a rapidly growing port complex. The region's coastal location also has given it an abundance of attractive beaches and historic sites which have made possible the development of a strong tourist and convention industry.

While the region has benefited from its coastal location, the area's presence along the eastern seaboard has made it vulnerable to hurricanes and tropical storms. Fortunately, hurricanes, while passing near the region on occasion, have typically been downgraded to tropical storm status by the time they have reached Hampton Roads.¹ One indication of the infrequency with which hurricanes pass through the area is that, according to the National Oceanic and Atmospheric Administration, no hurricane made landfall in Hampton Roads or Virginia from 1950 to 2003 while numerous landfalls were made in nearby North Carolina. Even Maine, a state not normally associated with hurricanes, experienced more landfalls than did Virginia (3 from 1950 to 2003).

While the probability that a powerful hurricane with wind speeds of 125-mph or more will strike Hampton Roads in any given year is only one percent, such storms do occur, and a storm of that magnitude is likely in the future (Burt 2004). Given the likelihood that a major storm will eventually cross the region, it is important to assess the impact that a powerful hurricane might have on the area's economy. This information can be used to help develop more effective mitigation and recovery strategies. This report will outline the results of efforts that have been made at the Hampton Roads Planning District Commission to both understand the economic effects of hurricanes as well as to estimate the impact that future hurricanes might have on the region's economy.

BACKGROUND

The Natural Phenomenon

Hurricanes are the most severe category of low-pressure weather systems that form in tropical locations.² The weakest of these is a tropical depression,

¹ Since 1851, 106 hurricanes and tropical storms have passed within 75 miles of South Hampton Roads (Isle of Wight Co., Norfolk, Portsmouth, Suffolk, and Virginia Beach) while 29 crossed directly through the area (SHRHMP 2006).

² Meteorologically speaking, there is no difference between hurricanes, typhoons, and cyclones. All are tropical storms that rotate clockwise in the southern hemisphere and counterclockwise in

which has sustained winds of 38 mph or less. Somewhat stronger are tropical storms, which have sustained winds of 39 to 73 mph. The strongest of the tropical storms is a hurricane which has winds of 74 mph or higher.

While they vary significantly in size, hurricanes typically are about 300 miles wide and have an eye or center of relatively calm weather, which is 20 to 40 miles across. Hurricane force winds typically extend out from the eye about 25 miles in a small hurricane to more than 150 miles in the case of a large storm. Tropical force winds can be experienced as far as 300 miles from the center of a large hurricane.

Because of their great size and intensity, hurricanes are the single costliest and most damaging of all storms (Elsner 1999). They bring with them several threats to life and property. Typically, the greatest of these comes from a hurricane's storm surge, which is a dome of seawater, 50 to 100 miles wide, that sweeps across the coastline as a hurricane passes. This rise in the level of the sea floods low-lying areas, drowning residents who cannot get above the surging water.

Compounding the flooding problem are the torrential rains, which accompany hurricanes. These rains can flood both coastal and inland areas. The typical storm brings with it 6 to 12 inches of rain to areas in its path although rainfall amounts are, at times, much greater (NOAA 1999). For example, Hurricane Camille dropped 27 inches of rain over Nelson County, Virginia in a period of just eight hours in 1969 (Burt 2004).³ The arrival of a hurricane at high tide can increase the flooding produced by a storm.

Finally, high winds can damage structures especially when they are accompanied by tornadoes. Tornado activity is usually greatest in the right-front quadrant of the storm. Typically, the more intense the storm, the greater the threat from tornadoes (NOAA 1999).

Given their potential for damage, efforts have been made to characterize the strength of a storm. That effort culminated in the development of the Saffir-Simpson Scale which provides a quantitative assessment of the power of a storm

the northern hemisphere. Depending on where they form, severe tropical storms are called hurricanes in the Atlantic and Caribbean Basins and off the coast of Mexico, typhoons in the western North Pacific and South China Sea, and cyclones in the Indian Ocean and in the Coral Sea off Australia. These storms are at their most violent in the western Pacific (Burt 2004). Hurricanes in the North Atlantic Basin typically account for eleven percent of worldwide cyclonic activity in any single year (Elsner 1999).

³ Atlantic tropical storms have been named since 1953 from lists compiled by the World Meteorological Organization. These lists featured only woman's names until 1979. Since that time, men's and women's names have been alternated. The name of a storm that has been particularly costly and deadly is retired.

and its hazard potential.⁴ This scale ranges from a Category 1, the lowest rating to a Category 5, the highest (Burt 2004). Hurricane categories and their potential for damage are shown in Table 1. A hurricane is considered “major” if it reaches Category 3 status or higher. While a hurricane’s rating on the Saffir-Simpson Scale is instructive as to its potential for damage, it has been noted that under certain conditions lower category storms can sometimes produce greater damage than more powerful storms (NOAA 1999).

TABLE 1: SAFFIR –SIMPSON SCALE

Category	Maximum Sustained Wind Speed (mph)	Storm Surge (feet)	Damage Level	Damage
One	74-95	3-5	Minimal	No real damage to buildings. Damage to mobile homes, shrubs, and trees
Two	96-110	6-8	Moderate	Some damage to roofing materials, doors, windows. Considerable damage to mobile homes and vegetation.
Three	111-130	9-12	Extensive	Some structural damage to small buildings. Mobile homes destroyed. Some flooding.
Four	131-155	13-18	Extreme	Some roof failure. Extensive curtainwall damage.
Five	155+	19+	Catastrophic	Complete roof failure on many buildings. Some complete building failures. Major flooding.

Source: Southside Hampton Roads Hazard Mitigation Plan

⁴ The Saffir-Simpson Scale was introduced to the public in 1975. It was designed to estimate the relative damage potential of a hurricane due to wind and storm surge (Williams 2002).

Because tropical storms and hurricanes are spawned by heat in the atmosphere, their frequency varies with the season of the year. In the North Atlantic, the hurricane season extends from June to November with the greatest number of storms occurring from mid-August to late September.

The total number of storms varies dramatically from year to year but, according to many, the number has been gradually increasing with the passage of time. The average year produces about nine named storms with six of these becoming hurricanes. Two of these typically become intense storms of Category 3, 4, and 5 (Williams 2002). For 2006, the National Weather Service has predicted that there will be between 13-16 named tropical storms with 8 to 10 becoming hurricanes. As many as six of these could become powerful enough to attain Category 3 status or higher.

Summary Statistics on Impacts

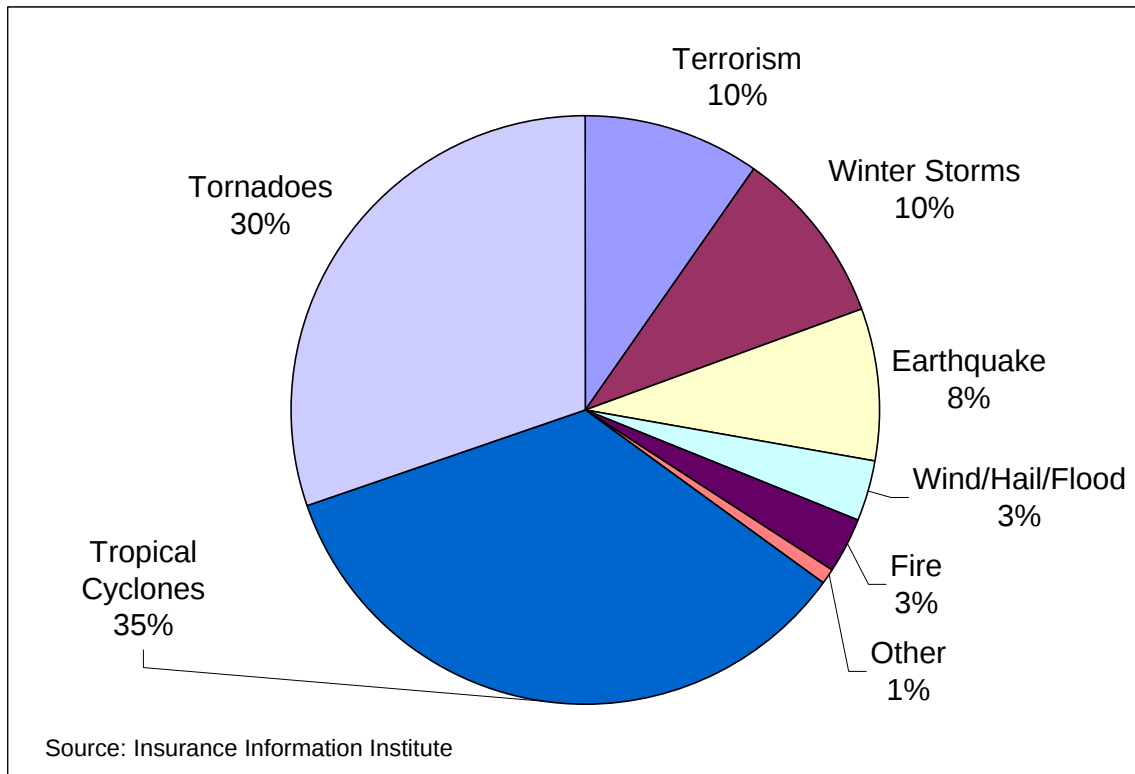
Of all the natural and manmade threats faced by communities in this country, hurricanes pose the greatest danger and do the most damage. Data collected by the Insurance Information Institute suggest the relative impact of various hazards on property. According to the Institute, after adjusting losses for inflation, tropical cyclones accounted for the largest loss experienced by U.S. insurance companies since they were responsible for 35 percent of the nation's insured losses. Second to tropical storms were tornadoes which accounted for 30 percent of the total insured loss. Terrorism and winter storms each accounted for another 10 percent. Earthquakes, while catastrophic when they occur, are infrequent so that they were responsible for only 8 percent of the total insured loss. The distribution of losses according to the Institute is shown in Figure 1.

It should be pointed out that while tropical storms lead the damage list in terms of insured loss, they are not responsible for the largest number of deaths and personal injury. In fact, according to Cutter (2001), hurricanes accounted for only 394 deaths and 4,026 injuries over the period from 1975 to 1998 as compared to 1,344 deaths and 29,437 injuries from tornadoes and 1,049 deaths along with 11,364 injuries from winter storms.

Hurricanes lead the list of catastrophes on an event basis as well. As can be seen in Table 2, Hurricane Katrina caused more than 38 billion dollars (2005\$) of insured losses and was the most damaging natural disaster in the nation's history. Hurricane Andrew, which until Katrina had been the nation's most costly storm, produced well over 21 billion dollars (2005\$) of damage. The damage would have been far greater had Andrew taken a path slightly to the north and passed through Miami or Fort Lauderdale. The bombing of the World Trade Center and the Pentagon in 2001 resulted in insured losses of nearly 21 billion dollars (2005\$) or almost as much as Andrew.⁵

⁵ Since the catastrophes occurred in different years, each of these estimated losses is expressed in 2005 dollars so as to make their impacts comparable.

FIGURE 1: INFLATION-ADJUSTED U.S. CATASTROPHE LOSSES BY CAUSE OF LOSS 1985-2004



Somewhat ominous is the fact that the losses from hurricanes have been increasing over the years. For example, the Insurance Services Office found that between 1949 and 1988, insured damage from Atlantic Basin storms averaged 1.1 billion dollars (2005 \$) annually. The average rose to 4.2 billion dollars (2005 \$) over the period from 1989 to 1999 – almost four times the loss over the earlier period. This increase was due, in large part, to the migration of the nation's population to its two coastlines, the increase in the frequency of hurricanes, and the rapid rise in the value of properties in coastal locations.⁶

The statistics on growth in the nation's coastal areas are impressive and highlight the nation's increasing vulnerability to storms. For example, according to the 2000 U.S. Census, 55 percent of the U.S. population lives within 50 miles of the coasts (including the Great Lakes). In similar fashion, the National Oceanic and Atmospheric Administration reported that the population density in southeast coastal areas increased by 129 percent versus 38 percent for the entire country over the period from 1960 to 1990. Another study found that the increase in population density was nearly 75 percent along the southeastern coast as compared to an increase of more than 20 percent for the nation from

⁶ The increase in value of properties was caused in part by the rapid increase in the size of populations in areas with only a limited supply of land.

1970 to 1990. Projections of further population increase in coastal locations suggests that the nation will be even more vulnerable to storm activity in the future (King 2005).

TABLE 2: THE TEN MOST COSTLY U.S. CATASTROPHES

Rank	Date	Peril	Dollars* When Occurred	In 2005 Dollars*
1	August, 2005	Hurricane Katrina	\$38,100	\$38,100
2	August, 1992	Hurricane Andrew	\$15,500	\$21,576
3	September, 2001	WTC/Pentagon Attack	\$18,800	\$20,732
4	January, 1994	Northridge Earthquake	\$12,500	\$16,473
5	October, 2005	Hurricane Wilma	\$8,400	\$8,400
6	August, 2004	Hurricane Charley	\$7,475	\$7,728
7	September, 2004	Hurricane Ivan	\$7,110	\$7,351
8	September, 1989	Hurricane Hugo	\$4,195	\$6,607
9	September, 2005	Hurricane Rita	\$5,000	\$5,000
10	September, 2004	Hurricane Frances	\$4,595	\$4,751

*Insured Loss in Millions of Dollars of Property Damage Only, Estimates Exclude Oil Rigs and Infrastructure.

Source: Insurance Information Institute

A measure of exposure to hurricane damage is shown in Table 3, which lists the value of insured properties along the Atlantic and Gulf coasts. Florida with its extensive coastline leads the list with 1.9 trillion dollars of insured property. Virginia, with far less coastal development, especially along the state's eastern shore, is lower on the list and ranks ninth with 130 billion dollars of insured property in coastal locations. While Virginia has far less vulnerability than Florida and New York, the state still has a significant exposure to loss from hurricanes and coastal storms.

ECONOMIC IMPACT OF A HURRICANE

The effects of a hurricane on a local economy have not been studied extensively. However, while there are large gaps in the research literature, it is possible to provide, in broad outline, a summary of what most would agree are the primary economic impacts commonly produced by a hurricane. The following is a distillation of the findings from a literature review on the local impact of

hurricanes. These conclusions, taken together, make up what may be regarded as the regional economics of hurricanes.⁷

TABLE 3: VALUE OF INSURED COASTAL PROPERTIES VULNERABLE TO HURRICANES IN 2004

	Value of Insured Coastal Properties (Billions \$)
Florida	\$1,937.4
New York	\$1,901.6
Texas	\$740.0
Massachusetts	\$662.4
New Jersey	\$505.8
Connecticut	\$404.9
Louisiana	\$209.3
South Carolina	\$148.8
Virginia	\$129.7
Maine	\$117.2
North Carolina	\$105.3
Alabama	\$75.9
Georgia	\$73.0
Delaware	\$46.4
New Hampshire	\$45.6
Mississippi	\$44.7
Rhode Island	\$43.8
Maryland	\$12.1

Source: Insurance Information Institute

Conclusion #1: Hurricanes Produce Stock and Flow Impacts

A fundamental distinction recognized in economics is between stocks and flows. As the terms are commonly used, stock variables are those having a fixed quantity at a point in time. Flow variables, by contrast, are those whose quantities change with the passage of time.

Hurricanes produce both stock and flow impacts. For example, storms produce physical damage which is a stock since that damage exists at a moment in time following the passage of the hurricane. By contrast, any disruption to the functioning of an economy can be thought of as a flow since hurricanes generally produce changes over time to a community's output, gross product, and personal and business income.

⁷ Drawing conclusions about the economic impact of hurricanes from the research literature can be difficult due to the unique nature of hurricanes. The differences between storm impacts can be substantial, especially between small, less powerful storms and those that are both large and powerful. Weaker storms produce minimal damage to structures and little disruption to business activity. Stronger storms, by contrast, produce extensive property damage and lengthy interruptions to business operations.

Unfortunately, the distinction between stocks and flows is commonly overlooked since members of the general public, the media, community leaders and governmental officials tend to focus on the dollar value of hurricane damage (a stock) rather than to changes in the volume of business activity (flows). The emphasis on the former arises out of the fact that estimates of hurricane damage are more visible and are easier to determine than are impacts on the economy which tend to be less obvious and harder to measure. The comparative ease of estimating hurricane damage arises in large part out of the fact that insurance companies pay on claims made by their policy holders making it possible to get early and reliable estimates of a hurricane's damage. Estimates of damage to the economy are less easy to measure and are available only many months after a storm has passed. Since the loss of economic activity can equal or exceed the value of damage, failing to focus on changes to the economy can lead to an underestimation of the impact of a hurricane (Rose 2004).

Conclusion #2: Most Residents and Businesses in Areas Vulnerable to Hurricanes are Not Adequately Insured.

Homeowner insurance policies typically cover damage due to wind, wind-driven rain, fire and arson, theft, vandalism, and damage caused by fallen trees. As a result, traditional policies cover much of the damage produced by a hurricane.⁸ Unfortunately, while these policies are very helpful in protecting property owners, they do not cover damage from flooding and tidal surge.⁹ This exclusion has existed in homeowner policies for decades. Aware of this gap in coverage and of the rising cost of disaster relief, Congress enacted the National Flood Insurance Act in 1968, which created the National Flood Insurance Program (NFIP). Unfortunately, the initial response to the program was weak. In an effort to increase participation, Congress passed the Flood Disaster Protection Act of 1973 which made it mandatory to purchase flood insurance in flood prone areas as a condition of financing under several federal programs. Participation has since increased but is still low leaving many people and businesses "naked" to the ravages of a storm (Hartwig 2005b).

Many residents of floodplains, for any variety of reasons, do not insure their homes and businesses against flooding.¹⁰ This was particularly a problem

⁸ The value of these homeownership policies has been diminished in recent years since many insurers have added hurricane deductibles. These deductibles are based upon a percentage of the total coverage stated in the policy and are generally higher than the standard deductible found in most policies. By adding the percentage deductible to their policies, insurers have been able to reduce their exposure to the risks which they face from hurricanes.

⁹ Flood damage is covered under the comprehensive section of standard auto policies. Not all drivers, however, have comprehensive coverage since it is not required by state law. Coverage for flooding is also available for businesses under special commercial insurance policies.

¹⁰ Individuals have two options when attempting to reduce their vulnerability to hurricanes. First, they can take actions before a hurricane arrives to mitigate storm damage by doing such things as "thinning" vegetation, strengthening the roof system, and securing outdoor furniture and other

for Katrina victims, only half of whom had flood insurance. One of the most important reasons that people do not purchase flood insurance is that they do not know that their homeowner's policy does not cover flooding.¹¹ Furthermore, many residents of hurricane prone areas are not able to accurately assess the extent to which they are vulnerable to floods and so do not avail themselves of the opportunity to purchase hurricane coverage. In effect, they perceive the insurance premium to be too high when compared to a payoff which they regard as uncertain. Instead, they mistakenly assume that federal assistance will be available to make them "whole" after a storm. This, however, seldom happens since federal assistance usually comes in the form of a loan that must be paid back with interest rather than as a grant with no strings attached. Furthermore, the potential buyers of flood insurance are unaware that flood disaster assistance is not always available from the federal government since a Presidential declaration, required for assistance, is issued in only 50 percent of flooding incidents. By contrast, people with federal flood insurance are reimbursed for all covered losses even if a disaster has not been federally declared (Mileti 1999).

As with homeowner policies, most policies sold to businesses do not cover flooding. Since only a limited number of businesses purchase flood insurance, many firms must go out of business after major storms. In fact, FEMA estimates that 25 percent of all businesses do not reopen after a major flood. Having flood insurance is especially important for small firms since the failure rate is generally higher for smaller companies occupying a single location as opposed to larger firms having multiple outlets, with at least some in areas that have not been damaged by a storm.

Many businesses also fail to take advantage of other types of commercial policies. In addition to flood insurance, businesses can also purchase business interruption coverage which can compensate them for the profits which they would have earned, based upon their financial records, had the storm not occurred. However, such coverage may not be triggered in all cases since many policies require that the business itself must have sustained physical loss or damage before the coverage becomes effective (Hartwig 2002). Additional coverage, referred to as contingent business interruption insurance, can be purchased to reimburse companies for their lost profits and extra expenses associated with an interruption in normal business activities at the premises of their customers and suppliers. This coverage can be very helpful to firms which lose their suppliers and customers in major catastrophes.

objects that might become airborne in a storm. Second, they can purchase insurance, which will not reduce the physical damage caused by a storm, but will minimize the financial damage. It is important that both efforts be taken by residents of hurricane prone areas.

¹¹ Many Katrina victims are now suing their insurance companies for selling them policies that did not cover flooding. If insurers are compelled to pay flood claims for which they have not collected premiums and have no reserves, insurance rates will have to rise and some companies may be forced into bankruptcy.

Estimates vary widely as to the extent to which insurance covers hurricane damage. For example, in the case of Katrina, private insured losses were estimated to be between 40 and 60 billion dollars. That compares to damage estimates of 200 billion dollars (King 2005). These estimates suggest that insured losses were in the range of 20 to 30 percent of Katrina's total damage. A similar estimate provided by Elsner (1999) is that insurance coverage for all natural disasters in the United States including hurricanes, earthquakes, tornadoes, and floods is less than 20 percent of the actual loss due to limited participation in voluntary insurance programs. These estimates are consistent with those provided by the U.S. Geological Survey (USGS) on the damage covered by insurance.

Estimates of flood damage covered by insurance are also low. One estimate of the proportion of damage covered by flood insurance comes from figures prepared by the Insurance Information Institute using data from NFIP. The Institute suggests that less than fifty percent of the single-family homes in special flood hazard areas where lenders require flood insurance have that insurance in force at any one time. That rate of coverage drops to just one percent in locations outside of special hazard areas. This is a problem of some significance since communities outside of special flood hazard areas account for between 20 and 25 percent of NFIP claims. Another estimate, this one from the Federal Insurance Administration, places the proportion of homeowners with flood insurance as low as one in four in areas with the highest risk of flooding (Insure.com 2006). Communities with high flood insurance coverage rates (percent of single family homes with flood insurance coverage) in Hampton Roads according to the Insurance Information Institute are as follows: Hampton, 25.4 percent; Norfolk, 17.8 percent; Virginia Beach, 16.3 percent; and Chesapeake, 12.6 percent. All other political jurisdictions in Hampton Roads have lower participation rates in the National Flood Insurance Program.

The low estimates of the extent to which damage is covered by insurance suggest the considerable financial vulnerability faced by many communities in coastal locations.

Conclusion #3: Estimating the Indirect Effect of Hurricanes is Difficult

When an economy experiences an economic shock such as an increase in a company's employment, the loss of a military base, the construction of a highway, or a hurricane, final demand in the economy changes causing the economy to adjust. The initial change in the economy is generally referred to as the direct effect whereas the derived change in the economy, caused by the direct effect, is referred to as the indirect effect. The total effect of the change in final demand is simply the sum of the direct and indirect effects. Dividing the total effect by the direct effect yields a number, referred to as a multiplier, which is the extent to which an initial change in the economy will be multiplied into a

total change.¹² Adjustments of greatest concern to the economy are changes in spending, employment, income, and output.

Just how the multiplier works and its size and importance are issues of some real concern when considering the effect of a hurricane on a local economy. Unfortunately, standard multipliers in regional economic models do not work well when examining hurricane impacts since they are based on typical people-to-business and business-to-business spending patterns. As a result, the multipliers from input/output, computable general equilibrium, and hybrid input/output and econometric models may be too large when used to measure hurricane impacts since they do not reflect the workings of a local economy following a hurricane. In effect, the multipliers in post-hurricane economies are likely to be much smaller than those found in conventional, “off the shelf” regional economic models since hurricanes disrupt local interindustry linkages when firms can no longer rely on their traditional suppliers. The breakdown of these traditional trading patterns forces many firms to find new suppliers outside the impacted area. This has the effect of increasing the leakage of spending from the economy which lowers a community’s post-hurricane multipliers.

Because multipliers are low following a hurricane, area residents, community leaders, and economists must be careful not to overestimate the potential for a hurricane to produce large indirect or ripple effects in an economy. Economists attempting to estimate the impact of a hurricane must be careful to adjust their models so that they reflect the smaller multipliers that typically accompany the changes in a regional economy that occur following a hurricane (BEA 2006).

Conclusion #4: Hurricanes Increase the Fiscal Stress Experienced by State and Local Governments

After a major hurricane, state and local governments face the challenge of both responding to the crisis and absorbing the effects of any reductions in revenue. On the expenditure side, state and local governments must increase their spending on such things as overtime wages, pay for repairs to community infrastructure damaged by the storm, and provide shelter and other support for those who are unemployed, homeless, or injured. On the revenue side, receipts from taxes and fees decline due to both the damage to taxable property and the reduction in business activity upon which many local revenues are based. The combination of lower revenue, coming at a time when expenditures are increasing, typically creates short-term budget problems for state and local governments. These problems can be exacerbated by balanced budget rules, which prohibit state and local governments from paying for current expenditures with debt. To meet these unexpected financial needs, most state and local

¹² For example, if a firm adds 100 new jobs which in turn causes another 100 jobs to be created, then the multiplier is 2 (a total of 200 new jobs generated by the creation of an initial 100 jobs yields a ratio of 200/100 or 2).

governments have set aside funds to provide financial resources in an emergency. Because these funds are frequently inadequate, especially in the case of the most devastating disasters, the federal government has provided assistance to both state and local governments to help them meet their needs.¹³ That assistance, in 2003 and 2004, was 20 billion dollars (Maguire 2005).

The net impact of hurricanes on state and local governments depends on such things as the structure of their revenue sources, the magnitude of the damage to property, and the extent of rebuilding following the storm. In general, those communities impacted by Category 1 and 2 storms are likely to experience little fiscal impact since those storms will produce only limited property damage with little resulting impact on property tax collections and because only modest rebuilding will be needed limiting the increase in retail sales. In addition, in such storms, the increase in demand for public services is typically modest. As a result, Category 1 and 2 hurricanes are not likely to produce large negative fiscal impacts although even small negative effects are frequently met with considerable public discussion.

By contrast, a powerful storm will destroy property which can lower property tax collections dramatically. In addition, in such a storm, rebuilding may proceed slowly since some residents will decide to relocate rather than to rebuild. As a result, property tax collections will not recover quickly as would happen in the case of a minor storm and retail activity will be slow to improve. In fact, in some cases, retail sale tax collections may actually decline because of a reduction in a region's population when residents who evacuated to avoid the storm do not return. Finally, because of the severity of the storm, the demands on local government can be substantial since the residents who decided to "ride out" the storm will require services and public infrastructure will require repair.

Furthermore, where net fiscal impacts are significantly negative, a community's longer term prospects for growth can be effected since spending to repair damaged infrastructure can cause communities to delay investing in already programmed capital improvements that have the potential to spur regional growth and development. Finally, to the extent that the national media covers a hurricane, perceptions that a region is vulnerable to disasters can spread. Should that perception become common, future business investments can be lost further impacting upon a community's prospects for economic development and revenue expansion.

In sum, the net fiscal impact upon state and local governments can range from moderately positive in the case of less powerful storms (Category 1 and some Category 2) to very decidedly negative in the case of super storms like Katrina.

¹³ This funding covers more than just natural disasters but has also been given to aid governments help them deal with economic downturns and large-scale terrorist events.

Several attempts have been made to estimate the fiscal impact of natural disasters. Most recently, the Congressional Research Service estimated that if Hurricane Katrina were to cause economic activity in the area of impact to decline by 50 percent in September of 2005, then the state of Alabama would lose 38.0 million in revenue. Louisiana and Mississippi would lose another 179.6 and 108.0 million dollars in revenue, respectively (Maguire 2005).

A further study, this one done by Pielke (1998), reports in some detail on the impact of Andrew on Dade County Florida. As a result of the storm, 63,000 homes were destroyed and another 110,000 residencies were damaged. This caused the value of real property to decline by 3.0 billion dollars in the year following the hurricane (1993) which led to a reduction in property tax collections of 50 million dollars. However, after reconstruction, property values increased in 1994 by 2.9 billion dollars, nearly making up for the loss in the preceding year. The good news was that the drop in property tax revenue was more than made up by the increase in sales tax collections which resulted from the increased sale of such things as building materials to repair damaged structures and furniture to replace the contents of buildings lost during the storm. The rise in retail sales caused sales tax collections to increase by an estimated 200 million dollars following the storm. The community sorely needed these revenues since it sustained severe damage to its infrastructure (Pielke, Jr. 1998).

Another estimate of a fiscal impact is available from Chang (1983) who examined the effects of Hurricane Frederic on Mobile, Alabama. Chang's regression work estimated that of the 17 revenue sources used by Mobile, only five were impacted by the storm. Those were two types of sales tax, inspection fees, business licenses, and the room tax. The combined changes from these revenue sources, like in Dade County Florida, produced an increase in revenue of 2.5 million dollars in the 12 months following the storm, which was 6.4 percent of the total general fund budget in fiscal year 1979-1980. The reason for the increase was that the "new money" coming into the community from federal government agencies, insurance companies, and personal savings were sufficient to increase the community's economic activity. In fact, the increase in revenue caused the fiscal director of Mobile to comment, "We need one every year."

Conclusion #5: The More Powerful the Storm - the Greater the Impact

It should be self-evident that more powerful storms produce greater impacts. However, while the speed of the wind goes a long way toward explaining the damage caused by a storm, there are other factors that also play a role in producing damage. Some of those other factors are the side of the storm striking a region, the size of the storm, the slope of the sea floor near shore, the amount of rain produced by the storm, the presence or absence of large water bodies within the impact area, and more.

In an effort to generalize about the destruction which various storms can produce, Pielke (2001) estimated the median damage of hurricanes by category. Those results are shown in Table 4. As can be seen in the table, the median damage caused by a tropical storm is less than one million dollars. By contrast, the median for a Category 1 storm is 33 million dollars. The median jumps to 336 million dollars for Category 2 hurricanes. The damage estimates are far higher for stronger storms with Category 4 hurricanes producing 8.2 billion dollars in damage. Surprisingly, the median calculated by Pielke for Category 5 storms is less than for Category 4. This unexpected result is probably an error in the data since Category 5 events more than likely produce more damage than do Category 4. Pielke's results suffer from the fact that his sample of Category 5 events included only two hurricanes – not enough to get a true picture of the damage caused by the most powerful storms.

TABLE 4: DAMAGE CAUSE BY VARIOUS CATEGORIES OF STORMS

	Number of Cases	Median Damage (1995 \$)
Tropical/Subtropical Storm	118	< 1,000,000
Hurricane Category 1	45	\$33,000,000
Hurricane Category 2	29	\$336,000,000
Hurricane Category 3	40	\$1,412,000,000
Hurricane Category 4	10	\$8,224,000,000
Hurricane Category 5	2	\$5,973,000,000
Damage has been normalized by standardizing for inflation and increases in both wealth and population.		

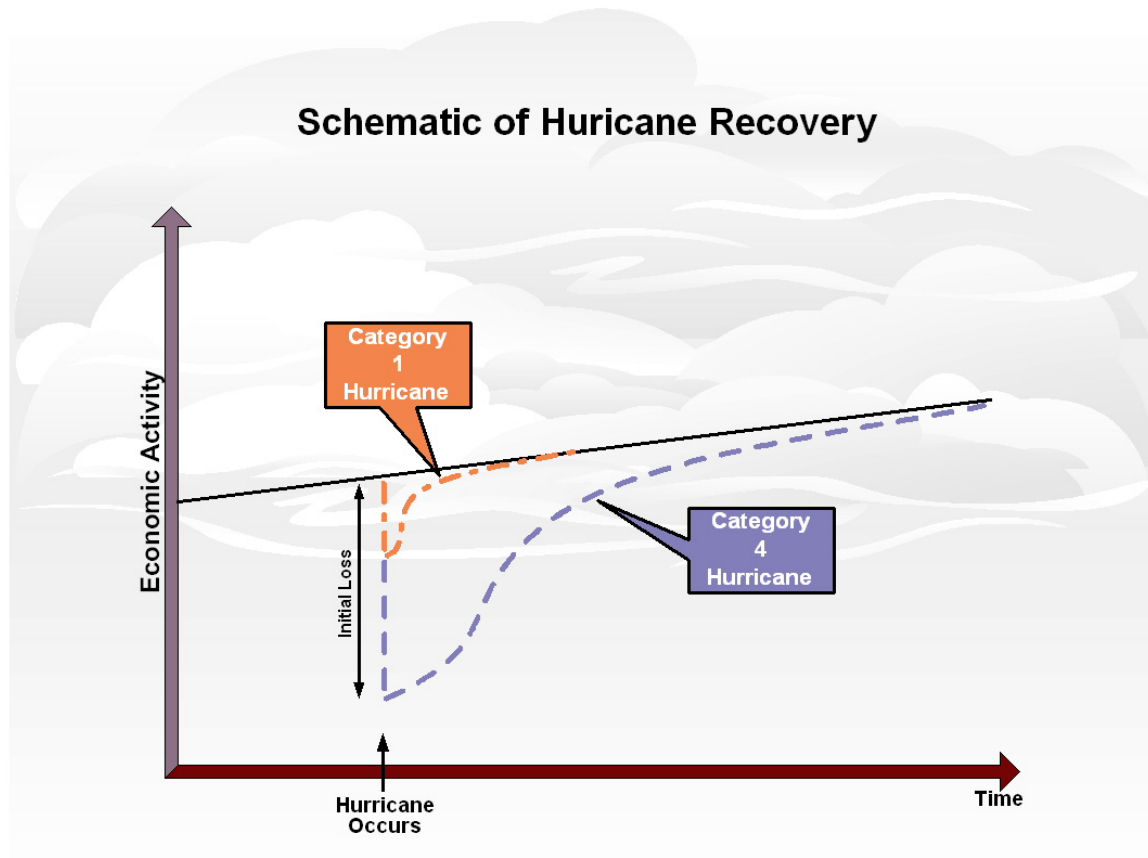
Source: Pielke, Jr. R. A. and C. W. Landsea, 1998: "Normalized Atlantic Hurricane Damage 1925-1995" *Wea. Forecasting*, 13, pp 621-631.

A large part of the explanation for the increase in damage with the increase in the power of a storm is that the force of the wind increases with the square of its speed so that, for example, a three-fold increase in the speed of the wind produces a nine-fold increase in its force. As can be seen in the table, the damage done by hurricanes increases dramatically from Category 1 to Category 5. A schematic representation of the change in a community's aggregate economic activity resulting from two hypothetical storms is shown in Figure 2 which demonstrates the greater damage caused by more powerful storms and the longer period required for recovery.

Fortunately, the most powerful storms, those rated Category 4 and 5, occur only occasionally. According to Pielke (2001), the most powerful storms constitute only 9.5 percent of the total. In other words, they might be expected to occur only about ten percent of the time. By contrast, Category 1 storms occur 36 percent of the time while Category 2 hurricanes account for 23 percent of all storms. In total, the weaker storms (Category 1 and 2) constitute nearly 60

percent of all hurricanes as compared to stronger hurricanes (Category 4 and 5) which account for less than ten percent. The frequency of storms and their damage expressed as a percent of all hurricanes is shown in Figure 3 (Hartwig 2002).

FIGURE 2: CATEGORY 1 VS. CATEGORY 4 HURRICANE SCHEMATIC

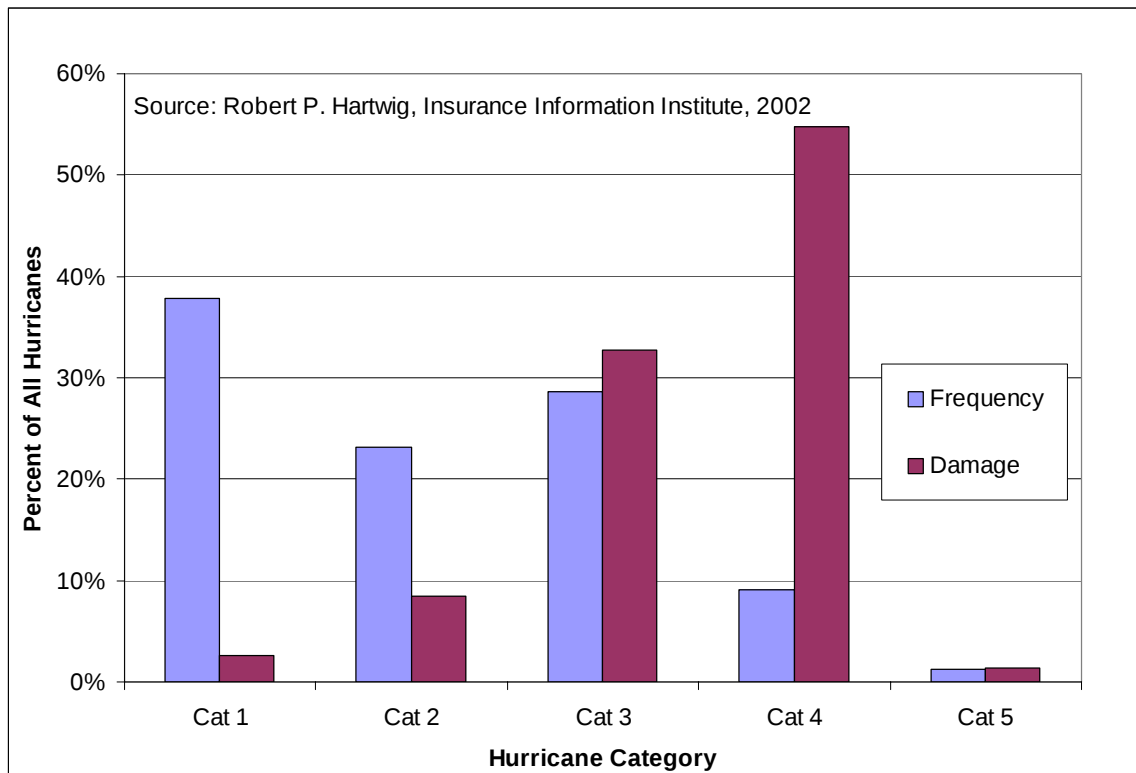


Conclusion #6: Recoveries from Major Hurricanes Proceed in a Series of Phases with Each Phase Enabling the Next.

A hint at the stages that economies go through when struggling to recover from a major hurricane is shown in Figure 4 while a more detailed description of the recovery process is shown in Figure 5. As can be seen in the illustrations, recoveries start with the restoration of lifeline services or those required for a modern society to function including power, water, sewer, and transportation. An additional prerequisite for recovery is the reestablishment of social order which requires the provision of police, fire, health, and trash collection services. Those things along with the reconstitution of a labor force, made up principally of persons who did not leave to escape the storm and the first of the returning evacuees, form the nucleus of a community's workforce as it begins the process of reopening its businesses. At the same time, the reemployed workforce

creates a market for the goods and services which are being provided by businesses struggling to reopen. Economic enterprises reopening during the beginning stage of a recovery include firms exporting to markets located outside of the impacted area, retail and service providers serving those households which either did not migrate or have returned following their departure to safer locations, some of the producer service businesses which supply reopening businesses and units of state, local, and federal government.

FIGURE 3: THE IMPACT OF HURRICANES MAKING LANDFALL IN THE U.S. DURING THE 20TH CENTURY



In the second phase of the recovery, repair and reconstruction expenditures provide an important new source of demand in the economy. Those expenditures supply additional jobs to area residents. Supplier firms reopen to further meet the needs of businesses which opened during the first phase of recovery as well as other businesses expanding to facilitate the rebuilding process. Businesses providing personal services will also reopen as the regional population returns to its former, pre-hurricane level.¹⁴

¹⁴ In the case of major storms, the regional population may remain well below pre-hurricane levels for some time.

FIGURE 4: HURRICANE RECOVERY FLOWCHART

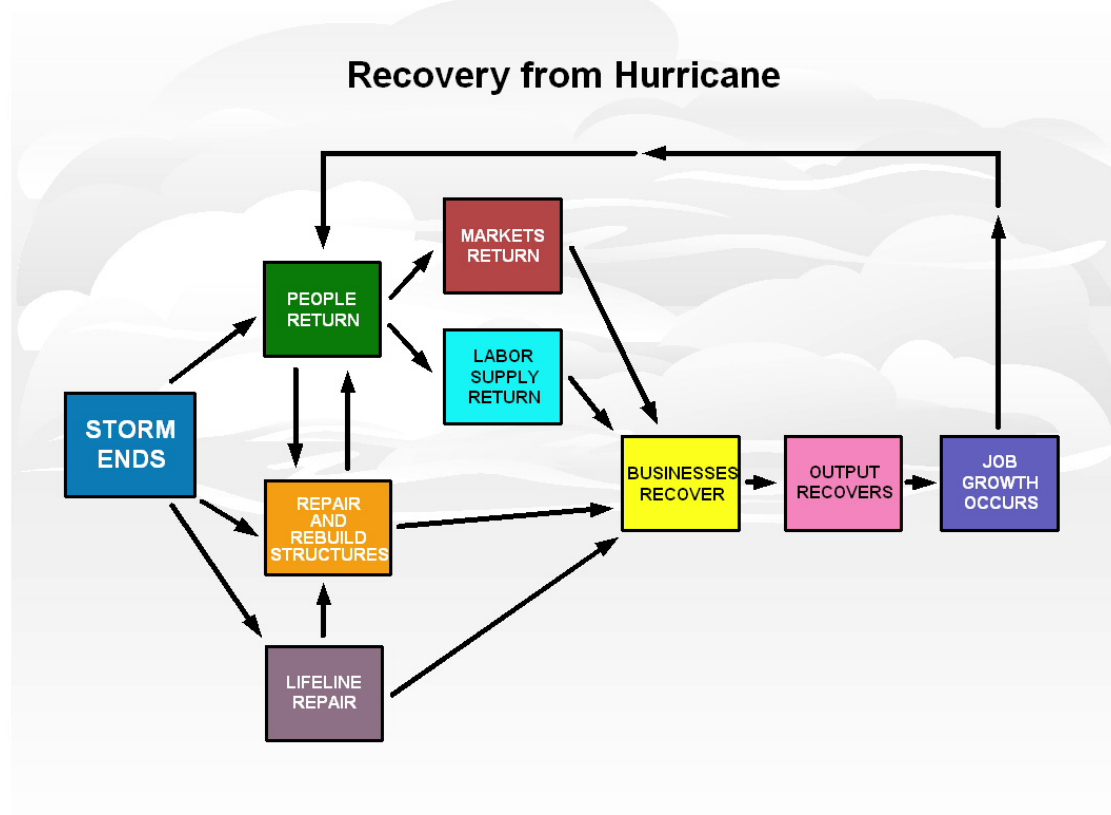


FIGURE 5: PROCESS OF ECONOMIC RECOVERY

Stages in the Recovery				
Stages One	Stage Two	Stage Three	Stage Four	Stage Five
Establishment of Business Infrastructure	Beginning Demand /Businesses in Operation Shortly After Storm	New Exogenous Demand	New Endogenous Demand	Final Demand/ Businesses Open After Full Recovery
Restoration of Lifeline Services: Electricity, Water, Sewer, Transportation	Exporting Businesses	Construction Demand Due to the Repair of Structures and Infrastructure Using Loans, Disaster Relief, Insurance Claims, and Business and Personal Savings	Business Growth Due to an Increase in Local Business Demand through Interindustry Linkages	All Businesses Back in Operation: Domestic and International Exporters, Producer Services, Personal Services, Retail / Wholesale, Government, Other
Creation of Labor Force from Non-Migrants and Gradually Returning Migrants	Retail and Services Businesses Supporting Non-Migrating Population		Growth in Retail and Personal Services Required by Returning Migrants	
Establishment of Social Order: Police, Fire, Health, Trash Collection	Producer Services			
	Government			

Finally, recovery is complete when the majority of businesses have reopened (excluding those that have failed or relocated) and the region's population has returned to pre-hurricane levels.¹⁵ Businesses operating at the end of the recovery process include, but are not be limited to, the region's domestic and international exporters, personal and business service firms, retail/wholesale/distribution facilities, units of government, and firms providing utility, transportation, and health services.

While there are identifiable phases through which economies go when recovering, it is important to stress that many parts of the process, must occur simultaneously since the economy is a system with each component interacting with all of the others. Public officials and business leaders need to appreciate the simultaneity of this process. This is important so that efforts can be made to bring the economy back on line at the proper time, in the proper sequence, and at the proper magnitude.¹⁶

The simultaneous interaction of the components in the recovery process is shown in Figure 6. Illustrative of this interactive process is the relationship between households and businesses. For example, as can be seen in the figure, households provide labor to businesses while businesses provide income in return. The income received by workers, in turn, creates a consumer market, which makes it possible for businesses to sell their goods and services. Each of these activities is driven by and drives, directly or indirectly, all of the others.

Conclusion #7: Recovery from the Majority of Hurricanes is Relatively Quick

Hurricanes typically cause a short-term disruption to economic activity, which produces a modest decline in gross regional product and related economic aggregates. For example, Benson (2004) reported that of the 35 disasters including hurricanes occurring in Latin America and the Caribbean between 1980 and 1996, real growth rates fell in the year of the disaster and then rose sharply for the next two years in 28 of the cases reviewed. Much of this increase occurred because of the ramp up of construction and associated repair and replacement activity in the aftermath of the disaster.

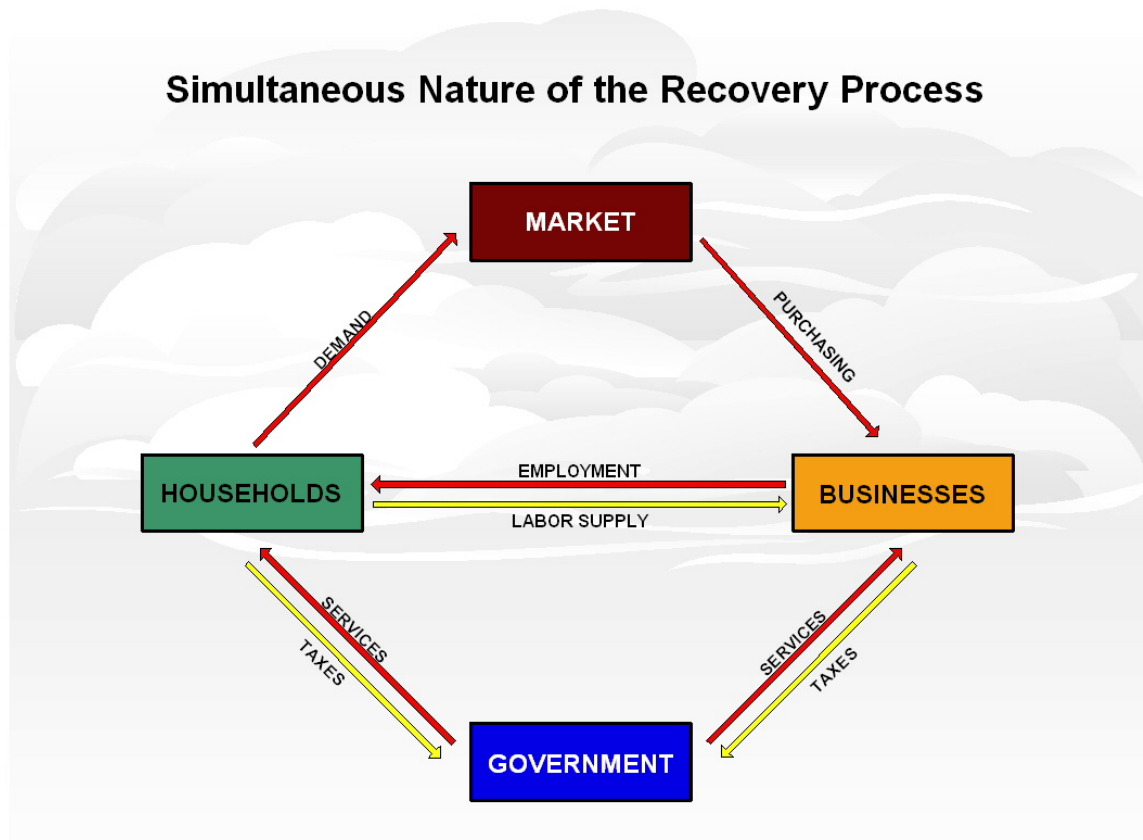
Similar outcomes have been experienced in the United States. The figures in Table 5 show the experience of fifteen hurricanes that have struck communities along the American coastline from 1975 to 1999. As can be seen in the table, during the year of the hurricane, the impacted areas increased their total personal income by 7.8 percent on average as compared to 7.6 percent for

¹⁵ In a few rare cases, full recovery may not occur since pre-hurricane levels are never reached.

¹⁶ This process is similar in some ways to the complex process that utilities must go through to bring their electrical systems back to life after a complete shut down. Following the proper steps in this process is analogous to the proper sequencing of efforts to revive a regional economy after a major hurricane.

the nation. By contrast, in the year following the hurricane, the impacted areas grew their total personal income by 10.1 percent on average as compared to 7.5 percent for the U.S. Stated somewhat differently, during hurricane years, the impacted regions grew their incomes by 101.7 percent of the comparable U.S. rate while during subsequent years, they grew those same incomes at 142.1 percent of the national rate.¹⁷

FIGURE 6: HURRICANE RECOVERY PROCESS



Similar results were recorded in the same communities with respect to their growth in regional employment. During hurricane years, the rate of growth in hurricane-impacted areas was 166.9 percent of the comparable rate for the U.S. By contrast, because of the economic stimulation which hurricanes produce, the rate of employment growth rose to 224.8 percent of the rate of increase in employment for the nation overall. Relative employment growth rates in U.S. and hurricane impacted areas are shown in Table 6.

¹⁷ The impacted areas grew their economies faster than the U.S. during hurricane years since those areas are in coastal, sunbelt states where growth has been well above average in recent years. The hurricanes, on average, reduced these growth rates from above average to near the U.S. average in the year when the hurricane occurred.

TABLE 5: IMPACT OF PAST HURRICANES ON THE GROWTH IN REGIONAL TOTAL PERSONAL INCOME

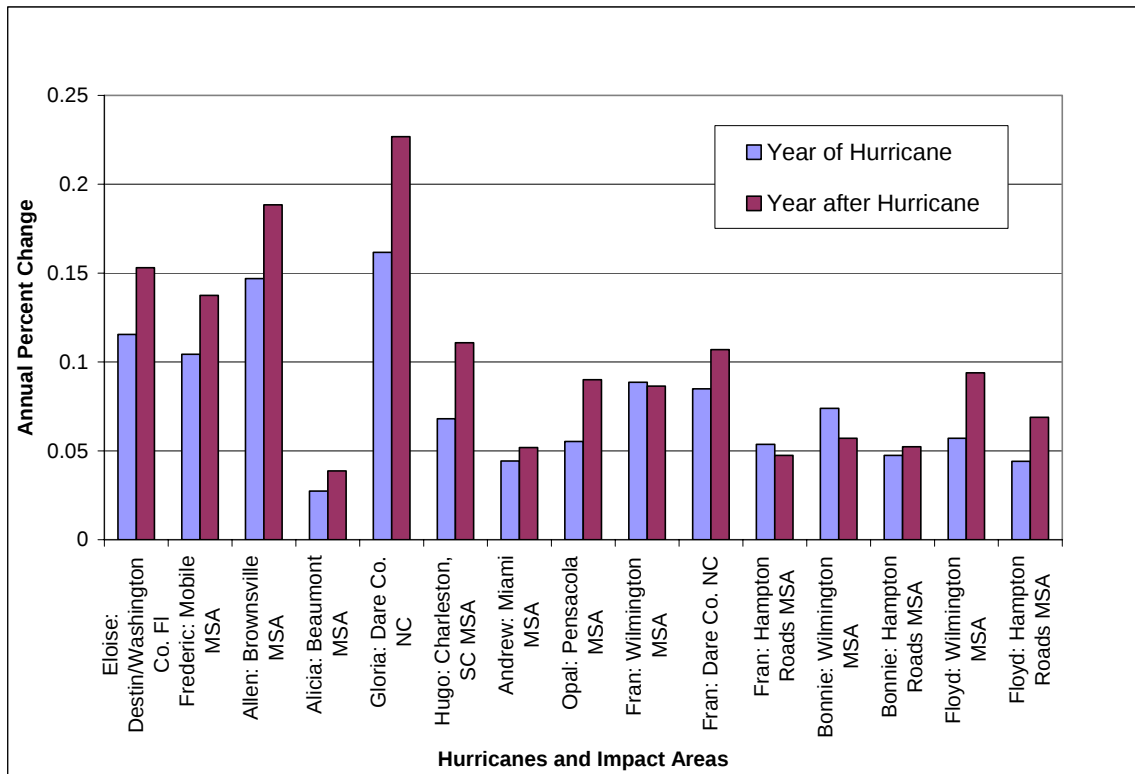
			Annual Percent Change in Regional Personal Income				Impact Area Growth as a Percent of U.S. Growth		Change in the Growth Rates from
			Year of Hurricane		Year After Hurricane Year		Year After Hurricane Year		Year of Impact to the Next Year
Hurricane	Year	Location of Landfall	U.S.	Impact Area	U.S.	Impact Area	Hurricane Year	Hurricane Year	
Eloise	1975	Destin/Washington Co. FIA	11.9%	11.6%	10.5%	15.3%	97.1%	145.9%	3.8%
Frederic	1979	Mobile MSA	12.2%	10.4%	11.9%	13.8%	85.9%	115.5%	3.3%
Allen	1980	Brownsville MSA	11.9%	14.7%	12.3%	18.8%	123.4%	153.4%	4.2%
Alicia	1983	Beaumont MSA	6.7%	2.7%	11.0%	3.9%	41.0%	35.1%	1.1%
Gloria	1985	Dare Co. NC	9.2%	16.2%	5.6%	22.7%	175.4%	404.3%	6.5%
Hugo	1989	Charleston, SC MSA	7.9%	6.8%	6.4%	11.1%	86.5%	174.2%	4.3%
Andrew	1992	Miami MSA	6.3%	4.4%	3.7%	5.2%	70.3%	139.5%	0.8%
Opal	1995	Pensacola MSA	5.3%	5.5%	6.0%	9.0%	103.8%	150.5%	3.5%
Fran	1996	Wilmington MSA	6.0%	8.9%	6.1%	8.7%	148.2%	142.7%	-0.2%
Fran	1996	Dare Co. NC	6.0%	8.5%	6.1%	10.7%	142.0%	176.6%	2.2%
Fran	1996	Hampton Roads MSA	6.0%	5.4%	6.1%	4.7%	89.8%	78.2%	-0.6%
Bonnie	1998	Wilmington MSA	7.4%	7.4%	5.1%	5.7%	100.5%	111.3%	-1.7%
Bonnie	1998	Hampton Roads MSA	7.4%	4.7%	5.1%	5.2%	64.4%	102.1%	0.5%
Floyd	1999	Wilmington MSA	5.1%	5.7%	8.0%	9.4%	111.3%	117.1%	3.7%
Floyd	1999	Hampton Roads MSA	5.1%	4.4%	8.0%	6.9%	86.2%	85.8%	2.5%
Average	-	-	7.6%	7.8%	7.5%	10.1%	101.7%	142.1%	2.2%

TABLE 6: IMPACT OF PAST HURRICANES ON THE GROWTH IN REGIONAL EMPLOYMENT

							Impact Area Growth as a Percent of U.S. Growth		Change in the Growth Rates from Year of Impact to the Next Year
Annual Percent Change in Employment							Year After		
Location of Landfall			Year of Hurricane		Hurricane Year		Hurricane Year	Hurricane Year	
			U.S.	Impact Area	U.S.	Impact Area			
Hurricane	Year		U.S.	Impact Area	U.S.	Impact Area			
Eloise	1975	Destin/Washington Co. FIA	-1.2%	4.8%	2.7%	4.7%	NA	171.0%	-0.1%
Frederic	1979	Mobile MSA	3.3%	0.5%	0.8%	3.1%	15.5%	367.5%	2.5%
Allen	1980	Brownsville MSA	0.8%	4.9%	0.9%	4.2%	595.2%	446.2%	-0.8%
Alicia	1983	Beaumont MSA	1.3%	-3.9%	4.3%	0.0%	NA	NA	3.9%
Gloria	1985	Dare Co. NC	2.8%	11.6%	2.0%	10.3%	410.3%	518.7%	-1.3%
Hugo	1989	Charleston, SC MSA	2.0%	1.9%	1.6%	4.9%	92.5%	308.2%	3.0%
Andrew	1992	Miami MSA	0.4%	0.2%	1.9%	4.1%	50.0%	216.5%	3.9%
Opal	1995	Pensacola MSA	2.6%	3.0%	2.1%	3.6%	115.4%	168.9%	0.6%
Fran	1996	Wilmington MSA	2.1%	5.5%	2.3%	6.2%	258.0%	271.4%	0.7%
Fran	1996	Dare Co. NC	2.1%	3.0%	2.3%	7.2%	140.6%	318.9%	4.3%
Fran	1996	Hampton Roads MSA	2.1%	1.8%	2.3%	1.7%	84.9%	74.0%	-0.1%
Bonnie	1998	Wilmington MSA	2.6%	3.6%	2.1%	1.7%	141.1%	83.7%	-1.9%
Bonnie	1998	Hampton Roads MSA	2.6%	1.1%	2.1%	1.0%	43.8%	48.1%	-0.1%
Floyd	1999	Wilmington MSA	2.1%	3.6%	2.3%	1.7%	174.0%	74.7%	-1.9%
Floyd	1999	Hampton Roads MSA	2.1%	1.0%	2.3%	1.9%	48.1%	79.4%	0.9%
Average	-	-	1.8%	2.8%	2.1%	3.7%	166.9%	224.8%	0.9%

A further demonstration of the recovery from a hurricane can be seen in a comparison of the rate of growth in regional personal income in years both before and after a hurricane. This comparison of fifteen U.S. storms is shown in Figure 7. As can be seen in the illustration, the rate of regional income growth increased in the majority of years following the hurricane.

FIGURE 7: THE IMPACT OF HURRICANES ON THE GROWTH IN PERSONAL INCOME



Conclusion #8: Efforts to Rebuild an Economy Following a Hurricane Account for the Rapid Recovery of Most Impacted Economies

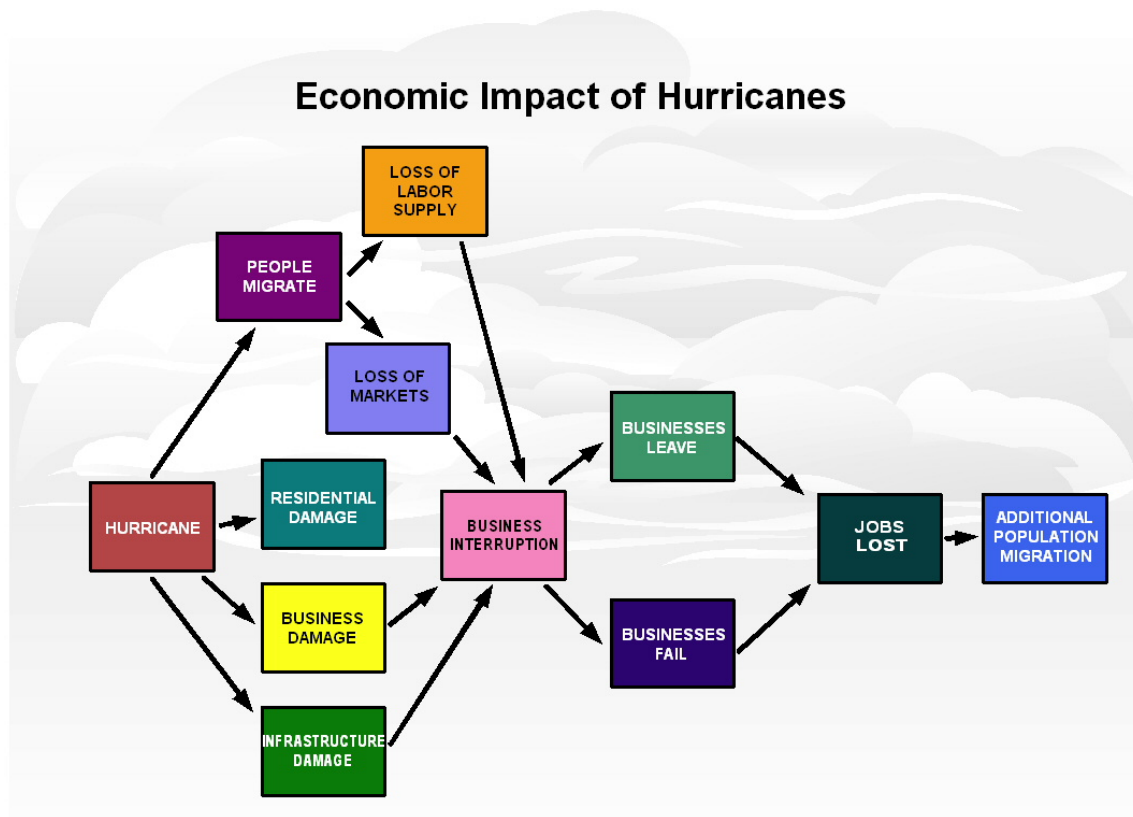
Hurricanes produce three primary economic impacts on regional economies.

First, hurricanes damage structures, their contents, and their inventories. To the extent that the things which are damaged are owned locally, the net worth of area residents and businesses drop by the amount of damage minus reimbursement payments from insurance claims and direct assistance from governmental agencies.

Second, hurricanes interfere with the ability of businesses to operate causing firms in the impacted areas to experience a reduction in their output or sales. This effect is commonly referred to as regional “business interruption.” This reduction in the level of business activity results from (1) the reduction in the size of the local market when hurricane victims flee the storm, (2) the reduction in the supply of labor when the workforce relocates to safer areas, (3) the loss of

public services such as electricity, water, and public transportation which makes conducting business difficult or impossible, (4) the loss of suppliers who are unable to provide inputs into the productive process, (5) damage to structures and inventories making business operations impossible and (6) damage to a community's transportation infrastructure, making it difficult to ship production to markets. Eventually, if the disruption to business is long enough, some businesses will fail while others will relocate to areas perceived to have fewer risks. In either case, a loss of jobs will occur. This can lead to a second round of out migration as those who have experienced the loss of their homes and jobs leave the area permanently. These impacts are diagrammed in Figure 8.

FIGURE 8: ECONOMIC IMPACT OF HURRICANES SCHEMATIC



A third effect is the increase in both public and private expenditures to rebuild after a hurricane. These expenditures can have a powerful effect on hurricane-impacted economies since they represent an injection of “new money” into the economy or money that would not otherwise have been spent (usually coming from sources located outside of the impacted area). These expenditures are made from a variety of sources including payments on insurance claims, withdrawals from savings, “rainy day” funds maintained by state and local governments, loans from governmental agencies and private banks, and outright

grants from public sources. While the impact of these expenditures on the local economy will be reduced by the amount of other expenditures that can not be made because of spending to repair hurricane damage, the impact of this spending on the local economy is often enough to offset much, if not all, of the reduction in economic activity caused by a storm's interruption of business activity.¹⁸

Reconstruction spending is a catalyst leading to further economic expansions. Repaired and rebuilt structures increase the supply of housing allowing people to return to the impacted area. This restores local consumer markets and regenerates the region's labor supply. Repair of public infrastructure and commercial and industrial buildings allows productive activities to resume. With labor and markets fully restored along with repaired public and private infrastructure, businesses are in a position to ramp up their operations and restore jobs destroyed by the storm.

Considerable evidence exists as to the importance of construction spending to the recovery from a hurricane. Gauimaraes (1993), after looking at the impact of hurricane Hugo, wrote that "An irony of natural disasters is that although they destroy physical wealth, they often dramatically raise economic activity during reconstruction." In a news story in *USA Today*, Hagenbaugh (2004) quoted economist Steve Cochrane of Economy.Com as saying that "It's a perverse thing There's real pain, but from an economic point of view, it is a plus" when referring to the impact of reconstruction on jobs during the recovery from a storm. Burrus (2002) reports that Gillespie found that total economic activity in South Carolina suffered little from Hugo since reconstruction funded by disaster relief compensated for the loss of output, wealth, and jobs during the storm. Work done by Chang (1983) concluded that long-run municipal revenues were enhanced in the aftermath of Hurricane Frederick due to the flow of recovery spending in Alabama. Further, after reviewing the literature on storm impacts, Ewing (2004) writes that "It is possible for a disaster to lead to a more vibrant economy than existed before the storm if the community responds by reconstructing better production facilities and infrastructure or by enhancing organization and implementation of other mitigation strategies." Finally, West (1994) referred to the benefit coming from reconstruction as the "silver lining" of a disaster. However, while concluding that the economic stimulus following a storm can be considerable, Burrus (2002) cautioned that, this effect is minor in the case of low-intensity storms suggesting that business interruption losses may not be fully offset by recovery spending.

¹⁸ The size of the expenditures made to repair and rebuild public and private buildings can be considerable. For example, in a community the size of Hampton Roads, if this spending were to average 4 thousand dollars per household, then with 514,000 households, total new money expenditures would exceed 2 billion dollars. Assuming a multiplier of 1.5 on this spending, the total increase in regional spending could exceed 3.5 billions dollars.

Conclusion #9: Super Storms are Several Orders of Magnitude More Destructive than are the Vast Majority of Hurricanes so that Recovery is Slow and Halting

Recovery from monster storms or those causing extreme damage can be slow in coming. In fact, there can even be a change in the course of a local economy so that long-term trends may be significantly or permanently altered. In essence, recovery from smaller, less powerful storms, is usually relatively quick lasting for a matter of days and weeks, rarely as long as several months. However, super storms, just as Camille (Mississippi), Andrew (South Miami), Hugo (Charleston), and Katrina (New Orleans and the Gulf Coast), present recovery problems that are many orders of magnitude more complex than those created by weaker storms. Recovery can stretch into many months if not years for such large and powerful hurricanes.

Two hurricanes dramatize the severity of damage and the recovery difficulties common to super storms. The first is Hurricane Camille that hit the Gulf Coast of Mississippi in August of 1969. Winds accompanying the storm were measured at over 200 mph and the tidal surge reached nearly 35 feet. Property damage exceeded 11 billion dollars and 172 people were recorded as either dead or missing. As the storm moved inland, another 175 persons lost their lives or were classified as missing in Tennessee and Kentucky.¹⁹ Full recovery from the storm took many years. Fortunately by 1979, ten years after the storm, the seawall, sand beach, and scenic drive along the Gulf had been rebuilt. In addition, tourism recovered after new lodging facilities and restaurants were constructed to replace those destroyed in the storm. However, even today, more than 35 years later, signs of the storm are still visible. Stairs and driveways leading nowhere, vacant lots, and slabs where buildings once stood give evidence to the destructiveness of the storm (Hearn 2004).

A more recent example of the damage that can be wrought by a powerful storm is Hurricane Katrina which battered the shores of Louisiana, Mississippi, and Alabama in 2005. Katrina was a storm of huge proportions. Its hurricane force winds swept across 250 miles of coastline.²⁰ High winds extended inland more than 100 miles. In addition to the wind, the storm surge moved up the Mississippi River and into Lake Pontchartrain, a salt-water lake north of New Orleans. The surge overtopped and eroded the 350 miles of levees protecting the city and poured water into New Orleans flooding houses up to their rooftops. While the damage from flooding was enormous, even without the water damage, Hurricane Katrina would have been the most destructive hurricane on record due to the large size of its windfield and its path through areas having large concentrations of development (RMS 2005).

¹⁹ Considerable damage was also done in western Virginia.

²⁰ The hurricane made landfall as a Category 4 hurricane just south of Buras, Louisiana with sustained wind speeds of 140 mph (RMS 2005).

The storm produced hurricane impacts on a scale never before seen in the U.S. It is typical for populations to flee as a storm approaches, but in the case of Katrina, the exodus of people from New Orleans was historic. While the city's population rose above 600,000 in the mid-1960s, it had declined to about 462,000 just before Katrina. Some estimates put the number of people who evacuated at 400,000. As of late spring 2006, some of the evacuees had returned but the city's population was still only 144,000. Aware of the many difficulties which community's face in recovering from a devastating storm, a commission organized by the city's mayor estimated that its population would rise to just 247,000 by 2008.²¹ These figures confirm that while recovery from Category 1 and 2 storms is rapid, recovery from super hurricanes is very slow and the effect in some cases can be regarded as permanent (Economist 2006). In essence, residents and businesses are quick to repair their structures following a lesser storm, but they question whether it is wise to rebuild following a powerful storm, especially, when their properties have been completely demolished. Stated differently, repair is one thing; rebuilding is another. People are quick to do the former; they are reluctant to do the latter.

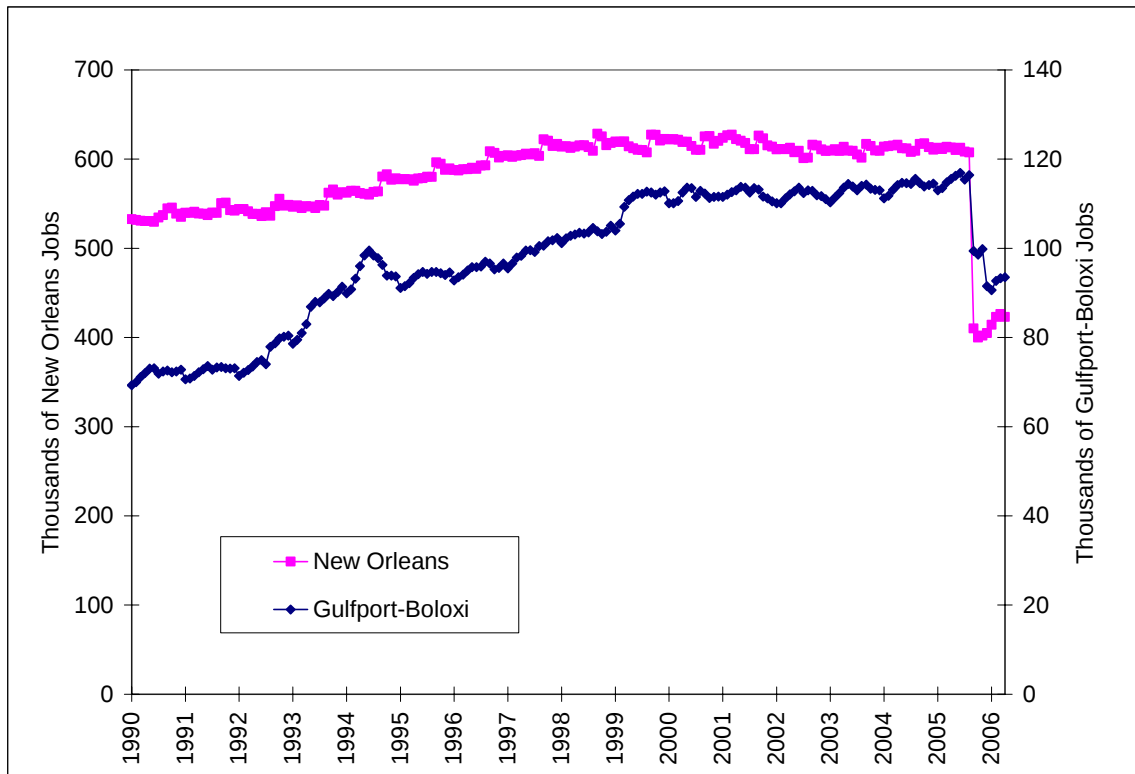
The job loss in New Orleans and nearby Gulfport and Boloxi was extreme as can be seen in Figure 9. Katrina wiped out roughly one-third of the city's jobs. Even in mid-2006, the city was down more than 200,000 jobs compared to pre-hurricane levels. In effect, some three decades of job growth in New Orleans was eliminated.

In sharp contrast is the region's unemployment rate which has changed little. In fact, the number of unemployed fell faster than did the size of the labor force due to the evacuation of the city's residents so that the unemployment rate actually fell in the months after the storm (FRBA 2006). This outcome is not entirely unexpected since the unemployed have less to lose and more to gain by moving elsewhere as compared to those who are employed and perceive themselves as having a reason to remain or return to the city. In essence, employed persons have a higher stake in their regional economy than do those for whom the economy has failed to provide jobs. The employed are more likely to return after a large storm than are the unemployed.

Finally, the events in New Orleans point out the inadequacy of emergency systems to response to super storms. Systems failed in New Orleans because of, among other things, the sheer enormity of the catastrophe. It appears that people and institutions can function to provide aid at low levels of hurricane damage but, at high levels, a community is simply overwhelmed.

²¹ It has been reported that the Rand Corporation projects the city's population to rise to between 250,000 and 270,000 by 2008.

FIGURE 9: THE IMPACT OF HURRICANE KATRINA ON DESEASONALIZED NONFRAM EMPLOYMENT IN NEW ORLEANS AND GULF PORT-BOLOXI MSAS



Conclusion #10: Communities Can Reduce the Impact of Hurricanes through Proper Planning

In light of the potential for hurricanes to impact upon a regional economy, especially large and powerful ones, communities should take steps to minimize their destructive effects. Essentially, there are three very different types of actions which can be taken to reduce the destructive potential of hurricanes.

The first of these is mitigation. Mitigation is simply an action(s) taken to reduce or eliminate the long-term risk to life and property from a storm. These actions can be taken by either public or private entities.

Actions available to public entities are, for the most part, those that can be taken by state and local governments. They include creating barriers such as sea walls, wetlands, and widened beaches to reduce flooding from the intrusion of water into land areas, improving drainage systems so as to remove water more quickly from areas prone to flooding, developing hardened shelters to accommodate area residents fleeing a storm, and zoning areas vulnerable to

flooding and storm surge into categories that will limit their potential for development, and creating rigorous building inspection programs so that the quality of a community's new structures is up to the standard set by its building codes. In addition, and perhaps most important, are actions which can be taken by state and local governments to strengthen building codes for both residential and commercial structures. Florida has been a leader in this area since its building codes have been dramatically changed in recent years to make structures more wind and water resistant. Examples of changes which can be made to building codes to improve the integrity of structures include the use of flood-resistant building materials such as concrete and pressure-treated lumber, the use of waterproof veneer on exterior walls, the placement of electrical system components above anticipated flood levels, anchoring fuel tanks, the elevation of HVAC equipment, the use of sewer backflow valves, the use of protective covering for doors and windows, and the protection of wells from contamination by flooding.

Since public mitigation efforts can be expensive, local and state governments may need to enhance their revenue stream so as to fund mitigation efforts. Careful cost-benefit analyses should be conducted for mitigation efforts so that the public can be assured that public expenditures will be more than made up for by a reduction in the damage caused by future storms. Using programs like HAZUS can help in outlining the benefit side of the cost-benefit equation.

In like manner, individuals and companies can take a variety of actions which will reduce their potential for property damage and personal injury. The list of actions which can be taken by individual property owners to mitigate the damage which they might sustain in the event of a storm is long. Certainly high on the list is trimming vegetation so that plants offer minimal profile to the wind, planting trees far enough away from structures so that they will not touch those buildings if they should be toppled in a storm, strengthening garage doors, anchoring roofs to buildings, and securing or storing outdoor furniture, grills, and other items which might become missiles during high winds.²²

Businesses can take additional actions to decrease their potential for damage and increase their likelihood of survival after a storm. They can, for example, protect critically important records in elevated hurricane-proof areas or offsite in locations safe from storms. Companies can also install generators in secure locations so that they can resume operation even before power is restored. In addition, plans can be prepared as to how a company is to reopen

²² The impact of mitigation efforts which could be taken by area residents is potentially substantial. Fortunately, many of these efforts can be done at little expense. Examples of low cost mitigation efforts which have the potential to pay big dividends include the trimming and thinning of vegetation, increasing the strength of roofs by adding fasteners between the roof and wall, and fitting windows so that protective coverings can be installed before a storm arrives.

after a storm. The preparation and execution of a good business-restart plan can make the difference between success and failure in the aftermath of a storm.

After state and local governments, area residents, and local businesses have made every effort to reduce their vulnerability to storms, it should be recognized that, no matter how comprehensive these efforts, some damage will inevitably occur. Fortunately, the economic effects of this damage can be largely offset by the use of insurance. For residents, this includes property, auto, and renters insurance to protect against wind and related damage as well as flood insurance in both flood-prone and non-flood-prone areas. For businesses, this includes property and flood insurance as well as insurance covering the interruption of business.

Finally, communities can set up emergency management plans designed to minimize personal injury and the loss of life. These plans need to be widely disseminated so that all involved in efforts to protect the community are well aware of their individual responsibilities.

In combination, if individuals, businesses, and state and local governments use the many tools which they have available to them, the damaging effects of hurricanes can be sharply reduced.

THE IMPACT OF PAST HURRICANES ON HAMPTON ROADS

Several tropical systems have impacted the Hampton Roads economy in recent years. Each has left its effect imbedded in the historical record of the region. These impacts are very suggestive of the extent to which the regional economy can be damaged by future storms.

Impact on Regional Income

When hurricanes strike, they damage or destroy property, threaten lives and disrupt business activity. This disruption leads to lower regional income since people are laid off, wages are not paid to workers who are unable to work, sales commissions decline, proprietors see their business profits decrease, and rental income falls. Each of these changes leads to lower regional income.

In an effort to determine the extent to which past hurricanes have had an impact on personal incomes in Hampton Roads, a regression equation was developed which was designed to explain or predict the change in regional disposable income brought on by the passage of a hurricane. The equation's dependent variable (the variable to be predicted or explained) was the percent change in Hampton Roads real disposable income. The independent variables (the variables used to predict or explain changes in the dependent variable) were the annual percent change in U.S. real disposable income, the annual percent change in real U.S. defense spending, and a variable for the presence or

absence of a hurricane. The time period used to estimate the relationship between hurricanes and the change in income was from 1970 to 2004. Annual data was used to estimate the model. Hurricanes included in the calibration of the model were Fran, Bonnie, Floyd, and Isabel.

Results from the regression suggest that recent hurricanes have reduced the rate of growth in real regional disposable income in Hampton Roads. The coefficient on the hurricane variable was statistically significant and suggested that the four past hurricanes under investigation have, on average, lowered the annual percent change in real disposable income by 1.3 percentage points over what would have occurred had there been no hurricane. This translated to an average loss of over 500 million dollars in loss disposable income. This estimate is consistent with a loss of slightly over one week of regional production.

These results are consistent with the findings of others. For example, in a study of the impact of Hurricane Hugo on South Carolina, it was estimated that Hugo was responsible for a 9.4 percent decline in personal income in the third quarter of 1989. In fact, South Carolina was the only state which experienced a decline in personal income at the time of the storm (Guimaraes 1993). A study of the impact of Hurricanes Hugo and Floyd on Charlotte and North Carolina done by Wachovia found that both storms reduced the rate of growth in personal income (Silvia 2005). Finally, in a study done of Wilmington, North Carolina by Burrus (2002), it was estimated that low-impact hurricanes reduced annual gross output (a concept closely related to aggregate personal income) by between 0.8 and 1.2 percent.

The Impact of Hurricane Isabel

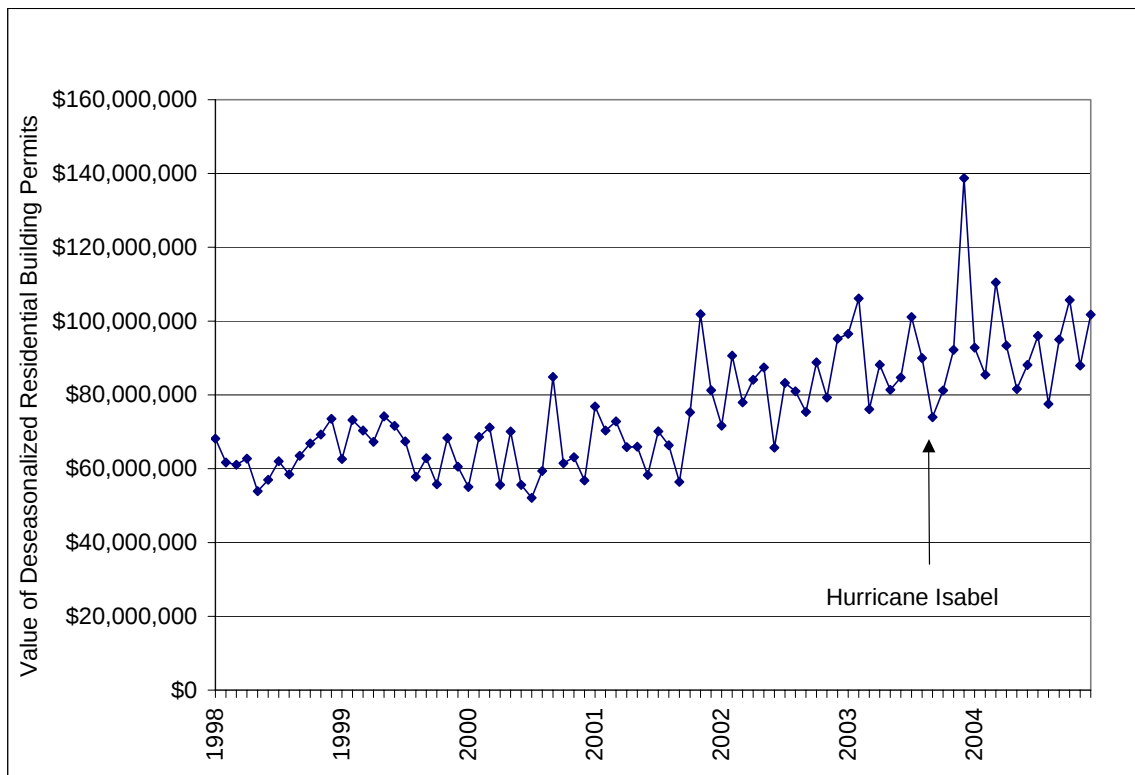
In addition to assessing the impact on annual income, examining the movement of monthly economic indicators can also help to assess the regional impact of a hurricane. Changes in regional economic indicators following the passage of Hurricane Isabel in September of 2003 demonstrate the effect that a hurricane can have on the Hampton Roads economy.

Hurricanes invariably set in motion activities that can lead to an expansion in regional economic activity. Perhaps the most obvious of these is the increase in construction that occurs as local residents repair the damage caused by a storm. In the case of Isabel, the increase in the value of building permits was pronounced as can be seen in Figure 10. The impact on building permits was particularly noticeable in the third month following the storm.

An increase in construction activity invariably produces an increase in the sale of certain retail items. Some of that increase is caused by the normal restocking activity of residents who purchase things that they were unable to buy during the storm. Further increases occur when construction materials are purchased to facilitate reconstruction. Additional sales are made to workers who

have come from elsewhere to assist with clean up and repair efforts. The increase in retail sales following Isabel was most pronounced in October of 2003 or one month following the storm. The increase in retail activity preceded the pick up in building permit activity since it takes time to both prepare and process building permit applications whereas retail activity can increase immediately after the storm when stores reopen. The increase in retail sales following Isabel is shown in Figure 11.

FIGURE 10: IMPACT OF RECENT HURRICANES ON HAMPTON ROADS
VALUE OF RESIDENTIAL BUILDING PERMITS

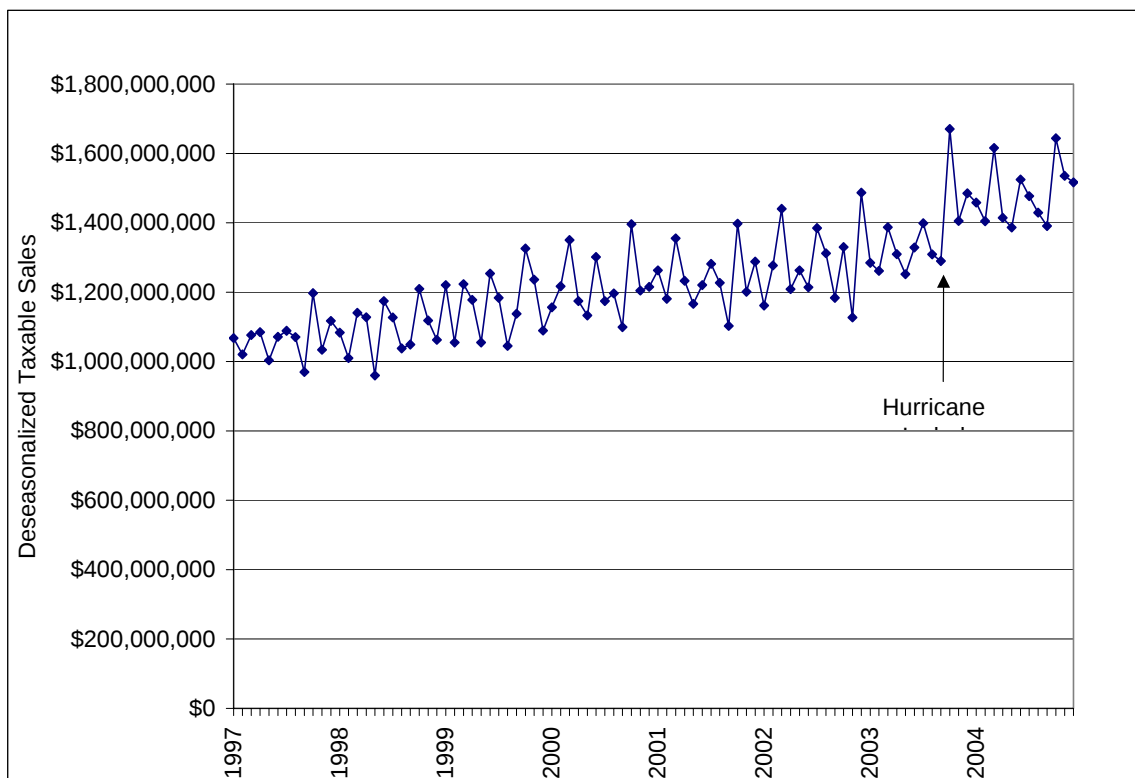


Another, and perhaps clearer view of the impact of Isabel on Hampton Roads can be seen by comparing the behavior of the economy with and without the effects of the hurricane. In order to make this comparison, an ARMA model was constructed for each of several important regional economic indicators, and each model was used to predict the near-term future without Isabel.²³ The ARMA forecast was then compared to what actually occurred when the storm crossed the region to assess the impact of the hurricane. The ARMA models

²³ ARMA is an abbreviation for autoregressive moving average which are the two processes that were employed in the construction of each model. ARMA models are highly refined curve-fitting devices that rely on current and past values of the dependent variable to produce a near-term forecast. They generally produce very accurate forecasts of one to several periods into the future and, as such, are an appropriate vehicle for determining how the Hampton Roads economy would have behaved without Hurricane Isabel.

were constructed so as not to include the impact of the hurricane by performing the calibration using only those months leading up to the storm. The difference between the ARMA forecast which did not include the impact of Isabel and the actual experience of the region which included the effect of Isabel was assumed to be the impact of the storm.²⁴ This technique has been used by others to investigate the economic impact of natural disasters.²⁵ A good example is the work done by Bram (2002) to determine the impact of the September 11 attack on the World Trade Center.

FIGURE 11: IMPACT OF RECENT HURRICANES ON HAMPTON ROADS TAXABLE RETAIL SALES



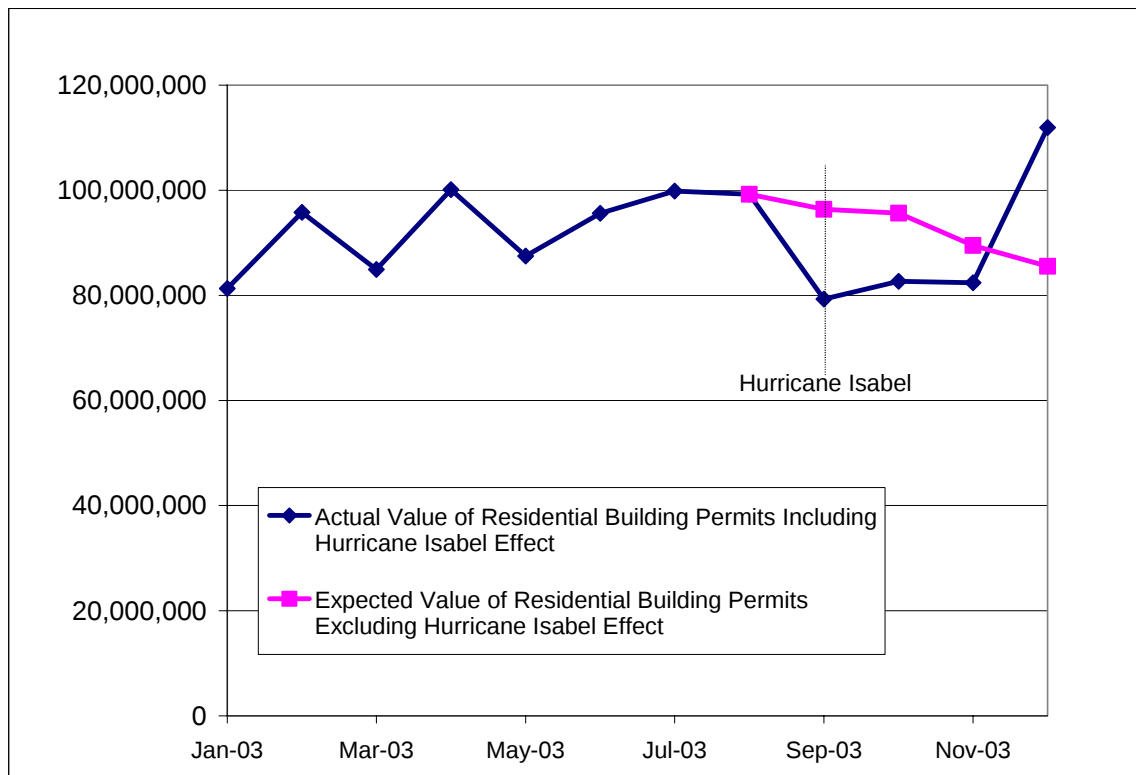
One of the most obvious impacts of hurricanes is upon construction and construction-related retail sales. As can be seen in Figure 12, building permits declined in September of 2003 when Isabel passed through the region. In fact, the value of building permits were 17.8 percent below what would have occurred, according to an ARMA simulation, had there not have been a hurricane during the month. By contrast, retail sales increased in September since they were 5.3

²⁴ There may have been other things occurring at the time of the hurricane but it is likely that the storm was the defining event that impacted on business indicators during the month when the storm occurred. This analysis makes the assumption that any other activities at the time were of little importance when compared to the effect of the hurricane and that the hurricane explains the difference between the actual and expected values of each of the variables analyzed.

²⁵ A slight variant on this procedure is to estimate an intervention or interrupted time series model.

percent above the no-hurricane scenario as residents stocked up with provisions before the arrival of the storm and then returned to area stores to make additional purchases to enable them make structural repairs and to replace items damaged by the storm. Retail sales were 14.0 percent higher than expected in October as people and businesses continued their post-hurricane spending. The impact of the hurricane on retail sales, or the difference between expected (from the simulation) and actual sales is shown in Figure 13.

FIGURE 12: IMPACT OF HURRICANE ISABEL ON THE VALUE OF RESIDENTIAL BUILDING PERMITS IN HAMPTON ROADS



Automobile sales, like retail sales, were also impacted by the storm. As is evident in Figure 14, auto sales declined in September in large part because area residents were unable to shop immediately before and during the storm and were prevented from shopping following the storm because of their attention to post-hurricane clean up activities. By contrast, in October, the month following the hurricane, regional auto sales were 25.8 percent higher than they would have been without the storm. The increase occurred as residents purchased vehicles which they were unable to buy due to the hurricane in the preceding month. In addition, many residents purchased new cars to replace those which were damaged by the storm. In fact, in an effort to facilitate this process, many area car dealerships offered hurricane rebates to residents whose cars had been damaged by the storm. The result was the large increase in auto sales.

FIGURE 13: IMPACT OF HURRICANE ISABEL ON TAXABLE RETAIL SALES IN HAMPTON ROADS

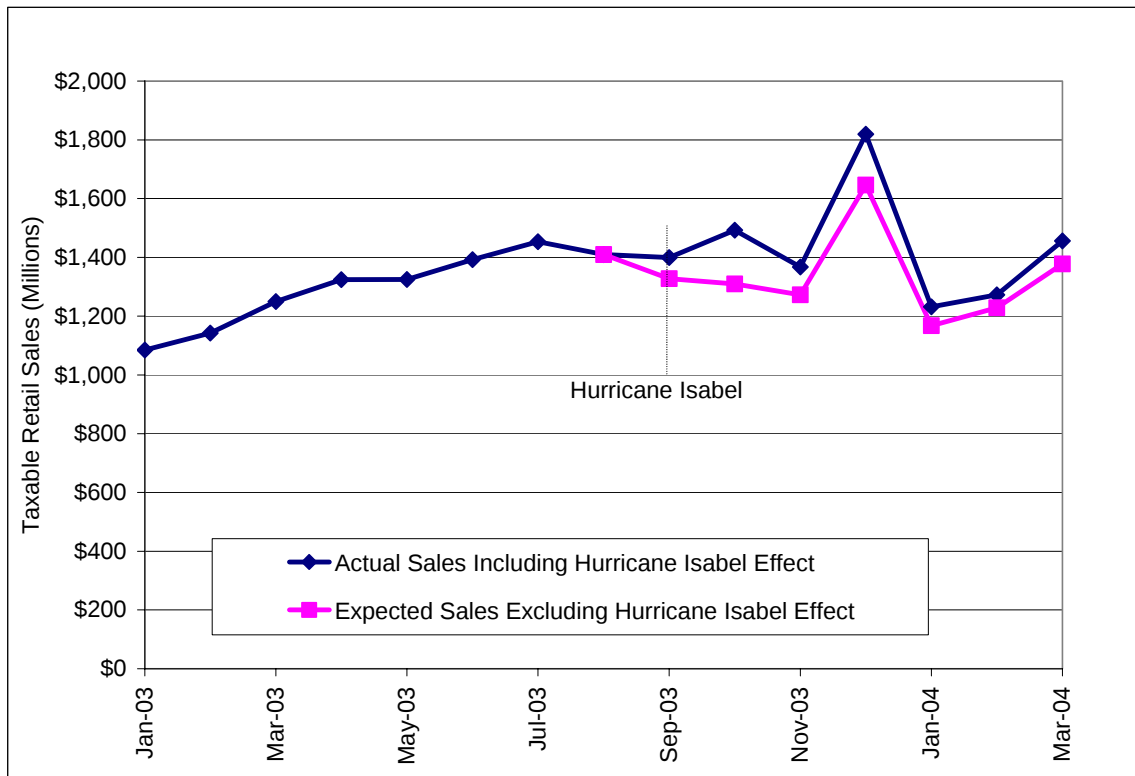
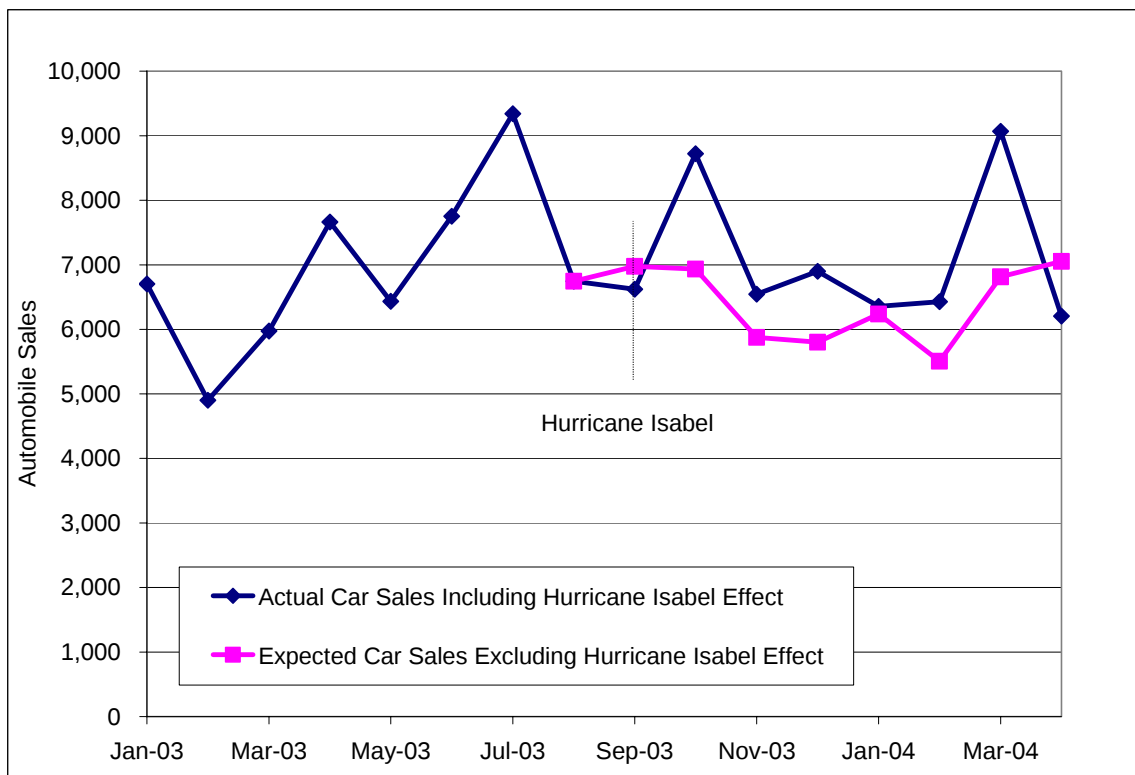
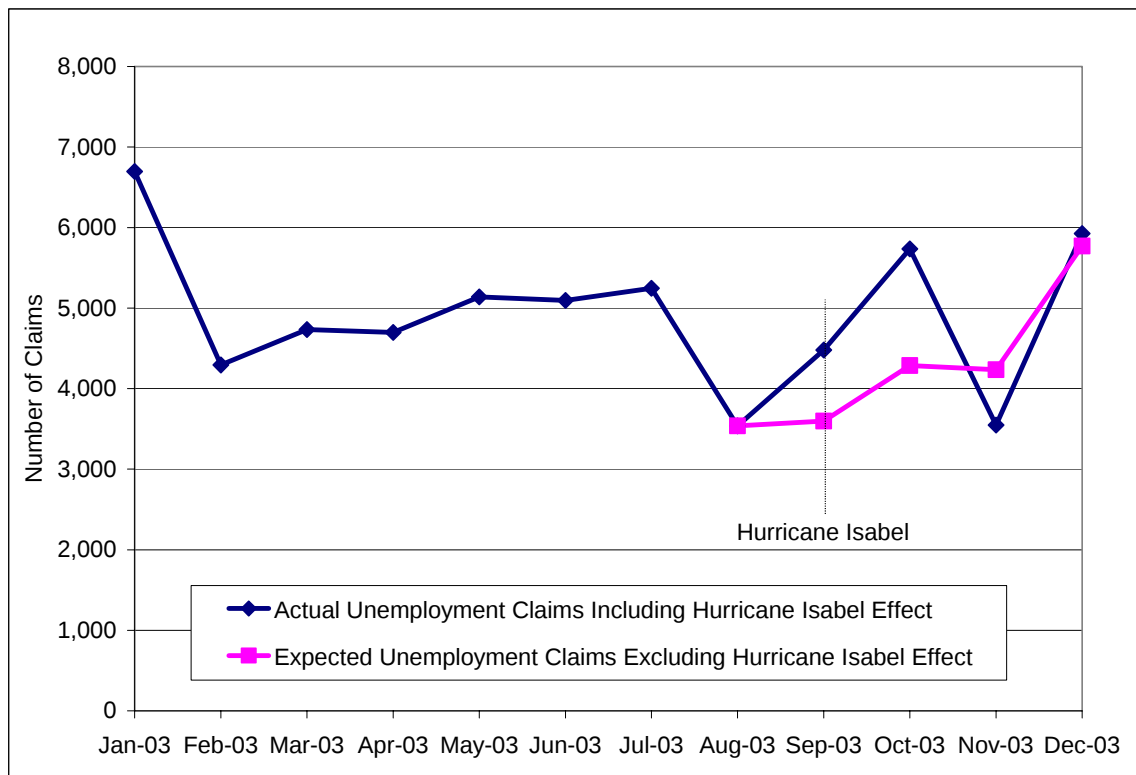


FIGURE 14: IMPACT OF HURRICANE ISABEL ON AUTOMOBILE SALES IN HAMPTON ROADS



In contrast to the increase in retail and auto sales following the storm, the net impact of the hurricane on regional employment was small²⁶. On the one hand, many area businesses lost sales and were forced to lay off employees. The result, as can be seen in Figure 15, was that initial unemployment claims, a measure of layoffs, were 24.5 percent above the level expected by the simulation of the economy without the storm. The month following the hurricane saw a further increase in layoffs since the number of initial unemployment claims was 33.0 percent above the expected number of claims that would have been experienced had there been no storm. The increase in layoffs led to a small decrease in the total number of persons working in the region since payroll employment was just 0.4 percent below the expected value for September, as can be seen in Figure 16. The decrease in the number of persons employed was roughly equivalent to the increase in initial unemployment claims.²⁷ These results are similar to those achieved in an analysis of the impact of Hurricane Hugo on South Carolina which concluded that the hurricane had little impact on the state's level of employment (Guimareas 1993).

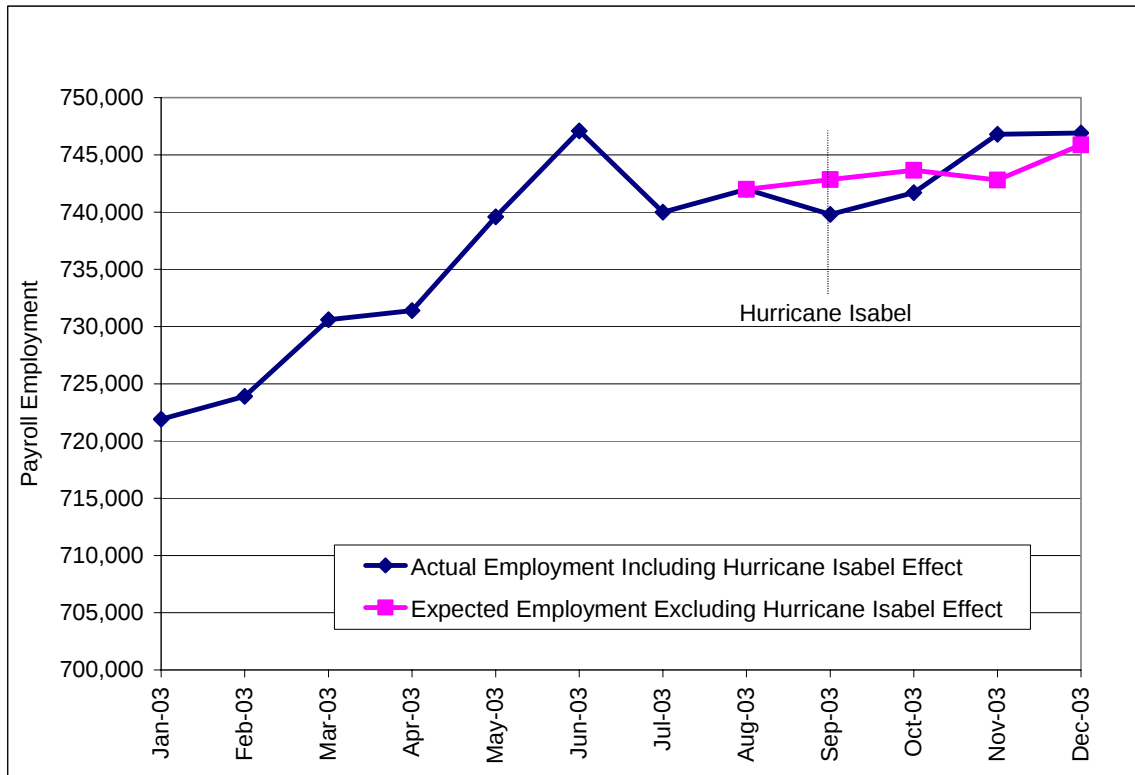
FIGURE 15: IMPACT OF HURRICANE ISABEL ON INTIAL UNEMPLOYMENT CLAIMS IN HAMPTON ROADS



²⁶ The employment impact of hurricanes is moderated in Hampton Roads by the presence of a large number of workers who are directly or indirectly employed by the federal government (military, federal civilian, shipyard workers, and defense contractors). Unlike private sector jobs, these federally-based jobs are not likely to be lost in the event of a hurricane.

²⁷ Part of the small discrepancy between the decrease in employment and the increase in persons laid off is that persons were hired to do building repair and to work in area retail stores.

FIGURE 16: IMPACT OF HURRICANE ISABEL ON PAYROLL EMPLOYMENT IN HAMPTON ROADS



Finally, port activity was adversely impacted by the hurricane since ships avoided the Atlantic sea-lanes off Virginia, Maryland, and the Carolinas so as not to be threatened by the storm. As a result, port activity as measured by general cargo tonnage was 7.5 percent below the expected value for September as can be seen in Figure 17.

THE IMPACT OF FUTURE HURRICANES ON HAMPTON ROADS

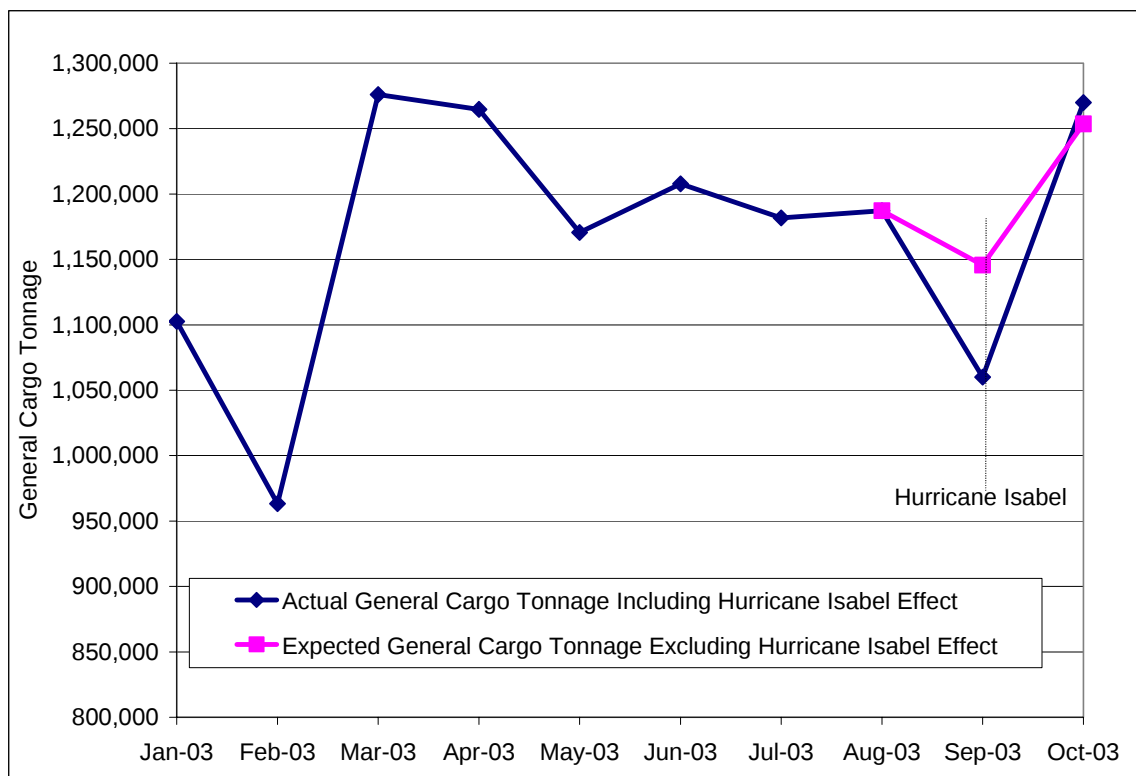
Hurricanes can cause billions of dollars in damage along with a loss of life. For that reason, communities need to assess their potential to experience the losses caused by these storms. The material to follow is an attempt to outline the extent to which future hurricanes can impact upon the economy of Hampton Roads.

HAZUS-MH Simulations

One method for assessing a region's vulnerability to a hurricane is to use the simulation capabilities of the Federal Emergency Management Agency's (FEMA) HAZUS model. The original HAZUS model was developed jointly by the

National Institute of Building Sciences (NIBS) and FEMA and was released in 1997. To date, three HAZUS models have been constructed which make it possible to estimate the potential losses from earthquakes, floods, and hurricane winds. The loss estimates produced by HAZUS-MH are based upon current scientific and engineering knowledge about the forces unleashed by hurricane force winds, floods, and earthquakes. In the case of hurricanes, the currently available model utilizes information on wind pressure, windborne debris, storm surge, atmospheric pressure change and rain to estimate loss. The model runs in default mode using a community's estimated stock of buildings or can be customized with local information. The model estimates a storm's direct damage to buildings, induced damage (damage that results from direct damage such as a fire following a disaster), social losses including estimates of casualties (excluding deaths), displaced households, the need for short-term shelter, and direct economic losses. In generating its output, the model estimates the impact on Hampton Roads in 2006 given the strength and track of a storm as well as current development patterns (MMC 2005).

FIGURE 17: IMPACT OF HURRICANE ISABEL ON GENERAL CARGO TONNAGE IN HAMPTON ROADS



The HAZUS-MH model was used to assess the magnitude of the economic impact which might result from a hurricane crossing the region. In conducting these studies, two very different types of simulations were performed. The first estimated the impact which six previous hurricanes would have on the

region were those hurricanes to pass through Hampton Roads again with the wind speeds and track of the original storm.²⁸ The six historical storms used as proxies for future hurricanes were Bonnie, Donna, Floyd, Fran, Hazel, and Isabel. Those storms along with their year of occurrence and wind speed are shown in Table 7. Since the region is more developed today than when the historical hurricanes crossed the region, the impacts which the model estimated are believed to be larger than those which occurred when the original storm passed through the region.

TABLE 7: HISTORIC HURRICANES IMPACTING ON HAMPTON ROADS

Hurricane	Year of Hurricane	Wind Speeds in Hampton Roads (Excluding Gusts)
Bonnie	1998	Tropical Storm Force Winds
Donna	1960	Tropical Storm Force Winds
Floyd	1999	Tropical Storm Force Winds
Fran	1996	Tropical Storm Force Winds
Hazel	1954	Tropical Storm Force Winds
Isabel	2003	Tropical Storm Force Winds

The second set of simulations assessed the economic impact of the most severe hurricane that might be expected to occur every 100, 200, 500, and 1,000 years.

Both sets of simulations estimated two kinds of losses. The first is the damage to buildings and includes the cost of repair and replacement of damaged and destroyed buildings along with the cost of damage to the contents of buildings and their inventories. The second consists of losses that are related to the length of time commercial establishments are out of operation because of structural damage. This includes relocation expenses for businesses and institutions, the loss of income from reduced business output or sales, the loss of wages paid to employees working in damaged properties, and the loss of rental income.²⁹

The HAZUS-MH results are believed to provide valuable information about the potential of hurricanes to impact on the Hampton Roads economy. However, because the model is not yet “mature”, the results should be looked at as approximations to the potential effect of future hurricanes.

²⁸ Those storms, while hurricanes elsewhere, had tropical storm force winds when they arrived in Hampton Roads.

²⁹ The economic losses reported by HAZUS-MH are a “mixed bag” of effects. They include a business expense (relocation expenses), business income or profit loss because of a decrease in sales or output (referred to in the language of HAZUS as capital-related income losses), rental income, and the loss of wages. All of these impacts can be thought of as income since all impact on a region’s total income stream.

One shortcoming of this analytical approach is that currently the model is unable to calculate the impact of hurricane flooding. However, because the model is generally believed to overestimate the effect of the wind, not including the impact of a flood is less damaging to the analysis than might be expected. In effect, the two biases in the analysis (overestimating the impact of the wind and not estimating the impact of water) tend to offset one another so that the results are believed to be meaningful. Furthermore, there is a hidden benefit to be gained by not considering the effect of flooding. Including flood damage can lead to “double counting” since the damage from wind and the damage from water may be the same damage.³⁰ As a result, excluding flood damage results in an underestimate of total damage but the magnitude of that underestimation is not the full impact of flooding. Finally, since damage from flooding as a percent of all storm damage typically declines with increases in the speed of hurricane winds, the simulation results may become increasingly reliable the greater the severity of the storm. In essence, it is likely that the HAZUS results, as currently calculated, are more reliable for powerful storms than for weaker ones.

Of greater concern is the fact that HAZUS-MH simulations do not include the impact on the economy of rebuilding and resupplying after the storm – in effect the model estimates the negative impact on the economy and not the positive economic impact of recovery efforts.³¹ The result of omitting the effect of recovery spending is to overestimate the negative impact of a storm since the positive, stimulative impact from construction expenditures is not counted.³² In effect, not counting the positive effect of construction leads to an overestimation of the impact of a storm but that overestimation is largely offset by the underestimation of the hurricane’s effect, which occurs when the model ignores flooding.

Reoccurrence of Historic Storms

³⁰ An example might be the destruction of a garage by wind and flooding. The destruction of the garage can only be counted once even though wind and water could each totally destroy the garage. Counting the damage to the garage from both wind and water would count the damage twice and represent an overestimation of damage. By contrast, it is also possible that the wind could produce partial damage to the garage and further damage of a different type could be caused by flooding. In that case, adding the two damages together would not constitute double counting. A final issue is that if repairing the damage from wind (or water) automatically includes repairing the damage to water (or wind), then it might be argued that the water (or wind) damage should not be counted in making a damage assessment regardless of the method of damage.

³¹ FEMA may have decided to exclude the impact of rebuilding from their model so as to eliminate the possibility of producing results which show a net positive impact upon the economy of a hurricane.

³² HAZUS-MH can be used to estimate wind and flood effects. However, these two estimates are made independently and are not aggregated by the model. At present, the wind model does not estimate the indirect effect of storms – only the direct economic impact is calculated. By contrast, the flood model estimates both the direct and indirect effects. Fortunately, while the HAZUS-MH work for this study includes the wind effect alone without an estimation of indirect effects, this is not viewed as a significant handicap since multiplier effects in the economy after a powerful storm are not likely to be large since the structural relationships in the economy are damaged by the hurricane, resulting in large “leakages” and small multipliers.

The impact of historic hurricanes crossing Hampton Roads today are shown in Tables 8-9. The damage to buildings and their contents and inventories are shown in Table 8 while the impact of the disruption to business activities are shown in Table 9.

TABLE 8: HURRICANES IN HAMPTON ROADS – PROPERTY DAMAGE

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006							
	Hurricanes						Total of All Hurricanes
	Isabel	Hazel	Floyd	Bonnie	Donna	Fran	
Estimated Value of Damage*							
Buildings	\$3,487,526,400	\$493,005,430	\$324,785,470	\$100,115,340	\$76,138,090	\$19,840	\$4,481,590,570
Content	\$1,154,104,500	\$106,752,580	\$52,932,780	\$17,222,660	\$11,326,050	\$247,680	\$1,342,586,250
Inventory	\$10,666,800	\$397,420	\$171,140	\$1,430	\$5,120	\$0	\$11,241,910
Total	\$4,652,297,700	\$600,155,430	\$377,889,390	\$117,339,430	\$87,469,260	\$267,520	\$5,835,418,730
Damage as a Percent of the Value of All HR Real Property	5.990%	0.077%	0.049%	0.015%	0.010%	0.000%	NA
Number of Buildings by Damage Category							
No Damage	286,556	458,414	472,921	491,789	491,824	494,911	NA
Minor Damage	145,847	32,250	20,257	3,139	3,089	196	NA
Moderate Damage	49,617	4,181	1,871	181	195	8	NA
Severe Damage	7,197	140	36	6	5	2	NA
Destroyed	5,903	131	31	0	1	0	NA
Total**	495,120	495,116	495,116	495,115	495,114	495,117	NA
Buildings as a Percent of Total							
No Damage	57.9%	92.6%	95.5%	99.3%	99.3%	100.0%	NA
Minor Damage	29.5%	6.5%	4.1%	0.6%	0.6%	0.0%	NA
Moderate Damage	10.0%	0.8%	0.4%	0.0%	0.0%	0.0%	NA
Severe Damage	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	NA
Destroyed	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	NA
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	NA

* Figures in 2002 dollars

** Slight differences in the totals due to rounding

TABLE 9: HURRICANES IN HAMPTON ROADS – PROPERTY DAMAGE AND BUSINESS INTERRUPTION LOSSES

Projected Property Damage and Business Interruption Losses Assuming the Historic Storm Occurred in HR in 2006*							
Hurricanes	Property Damage	Business Interruption Loss					Total of All Losses
		Capital-Related Income (Sales)	Relocation	Rental Income	Loss of Wages	Total	
Isabel	\$4,652,297,000	\$16,452,000	\$594,492,000	\$232,747,000	\$25,496,000	\$869,187,000	\$5,521,484,000
Hazel	\$600,155,000	\$1,488,000	\$34,818,000	\$19,774,000	\$2,134,000	\$58,214,000	\$658,369,000
Floyd	\$377,889,000	\$951,000	\$18,070,000	\$12,853,000	\$1,353,000	\$33,227,000	\$411,116,000
Bonnie	\$117,339,000	\$0	\$2,102,000	\$2,061,000	\$0	\$4,163,000	\$121,502,000
Donna	\$87,469,000	\$4,000	\$2,996,000	\$2,029,000	\$8,000	\$5,037,000	\$92,506,000
Fran	\$267,000	\$0	\$13,000	\$0	\$0	\$13,000	\$280,000
Total	\$5,835,416,000	\$18,895,000	\$652,491,000	\$269,464,000	\$28,991,000	\$969,841,000	\$6,805,257,000

*Figures in 2002 dollars

As can be seen in Table 8, the six hurricanes investigated with HAZUS-MH (Bonnie, Donna, Floyd, Fran, Hazel, and Isabel) would produce cumulative impacts of 5.8 billion dollars of damage in Hampton Roads were they to strike the

region today.³³ Of that total, 4.5 billion dollars would be damage to buildings, 1.3 billion dollars would be damage to the content of buildings, and only 11 million dollars would be damage to inventories. Of the storms investigated, Hurricane Isabel would be the most destructive since it would account for 4.7 billion dollars in damage as compared to only slightly over one quarter of a million dollars in the case of Hurricane Fran. Isabel's damage would constitute nearly six percent of the value of all buildings in Hampton Roads.

Another way to look at the destructiveness of a storm is to examine the percent of all buildings projected to sustain damage. In total, the model projects that nearly 42 percent of the structures in Hampton Roads would sustain damage if Isabel were to cross the region in 2006 as it did in 2003. As can be seen in the table, the damage to most buildings is projected by the model to be minor. Projected property damage reports caused by past storms are contained in the appendices.

Hurricanes not only produce damage but they also cause a disruption to business activity, which results in a further loss to the economy. Those losses in Hampton Roads following the reoccurrence of the six past hurricanes under investigation are shown in Table 9. As can be seen in the table, HAZUS-MH estimates that the six hurricanes, in combination, would produce nearly a billion dollars in business losses in Hampton Roads. Isabel, the most damaging of the six storms used to suggest the impact of future storms, would produce business losses of nearly nine hundred million dollars. The indirect or spin-off impacts in the economy are not included in these estimates.

Probability Storms

In contrast to estimating the impact of the reoccurrence of past storms, HAZUS-MH can also be used to estimate the impact of hypothetical storms such as the maximum hurricane to strike the region over varying intervals of time. The impact of the maximum hurricane which can be expected to occur once every 100, 200, 500, and 1,000 years are shown in Tables 10-12. These tables clearly illustrate that the destruction of storms increases significantly as the strength of the hurricane increases. For example, in Table 10, it can be seen that storms likely to strike the region once every 100 years (a storm with only a one percent chance of occurring in any one year) would displace 12,893 households long term and would require short-term shelter for 2,929 people. In sharp contrast, a hurricane likely to strike once every 500 years (a storm with a 0.2 percent chance of occurring in any one year) would displace 106,016 households and require short-term shelter for 27,874 people.

In similar fashion, an increase in the severity of a storm will increase the damage to the economy. Table 11 demonstrates how the maximum storm that

³³ Impacts were combined so as to show the long-term burden upon the economy of its tendency to experience storms.

might be expected to occur once every one hundred years would produce 3.2 billion dollars in property damage while a once every 500 year hurricane would increase that damage total to 20.5 billion dollars. Similarly, the business interruption losses would increase from 589.4 million dollars (100 year storm) to over 4 billion dollars (500 year storm). The number of structures damaged in storms of varying strength as evidenced by their frequency is shown in Table 12.

TABLE 10: SHELTER REQUIREMENTS IN HAMPTON ROADS

Frequency of Occurrence in Years	Probability of Hurricane Striking in a Single Year	Number of Displaced Households	People Needing Short Term Shelter
100	1.0%	12,893	2,920
200	0.5%	34,196	8,381
500	0.2%	106,016	27,874
1000	0.1%	180,859	47,051

TABLE 11: ECONOMIC LOSS FROM HURRICANES STRIKING HAMPTON ROADS

Frequency of Occurrence in Years	Property Damage		Business Interruption Losses (Income)	Business Loss as a Percent of Property Damage
	Residential	Total		
100	\$2,936,461,000	\$3,173,204,000	\$589,442,000	18.6%
200	\$7,408,110,000	\$8,150,610,000	\$1,608,291,000	19.7%
500	\$18,423,874,000	\$20,513,182,000	\$4,005,609,000	19.5%
1000	\$27,704,000,000	\$30,959,156,000	\$5,839,612,000	18.9%

TABLE 12: NUMBER OF RESIDENTIAL BUILDINGS DAMAGED IN HAMPTON ROADS

Frequency of Occurrence in Years	Minor	Moderate	Severe	Destruction	Total
100	59,923	22,219	5,989	5,686	93,817
200	124,167	61,752	16,409	14,227	216,555
500	164,114	121,011	45,911	40,400	371,436
1000	140,866	137,393	71,624	69,941	419,824

Finally, HAZUS-MH estimates the long-run average annual cost of hurricanes striking Hampton Roads. In essence, these estimates are the annual cost, measured over many years, of the region's vulnerability to hurricanes. HAZUS-MH assesses this annual cost at 174.2 million dollars in damage along with an accompanying loss of 30.5 million dollars of lost income each year for a combined annual cost of 204.7 million dollars.

Knowing the annual cost of hurricanes to Hampton Roads is of considerable value since it can put into perspective the cost of efforts which might be made to reduce the region's vulnerability to storms. However, it should not be concluded from these estimates that the region can afford to spend up to approximately 200 million dollars annually on hurricane mitigation before it would begin to overspend on those efforts. Instead, the area needs to evaluate the wisdom of each of its mitigation expenditures by comparing the cost of those efforts with the benefits that might reasonably result. Given the uncertainty of the benefits, ratios between the benefits received and the costs incurred should be substantially above one.

CONCLUSION

The region's location along the eastern seaboard has conferred numerous advantages upon its economy. Hurricanes are not one of them. Since 1851, 106 hurricanes and tropical storms have passed within 75 miles of South Hampton Roads. When they strike, these storms damage property and disrupt the normal functioning of the regional economy. Unfortunately, the frequency of storms is increasing and, as a result, the area's vulnerability to hurricanes is growing.

It is important that the region understands the nature of the tropical storm threat that it faces so that actions can be taken to reduce the damage to property, fortify the economy against the negative consequences of interruptions to normal business activity, and protect people from injury and death. This report has attempted to delineate the nature of hurricane impacts and project the magnitude of damages which future hurricanes might produce.

Fortunately, Hampton Roads has an abundance of opportunities to diminish the effect of hurricanes on its people and economy. Emergency management plans which have already been developed will help in the evacuation of persons living in the lowest, most vulnerable locations while providing shelter to those who remain. Procedures for providing emergency services in the early hours after a storm has passed can also be developed. The number of injured and dead can be greatly reduced by effective emergency management planning.

Longer-term strategies, many of which must be developed by state and local governments, also need to be developed which can help to mitigate the damage from storms. These efforts, no matter their magnitude, will be slow in

producing results since the regional economy already has a large capital stock which can only be changed gradually to make the area's structures more hurricane resistant.

Area residents and businesses must also come to the realization that they need to take their own actions to mitigate the impact of a storm on their properties and lives. Businesses, for example, need to develop restart plans that will make it possible for them to get their operations back up and running following a hurricane. Planning by the private sector is vital if the regional economy is to recover quickly following the passage of a hurricane.

Finally, area residents and businesses must increase their voluntary participation in the various types of property insurance plans that are available. Mitigation can reduce some of the negative effects of storms but insurance is still needed to compensate people and businesses for the damage which they will inevitably sustain no matter how hard they work to reduce or eliminate storm damage.

One of the lessons learned from Katrina is that hurricane planning must be thought of as one of the components of good regional economic planning. Preparing plans to help the regional economy get through a hurricane must be an important regional priority just as is preparing emergency management plans to help the region cope with the pain, injury, and death which storms can produce. In fact, in a very real sense, in an era of enhanced tropical storm activity, hurricane preparedness should be viewed as an important complement to the area's economic development efforts since strengthening the local economy against the worst ravages of storms can make the region more attractive to business and can help the area to retain the commercial enterprises that it has worked so hard to create. While efforts to prepare for hurricanes must first emphasize such things as the creation of shelters, the development of workable evacuation plans, and strategies for providing emergency medical services, they must also include efforts to prepare a community for its future economic life following a storm.

Hampton Roads has a bright future. It's economy continues to expand following a period of above average growth and prosperity which has resulted from increases in defense spending. In order to continue this pattern of economic success, the region must prepare itself for the powerful storms which will inevitably pass near or through the area in future years.

APPENDIX A

HURRICANE BONNIE IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	97,857.7	1,783.9	204.2	269.6	100,115.3
Content	17,207.9	9.9	3.2	1.7	17,222.7
Inventory	0.0	0.2	1.0	0.3	1.4
Total	115,065.6	1,794.0	208.3	271.5	117,339.4

* Figures in 2002 Dollars

HURRICANE DONNA IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	74,381.1	1,390.1	142.1	224.7	76,138.1
Content	11,257.4	50.2	8.1	10.4	11,326.1
Inventory	0.0	1.8	2.2	1.1	5.1
Total	85,638.6	1,442.1	152.4	236.2	87,469.3

* Figures in 2002 Dollars

HURRICANE FLOYD IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	314,548.3	7,868.5	1,096.8	1,271.9	324,785.5
Content	51,096.8	1,255.6	407.9	172.5	52,932.8
Inventory	0.0	50.3	111.4	9.4	171.1
Total	365,645.1	9,174.5	1,616.0	1,453.9	377,889.4

* Figures in 2002 Dollars

APPENDIX A CONTINUED

HURRICANE FRAN IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	19.8	0.0	0.0	0.0	19.8
Content	247.7	0.0	0.0	0.0	247.7
Inventory	0.0	0.0	0.0	0.0	0.0
Total	267.5	0.0	0.0	0.0	267.5

* Figures in 2002 Dollars

HURRICANE HAZEL IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	474,846.2	13,612.5	2,206.7	2,340.0	493,005.4
Content	102,467.6	2,781.2	1,065.0	438.8	106,752.6
Inventory	0.0	108.5	267.8	21.1	397.4
Total	577,313.8	16,502.2	3,539.5	2,799.9	600,155.4

* Figures in 2002 Dollars

HURRICANE ISABEL IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	3,235,077.9	181,735.8	38,439.9	32,272.8	3,487,526.4
Content	1,026,850.5	84,156.2	28,877.8	14,220.0	1,154,104.5
Inventory	0.0	3,442.1	6,920.4	304.3	10,666.8
Total	4,261,928.4	269,334.1	74,238.1	46,797.1	4,652,297.7

* Figures in 2002 Dollars

APPENDIX A CONTINUED

TOTAL IMPACT OF HURRICANES BONNIE, DONNA, FLOYD, FRAN, HAZEL AND ISABEL IN HAMPTON ROADS

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006					
Thousands of Dollars*					
	Residential	Commercial	Industrial	Others	Total
Building	4,196,731.0	206,390.9	42,089.7	36,379.0	4,481,590.5
Content	1,209,127.9	88,253.1	30,361.9	14,843.4	1,342,586.3
Inventory	0.0	3,602.9	7,302.8	336.3	11,241.9
Total	5,405,858.9	298,246.9	79,754.3	51,558.6	5,835,418.7

* Figures in 2002 Dollars

APPENDIX B

DAMAGE DISTRIBUTION CAUSED BY HURRICANE BONNIE

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	9	99.29	0	0.67	0	0.04	0	0.00	0	0.00
Commercial	5,015	99.21	39	0.77	1	0.03	0	0.00	0	0.00
Education	24	99.23	0	0.77	0	0.00	0	0.00	0	0.00
Government	323	99.15	3	0.85	0	0.00	0	0.00	0	0.00
Industrial	540	99.18	4	0.81	0	0.01	0	0.00	0	0.00
Religion	309	99.36	2	0.63	0	0.02	0	0.00	0	0.00
Residential	485,569	99.36	3,091	0.63	180	0.04	6	0.00	0	0.00
Total	491,789	-	3,139	-	181	-	6	-	0	-

DAMAGE DISTRIBUTION CAUSED BY HURRICANE DONNA

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	9	99.46	0	0.50	0	0.03	0	0.00	0	0.00
Commercial	5,020	99.31	33	0.66	1	0.03	0	0.00	0	0.00
Education	24	99.40	0	0.60	0	0.00	0	0.00	0	0.00
Government	324	99.24	2	0.75	0	0.01	0	0.00	0	0.00
Industrial	541	99.37	3	0.62	0	0.01	0	0.00	0	0.00
Religion	309	99.47	2	0.51	0	0.01	0	0.00	0	0.00
Residential	485,597	99.34	3,049	0.62	194	0.04	5	0.00	1	0.00
Total	491,824	-	3,089	-	195	-	5	-	1	-

DAMAGE DISTRIBUTION CAUSED BY HURRICANE FLOYD

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	9	96.19	0	3.15	0	0.47	0	0.18	0	0.00
Commercial	4,882	96.58	153	3.03	18	0.36	2	0.03	0	0.00
Education	23	97.08	1	2.78	0	0.14	0	0.00	0	0.00
Government	315	96.67	10	3.12	1	0.21	0	0.00	0	0.00
Industrial	525	96.54	17	3.05	2	0.33	0	0.00	0	0.00
Religion	302	97.00	9	2.83	1	0.17	0	0.07	0	0.00
Residential	466,865	95.50	20,067	4.10	1,849	0.38	34	0.01	31	0.00
Total	472,921	-	20,257	-	1,871	-	36	0.01	31	-

APPENDIX B CONTINUED

DAMAGE DISTRIBUTION CAUSED BY HURRICANE FRAN

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	9	99.85	0	0.15	0	0.00	0	0.00	0	0.00
Commercial	5,045	99.81	10	0.19	0	0.00	2	0.00	0	0.00
Education	24	99.78	0	0.22	0	0.00	0	0.00	0	0.00
Government	325	99.78	1	0.22	0	0.00	0	0.00	0	0.00
Industrial	543	99.78	1	0.22	0	0.00	0	0.00	0	0.00
Religion	311	99.84	0	0.16	0	0.00	0	0.00	0	0.00
Residential	488,654	99.96	184	0.04	8	0.00	0	0.00	0	0.00
Total	494,911	-	196	-	8	-	2	-	0	-

DAMAGE DISTRIBUTION CAUSED BY HURRICANE HAZEL

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	8	91.60	1	0.67	0	0.04	0	0.00	0	0.00
Commercial	4,787	94.69	227	0.77	38	0.03	4	0.00	0	0.00
Education	23	96.23	1	0.77	0	0.00	0	0.00	0	0.00
Government	307	94.16	16	0.85	3	0.00	0	0.00	0	0.00
Industrial	514	94.55	24	0.81	4	0.01	1	0.00	0	0.00
Religion	294	94.57	15	0.63	2	0.02	0	0.00	0	0.00
Residential	452,481	92.56	31,966	0.63	4,134	0.04	135	0.00	131	0.00
Total	458,414	-	32,250	-	4,181	-	140	-	131	-

DAMAGE DISTRIBUTION CAUSED BY HURRICANE ISABEL

Projected Property Damage Assuming the Historic Storm Occurred in HR in 2006										
	None		Minor		Moderate		Severe		Destruction	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Agricultural	5	53.27	2	25.54	1	12.76	1	6.99	0	0.00
Commercial	3,113	61.59	1,105	21.86	660	13.06	175	3.47	2	0.00
Education	16	65.14	5	20.73	3	11.88	1	2.25	0	0.00
Government	193	59.06	71	21.70	49	14.91	14	4.33	0	0.00
Industrial	322	59.10	113	20.72	78	14.34	29	5.34	3	0.00
Religion	186	59.92	79	25.27	38	12.07	9	2.75	0	0.00
Residential	282,721	57.83	144,472	29.55	48,788	9.98	6,968	1.43	5,898	0.00
Total	286,556	-	145,847	-	49,617	-	7,197	-	5,903	-

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