Housing Damage and Population Displacement During Florida's 2004 Hurricane Season

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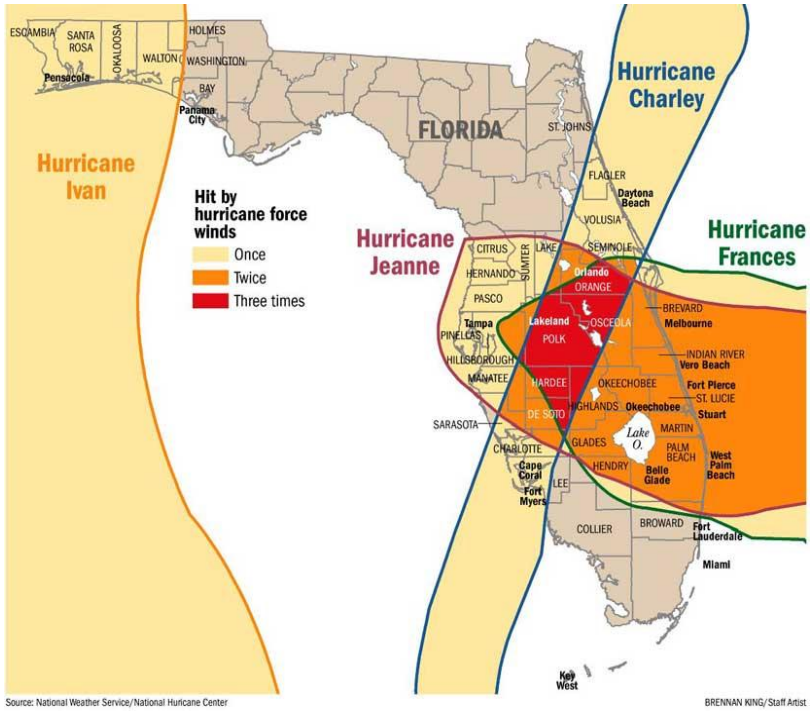
ABSTRACT

The 2004 hurricane season was the worst in Florida's history. Four hurricanes made landfall, causing at least 47 deaths and $45 billion in damages. In this study, we use survey data to estimate the housing damage and population displacement caused by these hurricanes. We estimate that some 2.6 million housing units sustained at least minor damage and almost 1.6 million people were forced to move out of their homes at least temporarily. In some regions, more than 80% of the housing units were damaged and more than 30% of the residents were forced out of their homes. Most moves were short-lived, however, as most displaced residents soon returned to their pre-hurricane homes. Based on this and other studies, we conclude that hurricanes and other natural disasters often have a substantial impact on population growth in the short run but generally have little or no impact on growth rates in the long run.

KEY WORDS: Natural disasters, hurricanes, population estimates, housing damage, population displacement, forced migration.

INTRODUCTION

By most measures, the 2004 hurricane season was the worst in Florida's history. Four hurricanes blasted through the state between August 13 and September 25, with Charley making landfall on the southwest coast, Frances on the southeast coast, Ivan in the panhandle, and Jeanne nearly retracing the path followed by Frances (see Figure 1). This was the first time in recorded history that four hurricanes had struck Florida in a single year. Most parts of the state were hit by at least one hurricane and some were hit by two or even three. Overall, the storms were responsible for at least 47 deaths (National Oceanic and Atmospheric Administration 2005) and caused approximately $45 billion in damages (NOAA Technical Memorandum NWS TPC4 2006).



Unfortunately, there are no readily available data sources providing information on the demographic impact of hurricanes and other natural disasters (Hore et al. 2009; Rossi et al. 1981; Smith 1996; Swanson et al. 2009). To remedy this problem, we conducted a series of sample surveys in Florida and the local areas most heavily affected by the hurricanes. In this study, we use these data to develop estimates of the housing damage and population displacement caused by the 2004 hurricanes.

We start by describing our data set and estimation methodology. Then, we present our estimates of housing damage and insurance coverage, discuss moves caused by the hurricanes, and describe a technique for estimating the number of residents who left the area and did not return. We compare our estimates with estimates of housing damage and population displacement caused by hurricanes Andrew in 1992 and Katrina in 2005. We close with an assessment of the effects of the 2004 hurricanes on population growth in Florida and a brief discussion of the potential impact of hurricanes and other natural disasters on long-term population growth in Florida and other coastal areas.

Although a great deal has been written about the socioeconomic and demographic effects of other hurricanes—particularly Andrew and Katrina— relatively little has been written about Florida's 2004 hurricane season. The present study helps fill this gap. It is unique in that it analyzes multiple hurricanes rather than a single event, covers an entire state as well as five individual sub-state regions, and considers both short-term and long-term effects. We believe it provides the most comprehensive analysis yet of the demographic effects of the 2004 hurricane season in Florida.

DATA

We collected data on housing damage and population displacement through a series of household surveys conducted at the state and local levels. At the state level, we used list-assisted random-digit dialing to contact approximately 500 households each month between February and May, 2005. These surveys covered the entire state, including some areas with heavy hurricane damage and others with little or no damage. Using a database maintained by the Marketing Systems Group/GENESYS of Ft. Washington, Pennsylvania, we identified working telephone banks with at least one residential number (a bank consists of the area code, prefix, and first digit of the suffix). The database excluded banks that had not been assigned or that had been assigned exclusively to commercial or government entities. It also excluded banks associated with cell phone numbers because cell phones typically represent individuals rather than households.

We do not believe excluding cell phone numbers affected the survey results because the vast majority of households had a landline phone at the time the surveys were conducted. Blumberg et al. (2005) reported that households with a cell phone but no landline phone accounted for less than

4% of all households in the United States in 2003. Cell phones are increasingly replacing landline phones, however, and future survey research must find ways to account for this trend. The U.S. Department of Health Services (2011) estimated that 26.6% of U.S. households had cell phones but no landline phones in the first six months of 2010.

Random digits were added to the partial numbers in the banks and the resulting numbers were called. The household member age 18 or older who most recently had a birthday was selected as the survey respondent. Only those who reported that they were permanent residents of Florida in August, 2004 were included in the sample. Each number was called up to ten times before it was dropped from the sample. This process led to 1,881 completed interviews. The response rate—calculated as the number of completed interviews as a percentage of eligible numbers called—was 24.5%. This calculation was based on the most conservative formula (RR1) sanctioned by the American Association of Public Opinion Research. Response rates can be calculated in a variety of ways, leading to widely varying estimates (Bourque et al. 1997; Dow and Cutter 1998; Zhang et al. 2004). Several studies have concluded that low response rates do not necessarily compromise the quality of survey data (Curtin et al. 2000; Keeter et al. 2000).

We also conducted surveys in the local areas sustaining the greatest hurricane damage. Using data from the Federal Emergency Management Agency (FEMA), we identified the 13 counties with the highest proportion of housing units sustaining major damage. In the ten counties with the greatest damage, samples were drawn for 16 cities and for the balance of each county. In the other three counties, samples were drawn for the county as a whole. For the 16 cities, we used a combination of listed numbers and random-digit dialing; for the three full counties and ten county balances, we relied solely on random-digit dialing. These surveys were conducted between March and June, 2005 and produced 11,559 completed interviews. Again, each number was called up to ten times before being dropped from the sample. The aggregate response rate for these surveys was 33.3% using the RR1 formula.

Although data for individual cities and counties are essential for some purposes, our focus in this study is primarily on larger geographic areas. We therefore combined the 29 local areas into five regions based on their proximity to the

paths followed by the hurricanes (see Table 1). In order to make the sample representative of each region's population, data for each city, balance of county, and county were weighted according to their share of the region's households in 2004. We excluded respondents who were not permanent residents in August, 2004 or who lived in two counties that did not fall into any of the five regions; this reduced the sample to 9,048 completed interviews. All the survey results reported here have a margin of error of less than 3% at the state level and less than 5% at the regional level.

Table 1. Regions and Sample Size

Region	Counties	N
Southeast	Indian River, Martin, St. Lucie	2,739
Central	Highlands, Osceola, Polk	1,711
Southwest	DeSoto, Hardee	2,105
Charlotte	Charlotte	568
Northwest	Escambia, Santa Rosa	1,925
Total		9,048

Table 2 summarizes demographic characteristics and damage estimates for the state and each region. The Southeast (SE) region has an older population than the state as a whole and has lower proportions of African-American and Hispanic residents. Its median income is slightly above the state average but its educational level is slightly lower. The Central region is similar to the state in terms of age, race, and ethnicity, but has lower income and educational levels. The Southwest (SW) region is slightly younger than the state as a whole and has a relatively small proportion of African-American residents, but has a high proportion of Hispanic residents and very low income and educational levels. Charlotte County has a large elderly population and low proportions of African-American and Hispanic residents. Its income and educational levels are a bit below the state average but it has a very low poverty rate. The Northwest (NW) region is slightly younger and has a lower proportion of Hispanic residents than the state as a whole, but is similar to the state on other characteristics.

Mobile homes account for a very large proportion of the housing stock in both the Central and SW regions.

Table 2. Demographic and Damage Characteristics of Regions

Characteristic	SE	Central	SW	Charlotte	NW
Median Age	48.1	39.6	35.2	54.3	36.4
% 65+	25.6	18.3	17.0	34.3	13.3
% Black	11.1	12.8	11.7	5.2	16.9
% Hispanic	9.2	18.3	31.9	3.8	2.9
Median Income (000s)	39.2	35.9	30.5	36.4	37.2
% Poverty	11.0	12.8	24.0	8.2	13.7
% College Graduates	20.5	14.9	8.4	17.6	21.6
% Mobile Homes	12.1	25.3	34.0	14.6	12.0
% Major Damage	35.5	25.0	50.2	49.0	40.6
% Minor Damage	42.0	41.3	38.2	32.6	38.9
% No Damage	22.5	33.7	11.6	18.4	20.5

Note: Data for age, race, Hispanic origin, and hurricane damage refer to 2004 and data for income, poverty, education, and mobile homes refer to 2000.

Sources: U.S. Census Bureau (2000 data) and Bureau of Economic and Business Research, University of Florida (2004 data).

The SE region was affected primarily by hurricanes Frances and Jeanne. The Central region was affected by Charley, Frances, and Jeanne, but was protected by its inland location. Charlotte County and the SW region were affected primarily by Charley, but Frances and Jeanne had an impact as well. The NW region was affected only by Ivan. Charley was a category 4 hurricane when it made landfall, Ivan and Jeanne were category 3, and Frances was category 2 (NOAA Technical Memorandum NWS TPC-4 2006). Of the five regions surveyed, Charlotte County and the SW region sustained the heaviest damages, with about half the housing units suffering major damage and only 12-18% escaping damage completely. The Central region had the lightest damages, with 41% of the units suffering minor damage and 34% sustaining no damage at all.

RESULTS

Housing Damage

Almost one in three Floridians reported at least some damage to their homes as a result of the hurricanes (Table 3). Few reported that their homes were completely destroyed, but 8% reported major damage (i.e., uninhabitable while repairs were made) and 23% reported minor damage (i.e., inhabitable while repairs were made). These proportions were based on households, or housing units occupied by permanent residents of Florida. Assuming that the distribution of damages for all housing units was proportional to that of units occupied by permanent residents, we estimated that more than 2.5 million of Florida's 8.1 million housing units were damaged by the storms, with 32,400 destroyed, 631,800 sustaining major damage, and 1,879,200 sustaining minor damage.

Table 3. Damage to Housing Units (Percent Distribution)

Region	N	Destroyed	Major Damage	Minor Damage	No Damage
SE	2,715	1.8	33.6	42.0	22.6
Central	1,698	1.1	23.9	41.4	33.7
SW	2,071	7.2	43.0	38.2	11.6
Charlotte	562	6.0	43.0	32.6	18.4
NW	1,911	2.0	38.7	38.9	20.5
Total	8,957	3.2	35.6	39.8	21.4
Florida	1,882	0.4	7.8	23.2	68.6

Damages were much greater in the five regions than for the state as a whole. More than 3% reported that their homes were completely destroyed, 36% reported major damage, and 40% reported minor damage. Only 21% reported no damage at all. In the SW and Charlotte regions, approximately half the housing units sustained major damage or were completely destroyed. These regions are located on the lower Gulf coast, directly in the path of Hurricane Charley. By this measure, Charley was responsible for more damage than any of the other hurricanes.

How did damages vary by the type of housing unit? At the state level, single family units had a higher proportion with damages than any other type of housing unit, including mobile homes (Table 4). We believe this result was caused by the geographic distribution of housing units within the state relative to the paths followed by the hurricanes, rather than by the characteristics of the housing units themselves.

Table 4. Damage by Housing Type (Percent Distribution)

In State:

Housing Type	N	Destroyed	Major Damage	Minor Damage	No Damage
Single family	1,344	0.3	8.6	25.4	65.7
Multi-family	267	0.3	4.6	14.6	80.5
Mobile home	147	1.9	7.7	21.1	69.3
Other	121	0.0	6.5	18.4	75.1
Total	1,879	0.4	7.8	23.2	68.6

In Five-Region Area:

Housing Type	N	Destroyed	Major Damage	Minor Damage	No Damage
Single family	6,574	1.4	36.3	41.7	20.6
Multi-family	522	1.0	21.0	35.0	43.0
Mobile home	1,273	12.8	40.4	31.7	15.2
Other	496	5.6	30.6	38.5	25.3
Total	8,865	3.2	35.7	39.7	21.4

This is borne out by comparing the results for the state with results for the five-region area. Whereas mobile homes accounted for 8% of housing units in the state sample, they accounted for 14% of housing units in the regional sample. In the five-region area, almost 13% of mobile home residents reported that their homes were destroyed by the hurricanes,

compared to 1% for residents of single family and multi-family units. More than 40% of mobile home residents reported major damage and only 15% reported no damage at all. Clearly, mobile homes in the five-region area were substantially more vulnerable to hurricane damage than other types of housing units.

It is noteworthy that a higher proportion of single family residents than multi-family residents in the five-region area reported complete destruction or major damage and that many multi-family residents reported no damage at all. There are several possible explanations for this finding. Large multi-unit structures may be built according to more exacting standards than single family units, leading to lower damage rates (U. S. Department of Homeland Security 2006). Also, some units in multi-family structures may have sustained damage while others did not, leading some residents to report no damage when other parts of the structure were in fact damaged. Further research is needed before we can draw clear conclusions on this point.

At the state level, 80% of the survey respondents suffering housing damage reported that they knew the dollar value of those damages. One-quarter reported damages of less than $500 and three-quarters reported damages of less than $10,000; only 10% reported damages of $25,000 or more. The median estimate was $3,200 (Table 5).

Table 5. Median Value of Housing Damage

Region	N	Median Value ($)
SE	1,717	12,000
Central	862	5,000
SW	1,392	16,000
Charlotte	454	30,000
NW	1,138	13,000
Total	5,563	12,000
Florida	473	3,200

Damages were much greater in the five-region area, with a median value of $12,000. Charlotte had by far the highest value of damages of any region, followed by the SW region. Both were affected primarily by Hurricane Charley, again reflecting the strength of that storm. The Central region had the lowest value of damages, reflecting the lower wind speeds of hurricanes passing through the interior parts of the state.

The 2004 hurricanes caused approximately $45 billion in total damages in Florida (NOAA Technical Memorandum NWS TPC-4 2006). According to the Florida Office of Insurance Regulation (2006), more than $23 billion in insurance payments were paid as compensation for those damages. This is consistent with the rule-of-thumb that insured losses are typically about half the value of total losses (Department of Commerce 2006).

In order to collect information on compensation for damages, we asked a series of questions regarding insurance coverage and insurance payments; these questions were included only in the surveys conducted at the state level during April and May. Of the respondents living in Florida when the hurricanes struck, almost 89% of those sustaining damage reported that their home was insured prior to the hurricanes. This is somewhat higher than the approximately 80% reported in several previous studies (Drabek 1986; Wright et al. 1983; Smith and McCarty 1996).

Of those with insurance coverage who sustained housing damage, just over 50% filed a claim; this represents 14% of all respondents. Applying this proportion to the total number of households in 2005 implies that 991,300 Florida

households filed a claim related to housing damages. Assuming that the distribution of claims for all housing units (including unoccupied units and those used seasonally or on an occasional basis) was the same as for units occupied by permanent residents, we estimated that approximately 1,142,100 claims related to housing damages were filed in Florida. This is very close to the 1,156,000 homeowner claims reported by the Florida Office of Insurance Regulation (2006).

Of those survey respondents filing claims for housing damage, 86% received a payment and another 3% were still waiting for their claim to be settled at the time of the survey. Those receiving payment reported an average payment of $15,575. Slightly fewer than 5% of survey respondents filed insurance claims for damage to personal property (including automobiles). Of those, 92% received a payment and 2% were still waiting for their claim to be settled at the time of the survey. The average payment for personal property damage was $7,608.

Applying these values to the estimated number of claims paid implies a total insurance pay-out of $17.8 billion for housing damage and $2.9 billion for personal property damage. This total of $20.7 billion is close to the $19.1 billion pay-out to non-commercial enterprises reported by the Florida Office of Insurance Regulation (2006). Although the two types of pay-outs are not identical, survey results again were consistent with information coming from an independent data source.

Population Displacement

The hurricanes wreaked havoc from one end of the state to the other. For the state as a whole, one in eleven survey respondents reported that they were forced to move out of their homes after at least one of the hurricanes (Table 6). Applied to Florida's 2004 mid-year population estimate of 17.6 million, this implies that 1,584,000 people were forced out of their homes. For the five-region area, one in four survey respondents were forced out of their homes; in Charlotte and the SW region, almost one-third moved out at least once.

Table 6. Percent of Respondents Forced to Move Out of their Homes

Region	N	Forced to Move	Not Forced to Move
SE	2,710	21.7	78.3
Central	1,709	18.6	81.4
SW	2,095	32.6	67.4
Charlotte	563	32.2	67.8
NW	1,912	24.8	75.2
Total	8,989	25.0	75.0
Florida	1,885	9.0	91.0

For the state, most people left their homes because of the loss of electricity, water, gas, or telephone service (Table 7). Including multiple moves, 74% left because of a loss of utilities, 14% because of structural damage to the housing unit, and 12% for some other reason. For the five-region area, 49% left because of a loss of utilities, 39% because of structural damage, and 13% for some other reason.

Table 7. Primary Reason for Moving out of Home (Percent Distribution)

Region	N	Structural Damage	Loss of Utilities	Other
SE	569	32.5	54.1	13.4
Central	316	21.7	68.0	10.3
SW	672	45.5	42.1	12.4
Charlotte	179	43.0	43.8	13.2
NW	472	45.5	40.5	14.0
Total	2,208	38.5	48.7	12.8
Florida	163	13.8	74.3	11.9

At the state level, 74% of those leaving their homes moved in with family or friends; 13% went to a hotel or motel; 4% stayed on the same property in a tent, RV, or some other type of temporary housing; 1% went to a public shelter; and 8% made other types of lodging arrangements (Table 8). For

the five-region area, the proportion staying with family and friends was substantially lower than for the state as a whole, most likely because the length of stay was considerably longer. A large proportion of displaced residents staying with family and friends is a common finding in the literature (Drabek 1986; Smith and McCarty 1996).

Table 8. Type of Lodging Immediately after Moving Out of Home (Percent Distribution)

Region	N	Family/ Friend	Hotel/ Motel	Same Property	Public Shelter	Other
SE	572	55.6	14.1	4.2	2.3	23.8
Central	316	59.8	20.7	5.0	1.9	12.6
SW	675	60.8	7.1	11.2	1.3	19.6
Charlotte	179	55.4	12.5	3.6	0.9	27.6
NW	472	56.2	7.6	12.2	1.5	22.5
Region	2,214	57.9	11.4	8.2	1.7	20.8
Florida	163	73.8	13.4	4.4	0.8	7.5

For the state, 88% of those forced to move had returned to their pre-hurricane homes by the spring of 2005 (Table 9). For the five-region area, only 82% had returned to their pre-hurricane homes. Not surprisingly, the highest proportions returning were found in the regions with the least damage.

Table 9. Percent of Respondents Who Returned to their Pre-hurricane Homes by Spring, 2005

Region	N	Returned	Have Not Returned
SE	588	85.6	14.4
Central	317	88.4	11.6
SW	681	76.6	23.4
Charlotte	181	76.2	23.8
NW	474	83.1	16.9
Total	2,241	82.0	18.0
Florida	169	88.2	11.8

For the state, 77% of movers who returned to their pre-hurricane homes were away for less than two weeks and only 3% were away for more than six months (Table 10). For the five-region area, time away from home was substantially

longer. For individual regions, the duration of stay away from home was strongly related to the level of damages: longest in regions with the most damage and shortest in regions with the least damage.

Table 10. Length of Absence for People Who Returned to their Pre-Hurricane Homes (Percent Distribution)

Region	N	<2 Weeks	2 - 4 Weeks	1 - 3 Months	3 - 6 Months	More than 6 Months
SE	715	65.8	14.0	5.0	8.8	6.3
Central	460	83.5	6.2	3.7	2.8	3.8
SW	638	44.9	19.8	15.1	9.6	10.7
Charlotte	137	29.2	26.2	12.6	21.4	10.6
NW	385	49.5	18.1	8.0	11.5	12.9
Total	2,334	58.8	15.4	8.5	9.0	8.4
Florida	160	77.2	8.8	5.9	4.8	3.2

It should be noted that the results described above refer solely to moves occurring *after* the hurricanes struck. They do not include evacuations occurring *prior* to the arrival of the hurricanes. It has been estimated that almost 4.5 million Floridians evacuated at least once during the 2004 hurricane season and that approximately 2 million evacuated more than once (Smith and McCarty 2009). There is a substantial literature describing and analyzing the factors affecting pre-hurricane evacuation behavior (Dow and Cutter 1998; Drabek 1986; Smith and McCarty 2009; Zhang et al. 2004).

A potential problem with our estimates of population displacement is that the sample included only people who were living in Florida in the spring of 2005, some six to nine months after the hurricanes passed through the state. It did not include people who were living in the state when the hurricanes struck but left before the surveys were conducted. If persons forced out of their homes were more likely to leave the state than others, the results reported above may under-estimate the number of people displaced by the hurricanes.

We dealt with this problem by using network (or multiplicity) sampling. Under this technique, information for persons outside the sample is collected from survey

respondents who have some personal connection with them (Kalton and Anderson 1986; Sirken 1970; Sudman et al. 1988). Network sampling has been used to estimate emigration from the United States (Woodrow-Lafield 1996), the incidence of HIV, rape, and homelessness (Killworth et al. 1998), population movements caused by Hurricane Andrew (Smith and McCarty 1996), and a number of other rare or difficult-to-estimate events.

We identified a network of neighbors, defined as persons living to the immediate right and immediate left of the survey respondents at the time of the hurricanes. At the state level, 95% of the respondents reported that they knew whether or not their neighbors moved out of their homes as a result of the hurricanes. Of those whose neighbors moved, 98% reported that they knew whether or not they had returned to their pre-hurricane homes.

We used this information to develop an alternative estimate of hurricane-related moves. Survey respondents reported that 6.4% of their neighbors moved out of their homes because of the hurricanes. This is lower than the 9.0% reported for the survey respondents themselves (see Table 6) and implies only 1,126,400 movers, compared to the 1,584,000 reported above. We believe the estimate based on data for neighbors is lower because many moves were for a short period of time and survey respondents were often unaware that their neighbors had been away. Consequently, the estimate based on data from the respondents themselves is likely to be more accurate than the estimate based on data from neighbors.

Survey respondents reported that 17.5% of their neighbors had not returned to their pre-hurricane homes by the time the surveys were conducted. This proportion is higher than the 11.8% reported for the respondents themselves (see Table 9). This is consistent with the assumption that many moves for neighbors went unnoticed by survey respondents: If neither the move nor the return was noticed, the number of movers was under-estimated and the proportion failing to return was over-estimated.

Although survey respondents may not have noticed all the short-term moves made by their neighbors, they most likely had accurate information on the return status of the neighbors they believed had moved. By multiplying the number of movers by the proportion not returning, we developed two alternative estimates of the number of movers who had not

returned, one based on data for neighbors and one based on data for the respondents themselves:

1) Neighbors: 1,126,400 x .175 = 197,120
2) Respondents: 1,584,000 x .118 = 186,912

These two estimates are quite similar, strengthening their credibility. Taking an average suggests that 192,000 Florida residents moved out of their homes and had not returned 6-9 months later. We can use this information to develop estimates of the destinations of displaced residents.

Of the survey respondents whose neighbors moved and had not returned, 82% reported that they knew where those neighbors went. According to these respondents, 69.8% of their neighbors went to another location within the same county, 13.3% went to another county in Florida, and 16.9% left the state. Applying these proportions to our estimate of movers, we estimate that 134,000 displaced residents were living in the same county as before the hurricanes struck, 25,500 were living in a different county in Florida, and 32,500 had left the state.

In summary, almost 1.6 million Floridians were forced out of their homes at least temporarily by the 2004 hurricanes. Most of these moves were of short duration and covered only a short distance. Although they packed a ferocious punch, the hurricanes had relatively little impact on the number of people residing in Florida 6-9 months later. The same was true for most counties. In a few cities and counties, however, the impact of the hurricanes lingered for several years; we return to this point later in the article.

COMPARISONS WITH OTHER HURRICANES

Hurricane Andrew

Hurricane Andrew ripped through the southern tip of Florida on August 24, 1992, with winds reaching 175 miles per hour. Before exiting the state, it claimed at least 25 lives and caused some $44 billion in property damage in 2005 dollars (NOAA Technical Memorandum NWS TPC-4 2006). The vast majority of the damage occurred in Miami-Dade County.

As a category 5 storm, Andrew was stronger than any of the 2004 hurricanes striking Florida. Its effects were similar to those of the 2004 hurricanes in some ways, different in others. Andrew destroyed 23,200 housing units, caused major damage to 120,900 units and minor damage to 285,000 units, and forced more than 353,000 people to leave their homes at least temporarily (Smith and McCarty 1996). In comparison, the 2004 hurricanes destroyed 32,400 housing units, caused

major damage to 631,800 units and minor damage to almost 1.9 million units, and forced almost 1.6 million people out of their homes. Clearly, the extent of housing damage and population displacement was much greater for the 2004 hurricanes than for Andrew.

There were other differences as well. Slightly fewer than 3% of the housing units in Miami-Dade County were destroyed by Andrew, 15% sustained major damage, and 36% sustained minor damage (Smith and McCarty 1996). For the five-region area analyzed in the present study, slightly more than 3% of the housing units were destroyed, 36% sustained major damage, and 40% sustained minor damage. Approximately 17% of the residents of Miami-Dade County were forced out of their homes by Andrew, compared to 25% of the residents of the five-region area. The types of lodging chosen by those forced from their homes by Andrew, however, were similar to the types chosen in 2004. For Andrew, 55% stayed with family or friends, 13% went to a hotel or motel, 8% stayed in temporary quarters on the same property, and 1% went to a public shelter. For the 2004 hurricanes, those proportions were 58%, 11%, 8%, and 2%, respectively, for the five-region area.

By most measures, then, Florida's 2004 hurricane season was more destructive than Hurricane Andrew. Taken as a whole, the 2004 hurricanes caused more deaths, damaged more housing units, and forced more people from their homes. The geographic area affected by the 2004 storms was vastly greater as well. Only in terms of the dollar value of damages does it appear that Andrew was about the equal of the 2004 hurricanes. Although Andrew remains the single most costly hurricane ever to strike Florida, its overall impact was substantially smaller than the impact of the 2004 hurricane season.

It should be noted that previous Florida hurricanes took far more lives than either Andrew or the 2004 hurricanes. The 1928 hurricane striking South Florida took some 2,500 lives and several other storms killed hundreds of people each (NOAA Technical Memorandum NWS TPC-4 2006). Although recent hurricanes caused more economic damage in Florida, they were not nearly as costly as earlier hurricanes in terms of human life.

Hurricane Katrina

Hurricane Katrina struck the Gulf Coast near the mouth of the Mississippi River on August 29, 2005, ravaging the coastal areas of Louisiana, Mississippi, and Alabama. It was the most costly hurricane ever to strike the United States (Department of Commerce 2006). There were a number of similarities between Katrina and the 2004 Florida hurricanes, but the differences were more dramatic.

By most measures, Katrina was much more destructive. The storm was responsible for the loss of at least 1,800 lives and caused damages in excess of $81 billion (Forgette et al. 2008), whereas the 2004 Florida hurricanes took 47 lives and caused $45 billion in damages. Katrina destroyed 109,000 housing units in New Orleans alone (Vigdor 2008), whereas the 2004 Florida hurricanes destroyed only 32,400 units statewide.

People forced out of their homes by Katrina moved further away and stayed away longer than those forced out of their homes by the 2004 Florida hurricanes. Most Floridians moved to nearby places and were away from home for only a few days or weeks. Many displaced by Katrina moved hundreds or thousands of miles and stayed away for many months; indeed, many have not yet returned and probably never will. Swanson and colleagues estimated that in July 2007—almost two years after the hurricane struck—the 79 hardest hit zip code areas in Louisiana and Mississippi had 311,000 fewer residents than they would have had if Katrina had not struck (Swanson et al. 2009). In contrast, of the five Florida counties losing population between 2004 and 2005 because of the hurricanes, three had made up for their losses by 2006 and the other two by 2008 (Bureau of Economic and Business Research 2010a).

Katrina also had a much greater economic impact than the 2004 Florida hurricanes. The Congress of the United States estimated that Hurricanes Katrina and Rita caused some 570,000 workers to lose their jobs at least temporarily, with most of the losses caused by Katrina (Congress of the United States 2006). Groen and Polivka (2008) estimated that payroll employment declined by 35 percent in the New Orleans metropolitan area in the two months following Katrina, and 12 percent for the entire state of Louisiana. In contrast, the 2004 hurricanes destroyed relatively few jobs in Florida and the state's total employment continued growing rapidly (Bureau of Economic and Business Research 2010b). Furthermore, the Florida hurricanes had little impact on the national economy,

whereas Katrina and Rita had a substantial impact, reducing the national economic growth rate by roughly half a percentage point during the second half of 2005 (Congress of the United States 2006).

In New Orleans, most of the damage was caused by flooding rather than by wind or storm surge (Fussell et al. 2010). Flooding is not covered by private insurance policies and most people do not purchase federal flood insurance; consequently, many of Katrina's victims suffered significant financial losses. Except for some areas affected by Hurricane Ivan, Florida did not experience major flooding in 2004 and 89% of those with damages were insured. Although many Floridians suffered financial losses, in most instances their losses were not as great as those suffered by Katrina's victims.

By most measures, Katrina had a greater impact than the 2004 Florida hurricanes. By at least two measures, however, the Florida hurricanes had a greater impact. Swanson (n.d.) estimated that Katrina may have displaced as many as 1.4 million people at least temporarily; we estimated that the 2004 hurricanes forced 1.6 million Floridians to leave their homes at least temporarily. Swanson (n.d.) estimated that 622,000 housing units were made at least temporarily uninhabitable by Katrina; we estimated 664,000 such units in Florida. Although Katrina caused more deaths, destroyed more housing units, created more long-term population displacement, and produced more economic upheaval, the 2004 Florida hurricanes damaged more housing units and displaced more people, at least temporarily.

IMPACT ON POPULATION GROWTH

What impact did the 2004 hurricanes have on population growth in Florida? An examination of growth trends in the years immediately preceding and following the hurricanes provides some answers to this question.

At the state level, the hurricanes had no perceptible impact on population growth. Although 2005 was also an active hurricane season, the state's population grew by near-record levels between 2004 and 2006 (Bureau of Economic and Business Research 2010a). If anything, the hurricanes may have had a positive impact on economic and population growth through the infusion of private insurance dollars and government disaster aid. Employment grew rapidly in between 2004 and 2006, especially in the construction industry (Bureau of Economic and Business Research 2010b). Although population growth has slowed dramatically since 2007, this

slowdown was caused by a severe recession and weak economic recovery, not by the 2004 hurricanes.

Hurricane effects were considerably more noticeable at the local level. Five of the counties in our sample lost population between 2004 and 2005. All had been growing prior to 2004 and four of the five gained population between 2005 and 2006. Three of the counties surpassed their 2004 population sizes by 2006 and the other two by 2008. In all five counties, annual population increases were about the same in the three years following the hurricanes as in the three years preceding them.

Results for the seven incorporated cities in these counties were similar to the results for the counties themselves (Bureau of Economic and Business Research 2010a). All had grown between 2001 and 2004 but lost population between 2004 and 2005. All seven gained population between 2005 and 2006. Three surpassed their 2004 population sizes by 2006 and one by 2007. In most instances, annual population increases were about the same in the three years following the hurricanes as in the three years before.

A similar pattern occurred following Hurricane Andrew in 1992. After an initial decline, the population of Miami-Dade County rebounded quickly and annual increases returned to levels similar to those occurring prior to the hurricane. Florida City and Homestead were the cities most severely damaged by Andrew, with each losing approximately one-third of its population as a result of the storm (Smith 1996). Both cities returned to their pre-hurricane population levels by the end of the decade and have continued to grow since that time (Bureau of Economic and Business Research 2001, 2010a).

What about Hurricane Katrina? Four months after the hurricane struck, the populations of the hardest hit counties were substantially lower than they had been prior to the hurricane. Hodges (2006) estimated a population decline of 382,000; Frey and Singer (2006) estimated a decline of 452,000. Even two years later, the 79 hardest hit zip code areas in Louisiana and Mississippi had 311,000 fewer residents than they most likely would have had if Katrina had not struck (Swanson et al. 2009). Clearly, many of the population losses caused by Katrina lasted much longer than those caused by Hurricane Andrew and the 2004 Florida hurricanes.

What accounts for these differences? In particular, why did many of the areas affected by Katrina recover more slowly and less completely than those affected by the 2004 Florida

hurricanes? Although several factors played a role, we believe three were particularly important: the severity of the damages, the demographic characteristics of the area, and previous population trends.

Common sense suggests that recovery from hurricanes and other natural disasters will be slower in areas experiencing more severe damage than in areas experiencing less severe damage. This expectation is supported by empirical evidence (Fussell et al. 2010; Myers et al. 2008). The tremendous damage and destruction caused by Katrina undoubtedly contributed to the slow recovery of many areas in Louisiana and Mississippi, affecting not only the availability of livable housing but also the provision of essential commercial and municipal services (Green et al. 2007). The lack of insurance coverage and disputes over insurance payments slowed recovery efforts as well (Cossman 2007), as did controversy regarding the costs and benefits of rebuilding in environmentally vulnerable areas (Glaeser 2005; Hahn 2005).

Several studies have found low-income people to be less likely than their more affluent counterparts to return home after being displaced by a hurricane (Bin et al. 2007; Myers et al. 2008; Stringfield 2010). Although there is not unanimity on this point (Elliott and Pais 2006), it is likely that the low income levels and high poverty rates of many of those displaced by Hurricane Katrina contributed to the slow pace of population recovery, especially in New Orleans.

Previous growth trends are also important. New Orleans' population has declined in every decade since 1960. Vigdor (2008) argued that the city's original economic rationale as a river port was greatly diminished as trains, trucks, and pipelines replaced river barges as a means of cargo transportation. With the loss of inexpensive housing caused by Katrina, another economic asset was diminished. Many residents displaced by the hurricane have returned, but many have not and the city's population remains well below what it was before the hurricane struck (U.S. Department of Commerce 2011). Although some areas affected by Katrina surpassed their pre-hurricane population levels within a year or two after the hurricane, the populations of the city of New Orleans and other slowly growing or declining areas are not likely to reach those levels for many years, if ever.

CONCLUSIONS

What conclusions can we draw regarding the effects of hurricanes and other natural disasters on population growth?

Although hurricanes often have a substantial negative impact on short-term population growth, our analyses of Hurricane Andrew and the 2004 Florida hurricanes suggest that they did not reduce long-term growth rates in places that had been growing prior to the occurrence of the hurricanes. A number of other studies have drawn similar conclusions (Friesema et al. 1979; Rossi et al. 1981; Vigdor 2008). In fact, some researchers have concluded that natural disasters may have a positive impact on economic and population growth by generating private insurance payments and government disaster aid (Pais and Elliott 2008) and by promoting more rapid technological change (Skidmore and Toya 2002). Given the available evidence, we believe that—after an initial period of population decline—growing areas will generally make up for their population losses within a few years after a disaster strikes and then return to their previous growth trajectories.

The pattern for places that were losing population prior to the disaster is likely to be similar, but the trajectory will be in the opposite direction. After an initial period of decline and partial recovery, population losses are likely to continue and may even accelerate. Places that were largely stagnant in terms of population growth may suffer losses as well. If new engines of economic growth do not replace those destroyed by the disaster, there will be nothing to induce population growth or prevent further losses.

People with low incomes often live in neighborhoods or types of housing that are particularly vulnerable to natural disasters and have limited access to the resources needed to recover and rebuild after a disaster strikes. In addition, housing costs may increase following a disaster, pricing some people out of the market, and employment opportunities may change due to shifts in an area's occupational structure. Consequently, the socioeconomic and demographic characteristics of those leaving an area may differ substantially from the characteristics of those who remain and of new residents moving in. Even when they do not affect long-term population growth rates, hurricanes and other natural disasters may create substantial changes in the socioeconomic and demographic composition of an area's population (Frey and Singer 2006; Pais and Elliott 2008; Vigdor 2008).

One caveat regarding the impact of hurricanes and other natural disasters on population growth should be mentioned. Yezer and Rubin (1987) hypothesized that the effects of natural disasters depend on prior expectations: If disasters occur at

their expected frequency, they will have no impact on economic activity (including migration), but if they occur more frequently than expected they may induce the out-migration of both labor and capital. If Florida or other rapidly growing coastal areas were to experience several highly destructive hurricane seasons in a row, the number of in-migrants might decline or the number out-migrants increase. Given that rising sea surface temperatures appear to be raising the intensity and perhaps the frequency of hurricanes (Hoyos et al. 2006; Saunders and Lea 2008; Trenberth 2005), this is a possibility that cannot be overlooked.

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