

# Conference Record

Of People, Place,  
and Progress:  
Extended Recovery  
on the Coastal Plain



Summary presentations, abstracts, and recommendations from a conference presented by East Carolina University and the North Carolina Area Health Education Centers Program, May 23 – 25, 2001, at East Carolina University, Greenville, North Carolina.





# Conference Record

## Of People, Place, and Progress: Extended Recovery on the Coastal Plain

Compiled and Edited by

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Resources Management

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## Sponsors

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## Preface

In May 2000 East Carolina University was the host for a major conference to assess the impact of the hurricanes and floods that ravaged eastern North Carolina in September 1999. That conference, "In the Aftermath of Hurricane Floyd: Recovery in the Coastal Plain," challenged scientists, citizens, and public officials to document this disaster, assess its causes and effects, and recommend actions that would mitigate the worst effects of future extreme events in this region. These findings and recommendations have been reported in a book, *Facing our Future – Hurricane Floyd and Recovery in the Coastal Plain* (2001).

Recovery is a long term process. Learning does not stop, and Floyd is not the last hurricane likely to afflict the region. East Carolina University is committed to understanding extreme natural events in order to mitigate their most destructive effects on individuals and communities in North Carolina, particularly those in the east. An important part of that understanding is to follow the process of recovery over months and years, and to determine how best to meet future natural hazards. To grapple with the issues provoked by the September 1999 hurricanes and floods public officials, citizens, and scientists convened a second conference in May 2001. That program, "Of People, Place, and Progress: Extended Recovery on the Coastal Plain", sought to put extreme natural events in the broader context of climate change, assess the impact of the floods on communities, individuals, and the economy, and to offer recommendations to mitigate future events. I am pleased to provide this summary of the research conducted by faculty from throughout the University of North Carolina system and the thoughtful recommendations of the participants. My hope is that through this increase in knowledge and continued discussion between citizens, researchers, and public officials, we will reduce future risks to life and property, and develop policies that will buffer our neighbors from the worst effects of future extreme events.

Thomas Feldbush  
Vice-Chancellor for Research and Graduate Studies  
East Carolina University  
June 15, 2002

## Introduction

In May 2000, some eight months after the hurricanes and floods that devastated large areas of eastern North Carolina in September 1999, scientists, citizens, and public officials gathered at East Carolina University to document those events and their impact on the region. Their findings and recommendations have been reported in the book, *Facing Our Future – Hurricane Floyd and Recovery in the Coastal Plain* (2000).<sup>\*</sup> It was clear even then that the process of recovery would be lengthy and that the lessons about response, recovery, and mitigation must be learned over years, not just months.

To grapple with issues of long-term recovery, East Carolina University helped plan and host a second conference, "Of People, Place, and Progress: Extended Recovery on the Coastal Plain, on May 23 – 25, 2001. Conference organizers identified four topics as critical for understanding the impact of extreme natural events on eastern North Carolina and mitigating their worst effects. First, planners and decision-makers need to understand the broad climatic and environmental changes that are likely to result in future hurricanes, severe storms, and floods. Hurricane Floyd was not an isolated event. The critical first step to reducing risks to life and property is to acknowledge that severe events have a high probability of recurring. Second, recovery is likely to be a prolonged process, but one that must be understood to guide future responses. Social, economic, and psychological effects tend to last long after the most visible signs of disaster have been removed. Third, the Floyd experience was a powerful reminder about the need to address matters of public and mental health, particularly for those with special needs such as the elderly, the very young, the disabled, and recovery workers. Finally, sound decision-making and public policy must be premised on the ability to learn from experience and to plan a future that minimizes loss from hurricanes, storms, floods, and tornadoes. The Floyd experience is rich in lessons about the ability of public and non-profit organizations to respond to crises, their ability to grapple with issues of long-term recovery, and their ability to mitigate the worst consequences of these events in the future.

This *Conference Record* presents the participants' key findings and recommendations in the context of demographic change in North Carolina, global trends in climate change, and the physical and mental health aspects of disasters. Our intent is to provide a concise, convenient summary of these findings and recommendations through abstracts and summaries of the research reported at the conference.

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<sup>\*</sup> John R. Maiolo, John C. Whitehead, Monica McGee, Lauriston R. King, Jeffrey C. Johnson, Harold Stone (Eds.) *Facing Our Future – Hurricane Floyd and Recovery in the Coastal Plain* (Carolina Coastal Press, 2001)

# Executive Summary

## The Setting for Recovery

### Changing Demographics

According to 2000 census data, North Carolina had the ninth largest population increase in the United States, making it the eleventh most populated state in the Union, and more urban than rural in character. Population in the 40 easternmost counties grew by 15 percent, to 2.22 million, but one-third of all municipalities in the East lost population, including several that were hit especially hard by Hurricane Floyd's severe floods. These counties are home to the largest African-American population in the state, as well as a rapidly growing Hispanic population. It is also the poorest region in North Carolina. These changes suggest that North Carolina is an urban state, that political power will shift to urban areas, and that the East will have less political power to contend with small town survival, poverty, racial diversity, and disaster mitigation.

Albert A. Delia, Regional Development Institute, *East Carolina University*

### Global Change, Local Impacts

Earth has its own natural variability, as illustrated by intermittent ice ages, long-term climate changes, and the role of the oceans in global heat exchange. These long and short-term changes can also be translated to changes on a regional and local scale, as indicated by the cycles of high and low hurricane activity in the mid-Atlantic region. Increasingly, scientists see the Earth as an interactive, interconnected system, with humans as an integral part of that system. For example, population growth and increased fossil fuel consumption since the early 1800's have contributed to climate and environmental change on a global scale. These changes may occur abruptly even in the historically brief span of a single generation. Scientific assessments of the possible effects of climate warming on the United States are under way. These address differing regional impacts; vulnerable ecosystems; changes in water availability; secure food supplies; near-term increases in forest growth; increased threat of damage to coastal margins and permafrost regions; and the relationship between environmental change, disease vectors, and public health.

Robert Corell, Ph.D., *Harvard University and American Meteorological Society*

### The Public Health Consequences of Disasters

The World Health Organization defines a disaster as a sudden ecologic phenomenon of sufficient magnitude to require external assistance. At the community level this can be defined operationally as any community emergency that seriously affects people's lives and property and that exceeds the capacity of the community to effectively respond to that emergency. The objective of disaster management from a public health perspective is to assess the needs of disaster-affected populations, match available resources to those needs, prevent further adverse health effects, implement disease control strategies for well-defined problems, evaluate the effectiveness of disaster relief programs, and improve contingency plans for various types of future disasters. Proper planning and execution of disaster medical aid programs requires knowledge of the types of disasters that might occur, the morbidity and mortality that might result, and the consequent medical care needs. Therefore, emergency responders should be expert on how to handle the type of disaster most prevalent in their own community, since

each type of disaster is characterized by different morbidity and mortality patterns and has different health care requirements. For example, hospitals in North Carolina should plan for hurricanes, while those in California should plan for earthquakes.

Floods are the most common natural disasters. They affect more people worldwide and cause greater mortality than any other type of natural disaster. They occur in almost every country, but 70 percent of all flood deaths occur in India and Bangladesh. In the United States, floods cause more deaths than any other natural disaster, with most fatalities resulting from flash floods. From a public health viewpoint, floods may disrupt water purification and sewage disposal systems, cause toxic waste sites to overflow, or dislodge chemicals stored above ground. In addition, makeshift evacuation centers with insufficient sanitary facilities may become substantially overcrowded.

Sound epidemiologic knowledge of the causes of death and the types of injuries and illnesses caused by disasters is clearly essential when determining what relief supplies, equipment, and personnel are needed to respond effectively in emergency situations. The overall objective of disaster management is to assess the needs of disaster-affected populations, to match resources to needs efficiently, to prevent further adverse health effects, to evaluate relief program effectiveness, and to plan for future disasters.

Eric K. Noji, MD, MPH, *National Center for Infectious Diseases,  
Centers for Disease Control, Atlanta, Georgia*

## Disasters and Mental Health

Disasters produce both individual and collective trauma, so behavioral health concerns are present in nearly all aspects of preparedness, response, and recovery. Several characteristics of traumatic events have a powerful influence on how individuals and communities respond. These include surprise, threats to physical well-being, intentional harm, injury, or death, exposure to the grotesque, the sudden violent death of a loved one, and the scope and uncertain duration of the event. Impacts on communities hinge on the extent of community disruption, the stability of families and the community prior to the disaster, and the role of community leadership. Emerging challenges to the field of disasters and mental health involve global epidemics, traditional terrorism, cyber-terrorism, and the use of biological, nuclear, and chemical agents for terrorist attacks. Compared to natural disasters, the psychological effects of terrorist events are more serious, complex, and long-term.

Among the challenges confronting improved understanding of the mental health effects of disasters are the scarcity of good research on risk and protective factors, the scarcity of good intervention research, training, and the lack of consistency of reporting service experience.

Continuing areas of controversy involve the roles of professionals and non-professionals, treatment versus crisis counseling, rivalries between disciplines, professions, and organizations, and duration of efforts to mitigate the mental health aspects of disasters.

Professionals in the field have learned that assigning blame for the event is a predictable response; that there is an expectation of immediate gratification and relief; that those at the social and economic margins are disproportionately affected by disasters; and that there continues to be widespread ignorance about mental health. However, the human spirit, reinforced by religious belief, symbolism, and ritual, is resilient.

RADM Brian W. Flynn, Assistant Surgeon General, U.S. Public Health Service

# Findings and Recommendations

## Forces Of Nature

### Findings:

- Although hurricanes and other severe climatic events do not occur predictably, they do occur often enough to warrant continuous activity, either recovering from the last event or preparing for the next one. Adapting to natural and demographic changes such as global warming, sea level rise, and the movement of human populations to the coasts will require new social and governmental institutions. Non-climatic natural hazards must also be included in a continuous process of response, recovery, and mitigation.
- The environment is more resilient than many had thought, but scientists do not fully understand the interaction of the many important biophysical variables involved in extreme climatic events. Citizens, scientists, and decision makers must realize the extent of human alterations of these land and seascapes; work to restore natural functions to the maximum extent possible; and design human institutions to preserve those functions.

### Recommendations:

- Reduce subsidies at all levels for the development of infrastructure such as highways, power plants, and water treatment facilities in hazardous areas; increase incentives for the removal or relocation of these facilities out of danger zones. The mechanisms for accomplishing this must be pursued at all levels of government through specific policies and strengthened regulations.
- Promote development of better baseline data and continuous monitoring programs for both natural and social scientific variables, such as riverine, estuarine, and sound water quality and micro-, meso-, and macro- faunal communities; demographic change, land-use, small business activities, housing activities, standards of living, and public opinion.
- Develop an ethic of community and environmental sustainability that is supported by a clear science of sustainability. This approach to research integrates global and local perspectives to shape an understanding of the interactions between environment and society as they influence what is happening in the places where people live, work, and govern. That new science must be effectively communicated to local private and public decision makers. Universities and other educational levels can provide valuable service in effective application of the science of sustainability.

## Better Decisions, Stronger Communities

### Findings:

- Hurricane Floyd and the floods demonstrated that there is much more effective capacity to respond to natural disaster than there is capacity to recover from one. The very slow pace of recovery has proved inefficient and costly for governmental and nongovernmental organizations.
- The tools exist, with proper financial and human capital, to turn vulnerability into the capacity to respond and recover. Cultural differences, for example, often yield cultural strengths. Human communities must reach out to each other with mutual respect and support. If impact is local, so must be capacity.
- Democratic institutions, particularly at the state and local level, will only provide the necessary framework if supplied with good information and the opportunity for full participation. Ironically, local communities are usually the most affected by and least experienced in dealing with the impacts of natural disasters.
- Many of the details of human perception and behavior and the processes governing the natural environment in situations of stress and crisis are still not well known or well documented. Social and natural scientific research can provide more knowledge. This knowledge must be transmitted through multiple communications media including state-of-the-art technology to a variety of audiences, from school children to adults.

### Recommendations:

- Provide for better documentation and evaluation of response and recovery efforts for use in adaptive management. Although adequate documentation must be produced primarily at the local level, the record and assessment of response and recovery is probably best located in a central archive jointly administered by the University of North Carolina system and those state agencies responsible for disaster response, recovery, and mitigation.
- Increase support and capacity for local community involvement in all aspects of planning for response, recovery, and mitigation. Such support probably will flow from the federal level.
- Develop local political leadership with necessary information and sensitivity to the full range of disaster mitigation, recovery and response. Policymaking must evolve from a reactive, defensive posture to one that is proactive in addressing all aspects of a healthy human and biophysical ecology.
- Include public, private, and non-governmental organizations in the planning process. Recent experiences demonstrate that such organizations and agencies at all levels must be included in the process and that the appropriate levels of this coordinating activity should occur at state and local levels.

- The economic rationality of adopting more rigorous building codes (and enforcement) must be illustrated to producers and consumers of the built environment. Although programmed and funded from higher levels, the local community is the appropriate level for the execution of these demonstrations.
- Dedicated funding and training must be provided for integrated response, recovery, mitigation and planning at the federal, state and local levels to guide resilient and sustainable development.
- Policies for preparedness and response must recognize and provide for the different circumstances and needs of the diverse cultures and populations of the coastal plain. Response capacity must also incorporate special circumstances such as handicapped or medical conditions, age, or language.
- Develop a state-level structure to organize and coordinate recovery efforts that are as effective as immediate response efforts. The effort to design that structure must involve participation from governmental agencies at all levels as well as non-governmental organizations.
- Because direct Small Business Administration (SBA) involvement confuses many in need and the language of loan applications is inappropriately difficult, these loan applications should be renamed and the language should be simplified.
- Programs of recovery must deal more effectively with low-income households that do not own property.
- Expanded involvement of the college and university community with primary, secondary, and continuing adult education, and with the provision of information and expertise to policy makers must be encouraged and supported. Environmental education and aspects of coping with environmental risk should be included in traditional curricula as well as in continuing education for adults. Examples include hazard conferences and speakers' programs for schools, civic groups, and political leaders.
- Communities should take advantage of digital technology to link human and information networks especially in response and recovery programs. Development of databases might include cell phone registry, mental and public health resources, resident special needs data base, and interpreters.
- There should be improved after-action documentation of the response and recovery efforts of individual agencies. The state recovery organization should be charged with coordinating and maintaining these records. Collation, summation, and analysis would provide valuable guidance in future responses and recoveries.

## Part 1. Forces of Nature

*The September 1999 hurricanes must be viewed in the context of broader patterns of global climate change, changes that have both regional and local impacts, particularly along the nation's coasts. Floyd, Dennis, and Irene were not isolated events. To understand eastern North Carolina's vulnerability to future storms, researchers describe how regional geology, land use, and drainage patterns resulted in massive flooding. They also assess the hydrologic character of the floods, their role in sedimentation, and impact on river and estuarine water quality. Geographers and climatologists have also begun projects to predict and model rainfall and floods in the region.*

### Global Change, Local Impacts

Earth has its own natural variability, as illustrated by intermittent ice ages, long-term climate changes, and the role of the oceans in global heat exchange. These long and short-term changes can also be translated to changes on a regional and local scale, as indicated by the cycles of high and low hurricane activity in the mid-Atlantic region. Increasingly, scientists see the Earth as an interactive, interconnected system, with humans as an integral part of that system. For example, population growth and increased fossil fuel consumption since the early 1800's have contributed to climate and environmental change on a global scale. These changes may occur abruptly even in the historically brief span of a single generation. Scientific assessments of the possible effects of climate warming on the United States are under way. These address differing regional impacts; vulnerable ecosystems; changes in water availability; secure food supplies; near-term increases in forest growth; increased threat of damage to coastal margins and permafrost regions; and the relationship between environmental change, disease vectors, and public health.

Robert Corell, Ph.D., *Harvard University and American Meteorological Society*

### U.S. Coastal Climate Change Impacts in the Context of Cumulative Stress

The U.S. coastline and territorial sea provide a wide range of essential goods and services through fisheries, storehouses of biological diversity, oil, gas, and mineral deposits, and commercial and recreational opportunities. In addition to these direct, measurable economic benefits, coastal and marine ecosystems provide critical services, such as nutrient cycling, flood control, waste treatment, species refuge, genetic resources, and recreational and cultural activities.

Within the next 25 years, coastal populations – already half of the total U.S. population- are likely to increase by approximately 25%, or by 18 million people, with most of the growth occurring in the already crowded states of California, Florida, Texas and Washington. This growth, along with rising affluence, is increasing demand for coastal and marine resources, which increases both the stress on those resources and their vulnerability to climate change and variability.

This presentation summarizes the findings in recent coastal and marine assessments -- focused on the impacts of climate change (Boesch et al. 2001, Scavia et al. 2001) and on environmental quality (EPA 2001, Bricker et al. 1999, CENR 2000).

## Current Stresses

One can get an overall sense of the status of coastal water quality by reviewing the areas of coastal and estuarine waters designated by the states as impaired. To date, states have identified 1402 areas that do not meet designated use criteria, due primarily to levels of toxic organics, metals, and organics; mercury; nutrients; pesticides; pathogens; and sediment. This represents 44% of the assessed estuarine waters and 12% of the assessed shorelines. NOAA's eutrophication survey determined that over half of the nation's estuaries show symptoms of nutrient over enrichment -- overgrowth of algae and macrophytes, low oxygen waters, and harmful algal blooms. The most affected estuaries are along the East and Gulf coasts. That assessment also estimated that conditions are projected to get worse in over 70% of the estuaries by 2020.

Harmful algal blooms -- algae that produce toxins that can make fish, marine mammals, and people sick or die -- are becoming more common and more severe. For example, since the 1970s paralytic shellfish poisoning has spread to Puget Sound and through New England; neurotoxic shellfish poisoning was found for the first time in waters off Mississippi, Alabama, and Louisiana; and amnesiac shellfish poisoning spread along west coast, killed dozens of sea lions, and has been recently found in the Gulf of Mexico.

Benthic community condition, an index based on the size and composition of the animals that live in marine sediments, is reported as good in 56% of the areas assessed and marginal or poor in 44%. Most degraded areas are affected by contaminated sediments, low oxygen, and degraded habitat. Fish consumption advisories are also an indicator of environmental quality. Such advisories are found in all but 5 of the 27 coastal states, including 32 advisories in the Great Lakes, mostly for large, long-lived species that accumulate toxins. Estuarine and coastal advisories are based on elevated levels of PCBs, dioxins, DDT, and mercury.

## Potential Future Climate Forces

Potential climate change scenarios have been the subjects of major national and international assessments. For coastal and marine systems, the primary potential stresses include changes in sea level rise; coastal storms; patterns of precipitation freshwater inflow; and ocean temperature, circulation, ice extent, and concentrations of dissolved CO<sub>2</sub>. During the last 100 years, average sea level has risen approximately about 1 to 2 mm per year, with local rates of 2 mm/yr in New England, Florida, and parts of the Gulf Coast, to 3-5 mm/yr in the mid-Atlantic, 5-10 mm/yr in parts of Texas and Louisiana, and from -10 to +2 mm/yr along the Pacific Coast. Over the next 100 years, this rate is expected to accelerate and result in additional sea level rise from 31 – 49 cm. Coastal storms may become more frequent and more severe in the future; however even if they do not, due to sea level rise, these storms will be riding on a higher tide, exaggerating their coastal flooding and erosion.

The strength, timing, and volume of delivery of freshwater and its chemical and sediment load to coastal ecosystems are likely to change significantly. However, it is not yet clear what regions will experience increases and which will see decreases. There is agreement, though, that future rainfall events and subsequent run-off to coastal regions will become more intense. The ocean has already warmed over the past 45 years and it is projected to warm further.

Arctic ice has declined over the last 20 years and further declines are expected. These changes, along with changes in atmospheric dynamics will likely drive changes in the ocean currents, fronts, and upwelling and downwelling zones.

### Potential Climate Impacts

Potential climate impacts will be seen in shorelines and developed areas, wetlands, estuaries, coral reefs, and ocean margins and fishery resources. Rising sea level will inundate lowlands, erode beaches, cause barrier islands to migrate inland, increase coastal flooding, and increase the salinity of rivers, bays, and aquifers. Changes in the frequency of severe storms and increased rainfall intensity could further aggravate flooding and storm damage. An increased sea level that makes a future 50-year flood more severe than today's 100-year flood will increase the number of households in coastal floodplains from 2.7 million to 6.6 million. Wetlands that provide critical refuge and forage for wildlife, fish, and invertebrates, are at risk from rising sea level and decreases in sediment delivery. Natural biological and geological processes would allow wetlands to grow vertically or migrate upland to accommodate the rising sea. However, armoring coastal areas to protect human development prevents inland migration. In those cases wetlands will be lost if they are unable to accumulate substrate at rates adequate to keep pace vertically.

Estuarine impacts will be primarily through exacerbation of current stresses, particularly increased eutrophication, through higher nitrogen loads stimulated by increased (or more intense) precipitation and run-off. Climate change may also increase their vulnerability to eutrophication, by altering mixing characteristics through changes in freshwater runoff, temperature, sea level, and exchange with the coastal ocean.

Coral reefs, which are already under considerable anthropogenic stress, will likely see more bleaching events and will find it difficult to grow as increased atmospheric CO<sub>2</sub> increases the acidity of surface waters and decreases their rates of calcification.

Changes in ocean temperatures and currents will cause marine ecosystems to migrate resulting in significant dislocation of commercial and recreational fisheries. Some models suggest, for example, that the north Pacific will become too warm to support certain salmon.

### Adaptation and Coping Strategies

While there are significant uncertainties in forecasts of some climate forces, enough is known to begin to prepare for such changes. Coastal communities can either hold back the sea or allow the shore to move inland. Holding back the sea with dikes, seawalls, bulkheads, and revetments will sacrifice beaches, wetlands, and other intertidal zones, but leaves dry land relatively unaffected. There are two ways to allow the shore to move inland: prevent development in vulnerable areas, or use rolling easements, which allow development, but prevent structures that lead to loss of wetlands and beaches. Changes in river management can increase sediment flow to the coast, enabling wetland to also grow vertically.

Water management and land-use policies should anticipate changes in the amount and seasonal distribution of water availability, human demand, and the needs of estuarine ecosystems. In regions with a wetter future, improved land-use practices, such as more efficient nutrient manage-

ment, and more extensive restoration and protection of wetlands and riparian zones will be needed. In a dryer future, estuarine needs will have to be considered in water allocation decisions. Anthropogenic stresses already threaten many coral reefs. With increases in these longer-term, less controllable climate pressures (oceanic CO<sub>2</sub> and temperature), the key strategy is to reduce stresses from the direct anthropogenic stresses such as nutrient over-enrichment, over-fishing, and sedimentation.

Fisheries managers must begin to take into account longer time-scale effects in their management strategies. Sustainable yields are tied directly to the state of the environment, and exploitation and environmental variability can interact to destabilize harvested populations. Under periods of projected low productivity, allowable exploitation rates must be reduced to account for reduced recruitment rates. Under periods of projected high productivity, harvest limits can be increased.

Climate change, likely over the next century, will be superimposed upon, and interact with, the wide array of current stresses, including excess nutrient loads, over fishing, invasive species, habitat destruction, and toxic chemical contamination. While the ability of these ecosystems to cope with or adapt to climate change or variability is compromised by these extant stresses, the inverse is also likely true -- ecosystems will be better suited to deal with climate variability and change if other stresses are significantly reduced.

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Donald Scavia, National Ocean Service, *National Oceanic and Atmospheric Administration*, Washington, D. C.

## Anatomy of North Carolina's Coastal Plain Drainage Basins: A Critical Framework for Future Land-Use Management

The September 1999 floods in eastern North Carolina were overwhelmingly large and extremely devastating to the region's people and economy. The consequences of this severe hydrologic event resulted from the complex interaction between the natural riverine characteristics within each drainage basin and human modification and encroachment. The drainage basin anatomy is the subject of this abstract. The many different drainage basin components are intimately interrelated and operate in consort with each other like parts of a living organism. The complex plumbing scheme, with its numerous inputs and outputs and associated geologic framework, must be understood to adequately utilize and manage a drainage system. The trunk stream within each drainage basin consists of a series of riverine segments that are uniquely different from each other and effect the hydrologic dynamics of each segment during flood conditions. These riverine segments are defined by three sets of variables. 1) The underlying geologic framework defines the morphology and composition of both the paleo and modern channel—floodplain systems, as well as tributary drainages on associated uplands. 2) The location of each riverine segment along the stream gradient relative to sea level determines the degree of interplay with the estuarine dynamics at two temporal scales—the long-term scale of millennia to decades and short-term scale ranging from years to individual storm events such as the 1999 flood. 3) Fluctuations in climate and sea level associated with Quaternary glaciation and deglaciation produced complex patterns of erosional incisement and sediment deposition that the modern drainage system has inherited.

Thus, the inherited geologic framework, location within the basin, and evolutionary history define specific riverine segments, dictate the land and hydrodynamic characteristics, and determine the resulting flood impacts upon human utilization. All land is not equal and human land-use and subsequent management should be based upon both the geologic and hydrologic dynamics. If future impacts of similar flood events are to be minimized, key geologic and hydrologic data of the riverine systems must be integrated to form the basis of land-use and management plans for each drainage basin. The floods of September 1999 rezoned the Coastal Plain for us at a very high cost—we must listen to the EARTH when it speaks to us!

Stanley R. Riggs, Department of Geology, *East Carolina University*

## Hydrologic And Water-Quality Effects Of Hurricanes Dennis, Floyd, And Irene

The combined effects of Hurricanes Dennis, Floyd, and Irene in September and October 1999 resulted in 2 months of flooding throughout most of eastern North Carolina. Upon making landfall less than 2 weeks before Hurricane Floyd, Hurricane Dennis delivered 4 to 8 inches of rain to much of the Tar and Neuse River Basins, breaking a drought and saturating soils. Hurricane Floyd will likely be the second or third most costly hurricane to strike the United States in the 20th century, resulting in more fatalities than any hurricane to strike the United States since 1972. Rainfall amounts recorded during Hurricane Floyd (September 14-17, 1999) and accumulated during the months of September and October were unprecedented for many parts of eastern North Carolina during more than 80 years of precipitation records. Most recording stations in eastern North Carolina received at least half the average annual rainfall during the 2 months. Flooding was at record levels and 500-year or greater floods occurred in all of the State's river basins east of Raleigh, except in the Lumber River Basin.

Total freshwater inflow to Pamlico Sound during September – October was equivalent to about 83 percent of the total volume of the Sound; under normal conditions, total inflow volume during these 2 months is equivalent to about 13 percent of the volume of the Sound.

Following Hurricane Floyd, much of the Pamlico River had little salinity, and near-surface salinity remained less than 2 parts per thousand into December 1999, whereas salinity typically ranges from 7 to 11 parts per thousand in the fall.

More than half of the average annual nitrogen and phosphorus loads were transported in the Neuse and Tar Rivers by floodwaters during the 1-month period between mid-September and mid-October. However, the total nitrogen load carried in Hurricane Floyd floodwaters was quite similar to the load carried by Hurricane Fran (1996) floodwaters in these two rivers, despite the greater total streamflow resulting from Hurricane Floyd.

Fortunately, Hurricane Irene in mid-October did not make landfall in North Carolina, but rainfall from the storm did help ensure that several rivers in eastern North Carolina remained above flood stage for almost 2 months.

Jerad Bales, *U.S. Geological Survey*

### Modeling Flooding Extent from Hurricane Floyd in the Coastal Plains of North Carolina

In this research two modeling approaches based on the use of U.S. Geological Survey (USGS) digital elevation model (DEM) data were developed. In the first approach, the geographic information system ArcView 3.2 and the HEC-GeoRAS extension, were linked with the HECRAS 2.2 hydraulic model. In the second approach, a method was developed for inundating DEM data based on stage height data obtained at USGS gage stations. These models were used to delineate the extent of flooding induced by precipitation from Hurricane Floyd in a portion of Pitt County, North Carolina. The patterns of flood extent derived from the two models were compared to the extent of flooding indicated on a digital aerial photograph taken two days after peak flood levels had been reached. In addition, floodplain boundaries based on Federal Emergency Management Agency Q3 maps were compared to the extent of flooding on the aerial photo. Actual emergency response operations undertaken through the Pitt County Emergency Operations Center during the flood event were described, and were used to provide a context for evaluating the potential utility of these models. The patterns of flood extent produced by the modeling methods represented the actual extent well, and indicated their potential utility for enhancing emergency response operations.

Jeffrey D. Colby, Karen A. Mulcahy, and Yong Wang, *Department of Geography, East Carolina University*

### Modeling The Extent Of A Flood By Using Landsat 7 Tm Data Acquired After The Flood Event

This abstract reports the progress of a modeling effort to map the maximum extent of the flood by using satellite data acquired days after a river crested. On the 21st of Sept. 1999, the Tar River within Pitt County crested at about 27 ft. or 14 ft. above flood stage; it created a massive flooding in the area. Due to fixed satellite orbit, it is almost impossible to have concurrent

remotely sensed data with a flood event; this undervalues the possible usage of the satellite data. For example, it takes a period of 16 days for the Landsat 7 TM sensor to revisit the same place, and its closest visit day for most of the Pitt County and Eastern North Carolina was on the 30th of September 1999. The Tar River surface water height fell from about 27 ft. on the 21st to 17.5 ft. on the 30th of Sept. 1999. Is it possible to use the remotely sensed data (acquired nine days after the peak of a flood event) to map the maximum flood extent?

To answer this question, the area between the City of Greenville and the City of Washington, NC, about 35 km<sup>2</sup> in east-west and 18 km north-south, covering an area of approximately 630 km<sup>2</sup> was studied. Two reasons for selecting the study area, availability of the ground observation and Landsat 7 TM data of path 14/row 35 acquired on the 23rd of Sept. 1999 and path 15/row 35 (acquired on the 30th of Sept. 1999. Tar River enters from the upper left and exits on the lower right corner within the study area. (On the 23rd of September 1999, the Tar River was only about 1 ft. below its crested height.) Examining both TM images showed that there were expanded dark signatures along the Tar River banks on both dates, and these signatures were very similar. The signatures on the 30th of September may be attributed to the stress on (and possible) damage to the vegetation along the river banks caused by floodwater. Thus, I developed following methods

- 1) to model the flood extent on the 30th of Sept,
- 2) to detect areas where the vegetation was under stress and possibly was damaged,
- 3) to combine the flood extent from 1) and the areas from 2) to derive the maximum flood extent for the flood event, and finally
- 4) to verify the maximum flood extent derived from 3) to that derived from the TM data on the 23rd of Sept. 1999.

The results were 1) the spatial correlation coefficient between the maximum flood extent derived from the 30th of Sept. and the 23rd of Sept. was 0.84, and 585.4 km<sup>2</sup> (out of a study area 630 km<sup>2</sup> or 92.9%) of both maximum flood extent maps agreed in terms of flooded areas or non-flooded areas. However, there were discrepancies: 1) areas derived based on the 23rd of Sept. data as non-flooded but the same areas classified as flooded on the 30th of Sept. data was 17.1 km<sup>2</sup> or 2.7% of the total study area, and 2) areas derived based on the 23rd of Sept. as flooded but the same areas classified as non-flooded on the 30th of Sept. data was 27.5 km<sup>2</sup> or 4.4%.

Yong Wang, Department of Geography, *East Carolina University*

## Multisensor Applications for Improved Flood Warnings

This presentation describes a project to design and develop advanced technologies for quantitative precipitation estimations (QPE) for hydrological management of surface water, flood prediction, and mitigation. Emphasis is on the use of mesoscale models integrated with satellite, environmental, and radar observations coupled with geographical information systems for QPE and QPE expert systems. These expert systems have been developed for electric utilities operations, power generation scheduling, watershed, dam, and river operations and management, and flood warning systems for international deployment.

Robert H. Bacon, *South Carolina Sea Grant* and Kenneth W. Howard,  
*National Severe Storms Laboratory, National Oceanic and Atmospheric Administration*

## Interactive impacts of human activities and climate on water quality of NC and national coastal ecosystems: What's manageable and what's not?

The impacts of growing coastal nutrient pollution and habitat alteration accompanying human encroachment are most evident and of greatest concern in suspended microalgae (phytoplankton) and associated bacteria at the base of the food web, where a vast bulk of coastal primary production and biogeochemical cycling takes place. Furthermore, estuarine and coastal ecosystems are under the influence of both human and natural perturbations such as major storms, hurricanes and flooding (e.g., coastal North Carolina during the hurricanes of fall '99); these may coincide and act synergistically or antagonistically. Distinguishing and integrating the impacts of natural and human stressors in time and space are difficult but essential for understanding and managing environmentally-driven change of water quality and ecosystem function. For example, variations in pollutant concentration and supply rate, salinity, dissolved oxygen, sedimentation, turbidity and water residence time can result in differential phytoplankton community responses with major nutrient cycling and food web ramifications. Here, we explore the complementary use of standard water quality indicators (e.g., salinity, temperature, dissolved oxygen, nutrient concentrations), diagnostic analytical (HPLC detection of chlorophyll and other algal photopigments), and physiological (primary productivity) measurements made through multi-university and agency collaborative Neuse River Modeling and Monitoring (ModMon; [www.marine.unc.edu/neuse/modmon](http://www.marine.unc.edu/neuse/modmon)) assessments made during non-hurricane (1994, 1995) and hurricane (1996, 1999) years in North Carolina's Neuse River Estuary-Pamlico Sound continuum. These indicator methods and tools can be adapted to automated surveys by ferries, synoptic monitoring, and remote sensing in order to evaluate environmental controls on phytoplankton community structure, function, subsequent habitat and food web responses over ecosystem to regional scales.

Hans W. Paerl, Institute of Marine Sciences, *University of North Carolina-Chapel Hill*

## Chemical Contamination Of Surface Waters In Eastern North Carolina: Influence Of Hurricane Floyd

Flooding in eastern North Carolina following Hurricane Floyd in September 1999 caused unprecedented impacts to the human and natural environment, including damage to over 200 wastewater treatment plants, flooding of over 300 animal operations, fuel oil spills, and flooding of landfills, hazardous waste sites, chemical storage facilities, and agricultural areas containing large quantities of pesticides. To help assess potential chemical hazards, we began a study in Spring 2000 to measure the magnitude and spatial extent of chemical contamination in surface waters and sediment of the rivers, estuaries and sounds of eastern North Carolina. Given the time that elapsed since the flood, we focused on contaminants that are persistent and might pose a chronic hazard. To assess surface water contamination, we deployed passive sampling devices (the semipermeable membrane device, or SPMD) that integrate exposure over time. We also collected sediment samples. Residues of over 100 chemicals were measured, including 48 polycyclic aromatic hydrocarbons (PAHs) that are contained in fuels and oils, and in combustion emissions; 35 historically-used chlorinated pesticides and 20 currently-used pesticides were measured to assess the magnitude of pesticide remobilization from agricultural soils and pesticide storage facilities. Where possible, we sampled sites with recent pre-hurricane measurements.

Data generated to date indicate that there are no statistical changes in concentrations of contaminants in sediments, with the exception of a few sites that exhibited elevated toxaphene and DDT in post-hurricane sampling. In all cases, the residues do not exceed published guidelines for the protection of aquatic life. Post-hurricane residue data from the SPMDs, which directly reflect exposure in the water, ranged from 0.03 to 14 times the pre-hurricane concentrations measured in 1997 and 1998. However, the pre-hurricane database is not sufficiently robust to establish rigorous statistical confidence in this change. Using the SPMD data to back-calculate the estimated concentrations in the water, we find that no samples exceed EPA water quality criteria for the protection of aquatic life, though some samples do exceed the EPA water quality criteria for the protection of human health.

Damian Shea, Department of Environmental and Molecular Toxicology,  
*North Carolina State University*

### Sedimentation On The Floodplain Of The Tar River Following Hurricane Floyd

Samples of sediment deposited on the Tar River floodplain following Hurricane Floyd were collected from 85 sites along the lower Tar River basin between Rocky Mount and Washington, NC. Samples were analyzed for total sedimentation thickness and heavy metal concentration. Despite the magnitude of the flood, little suspended sediment was deposited on the floodplain. In almost all cases the deposition was less than 0.2 cm and in many locations the sediment amounted to a "dusting" or was not present at all. Of the 85 sites examined, 35 had no measurable sediment deposition. Possible explanations for the low sediment concentration include, 1) low suspended sediment concentrations in the water, and so little was available for deposition, 2) most of the sediment available for transport might have been flushed from the system during the smaller flood of Hurricane Dennis while the flow was still largely within the river banks, and 3) the bulk of sediment in the system might have been too fine to settle from suspension and was evacuated along with the flood water. Although some samples showed varying levels of contamination with respect to heavy metals, the sediments deposited by the flood were generally not as heavily contaminated as we expected. Many of the highest contamination levels occurred in discrete locations with possible, local inputs, and were not distributed throughout the basin. The most notable sites include samples taken from 1) near the Rocky Mount waste water treatment release site which showed higher levels of Pb, Hg, and Cr, 2) the northwest, industrial section of Greenville which had elevated levels of Hg, As, and Cr, and 3) the Port Terminal site near a trash collection/recycling center just east of Greenville, which showed elevated levels of Pb, Hg, and Cr. Despite the elevated levels, most samples were not considered heavily contaminated relative to EPA residential soil and agricultural soil standards. Perhaps the metal of most concern, however, was arsenic, which was elevated at all sites, and had concentrations as much as 40 times above the acceptable levels for residential soil.

Patrick Pease, Scott Lecce, Paul Gares, Department of Geography,  
Catherine Rigsby, Department of Geology, *East Carolina University*

## Ecosystem Impacts Of Three Sequential Hurricanes (Dennis, Floyd, And Irene) On The United States' Largest Lagoonal Estuary, Pamlico Sound, NC

Three sequential hurricanes, Dennis, Floyd, and Irene, affected coastal North Carolina in September and October 1999. These hurricanes inundated the region with up to 1 m of rainfall, causing 50- to 500-year flooding in the watershed of the Pamlico Sound, the largest lagoonal estuary in the United States and a key West Atlantic fisheries nursery. We investigated the ecosystem level impacts on and responses of the Sound to the floodwater discharge. Floodwaters displaced three-fourths of the volume of the Sound, depressed salinity by a similar amount, and delivered at least half of the typical annual nitrogen load to this nitrogen-sensitive ecosystem. Organic carbon concentrations in floodwaters entering Pamlico Sound via a major tributary (the Neuse River Estuary) were at least 2-fold higher than concentrations under prefloodwater conditions. A cascading set of physical, chemical, and ecological impacts followed, including strong vertical stratification, bottom water hypoxia, a sustained increase in algal biomass, displacement of many marine organisms, and a rise in fish disease. Because of the Sound's long residence time (~1 year), we hypothesize that the effects of the short-term nutrient enrichment could prove to be multiannual. A predicted increase in the frequency of hurricane activity over the next few decades may cause longer-term biogeochemical and trophic changes in this and other estuarine and coastal habitats.

Hans W. Paerl, Jerad D. Bales, Larry W. Ausley, Christopher P. Buzzelli,  
Larry B. Crowder, Lisa A. Eby, John M. Fear, Malia Go, Benjamin L.  
Peierls, Tammi L. Richardson, and Joseph S. Ramus

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## Part II. Society and Economy

*The September storms dealt a sharp blow to the already depressed rural economy of eastern North Carolina. Census data from 2000 confirm that the region was already one of the poorest in the state, hence far less resilient in its ability to cope with the aftermath of Floyd. Economists determined that these realities were reflected in the slow pace of recovery, the effects on housing markets, and the economic impacts on the poor, the middle class, and on small businesses. Researchers also report on perceptions of hurricane risk and preparedness, how men and women differ in their response to evacuation notices, and the response to the floods of specific groups like students and the disabled.*

### The Demographic Setting – Eastern North Carolina in 2000

According to 2000 census data, North Carolina had the ninth largest population increase in the United States, making it the eleventh most populated state in the Union, and more urban than rural in character. Population in the 40 easternmost counties grew by 15 percent, to 2.22 million, but one-third of all municipalities in the East lost population, including several that were hit especially hard by Hurricane Floyd's severe floods. These counties are home to the largest African-American population in the state, as well as a rapidly growing Hispanic population. It is also the poorest region in North Carolina. These changes suggest that North Carolina is an urban state, that political power will shift to urban areas, and that the East will have less political power to contend with small town survival, poverty, racial diversity, and disaster mitigation recovery.

Albert A. Delia, Regional Development Institute, *East Carolina University*

### Long-Term Recovery From Hurricane Floyd

The storm and flood damage caused by Hurricane Floyd came on top of already depressed economic and social conditions in eastern North Carolina. It is probably more accurate to refer to the aftermath of Floyd rather than long-term recovery, and to regard recovery as a compromise between getting things back to the way they were prior to Floyd, but with a continued effort to improve conditions. Compared to the rest of the state, the east has continued to lose ground in population growth, income, educational attainment, manufacturing, and the capacity of small towns to meet key community needs such as infrastructure and effective educational systems. For example, North Carolina is ranked near the bottom among the fifty states in information technology. With the decline of tobacco, long the mainstay of the economy in the east, there is a major restructuring of agriculture in the region. The persistence of racism, sexism, and localism has conspired to further retard economic development in the region. (These conditions and their implications for rural North Carolina are described in the report, "Choices for a New Century," available from the Rural Economic Development Center.) The cumulative effect is a terrible deficit in the physical and human capital required to compete in the global economy. The floods resulted in a loss of life, property, jobs, and homes that further aggravated these conditions. They also promoted a sense of North Carolina identity and the feeling that everyone was in the relief and recovery effort together.

Billy Ray Hall, Director, *North Carolina Rural Economic Development Center*,  
Raleigh, North Carolina

## The Impact of Low-Intensity Hurricanes on Regional Economic Activity

Although low-intensity hurricanes cause far less structural damage than high-intensity hurricanes, these weaker hurricanes do affect regional economic activity through "business interruption". Because the strike frequencies of low-intensity hurricanes are orders of magnitude greater than those of stronger storms, the cumulative impact of frequent "business interruption" may be significant. Using Chamber of Commerce survey data, we estimate industry-specific business interruption losses for three low-intensity hurricanes striking the Wilmington, N.C. region. The average, per-storm regional impacts of business interruption, including direct, indirect, and induced impacts, are equivalent to between 0.8% to 1.23% of annual regional output, between 1.11% to 1.63% of regional employment, and between 1.21% to 1.81% of annual indirect business taxes. While these per-storm losses may appear small, the high strike frequencies of low-intensity hurricanes produce a cumulative (in expectation) impact equivalent to a high-intensity hurricane strike causing approximately \$3.7 billion in damage.

Robert T. Burrus, Jr. , Christopher F. Dumas , Claude H. Farrell , and William W. Hall, Jr.,  
Department of Economics and Finance, *University of North Carolina – Wilmington*,

## Hurricanes, Housing Market Activity, and Coastal Real Estate Values

Assuming hurricane landfalls are random events for a given coastal community, a single storm or even a pair of storms should have no appreciable effects on property values. The rational home buyer or seller recognizes the possibility of "bad luck" with a single or pair of "bad draws" and thus makes no adjustment in their home-buying willingness or pricing expectations as a result of one or two hurricane strikes. However, we hold that the increased frequency of strikes in our study areas does not favor housing prices. With successive hurricanes near Wilmington, North Carolina, over a relatively brief period, we believe that housing market participants in that region may no longer view the landfalls as random, and, consequently, home prices may fall. We develop a standard hedonic pricing model that permits us to examine real estate values following these natural disasters. After controlling for local economic and housing activity and costs of home financing – factors often influencing housing prices – we find little separable response by the market to initial hurricane strikes, with the housing market possibly perceiving them as nothing more than "bad luck." However, and associated perhaps with changing market perceptions of the susceptibility of the region to hurricanes, we observe adverse impacts on home selling prices in the months following the most recent hurricanes. These declines in value are progressively greater following the landfalls of Hurricanes Bonnie and Floyd in 1998 and 1999, respectively.

J. Edward Graham and William W. Hall, Jr., Department of Economics and Finance,  
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## Issues in Recovery for Middle Income Flood Victims

In September 1999, the passage of Hurricane Floyd created a catastrophic flood in eastern North Carolina. Residents of floodplains across the region were forced to evacuate their homes on short notice. Upon their return a week later, many residents found extensive damage to their homes, and total losses amounted to billions of dollars. A normal assumption would be that many of the individual losses within the 100 year flood zone would be covered under the

National Flood Insurance Program. The Floyd flood, however, was so catastrophic that areas outside the 100-year flood zone often found themselves under several feet of water. There has been limited examination of the effects of flooding on areas outside the NFIP zone. This study was designed to determine how much insurance coverage existed both inside and outside the 100 year zone, and why residents did or did not purchase flood insurance. Pertinent information was obtained by means of a questionnaire delivered to floodplain residents a year after the flood. The results show that whereas a large number of flood zone residents did not have insurance coverage, almost none of the residents outside the zone were covered. It was also found that respondents received little information concerning flooding potential of their property from realtors, mortgage officers or insurance agents. These three groups of agents play an important role in house purchasing, and should provide new homeowners with important information concerning house location on the floodplain, flood vulnerability, and insurance availability.

Paul Gares, Department of Geography, *East Carolina University*

### Hurricane Experience, Risk Perceptions, And Hurricane Preparedness

Measures of personal risk are the strongest factors affecting evacuation and other mitigating behavior, during hurricanes. The sample frame is households in the eight ocean-bordering counties in North Carolina. We interviewed households after Hurricane Bonnie (1998) in January 1999. After Hurricanes Dennis and Floyd (1999) we reinterviewed these same respondents. Risk perceptions are measured after each storm season. Our data allows an analysis of changes in risk perceptions following Hurricanes Dennis and Floyd. We conduct an analysis to determine if wind and risk perceptions influence measures of hurricane preparedness.

We find that respondents perceived lower wind and flood risks following the Hurricanes Dennis and Floyd experience. Those who face the highest risks from hurricanes, island, storm surge zone, and flood plain residents, are more likely to perceive greater wind and flood risks. Those who have incurred property damages perceive greater wind and flood risks. Mobile home owners perceive higher wind risks but not flood risks. Females perceive lower wind risks. Those who are older perceive lower flood risks. Those with higher incomes perceive greater wind risk but not flood risk. We find some geographic differences in wind and flood risk. We find that risk perceptions differ across storm season. Demographic and geographic differences occur after the 1998 season but not after the 1999 season. Mobile home owners perceive the same risks from wind as those in fixed structures after Hurricanes Dennis and Floyd. Homeowners and apartment dwellers perceive lower risks in 1999 but not in 1998. Property damage that occurred in 1998 positively effects flood risk perceptions in 1999, but current property damages do not. In terms of evacuation planning respondents are better prepared for evacuation after Hurricanes Dennis and Floyd than before. Surprisingly, however, respondents are less well prepared for a hurricane in terms of preparing property and storing supplies, after Hurricanes Dennis and Floyd than before. Perceived wind and flood risks are factors that are considered when preparing for a hurricane. However, these results are not stable over time. Also, the effects of demographics on preparedness changes occur over time.

John C. Whitehead, Department of Economics, *East Carolina University*

## Gender and Evacuation: A Closer Look at Why Women Are More Likely to Evacuate for Hurricanes

Studies of hurricane evacuation have often noted that women are more likely than men to evacuate, yet few examined those differences and tried to explain them. This paper undertakes a series of bi-variate and multivariate analyses to examine the relationship between evacuation and gendered variations in socio-economic status, care-giving roles in the household, evacuation incentives, exposure to risks, and perception of risk. A series of hypotheses are developed and tested in order to help explain why women are more likely than men to evacuate. The data used come from a cross-sectional survey of 1,050 coastal North Carolina households affected by Hurricane Bonnie which made landfall near Wilmington, NC on August 25, 1998. Results from a series of bi-variate and multi-variate logistic regression analyses indicate that women are more likely to evacuate than men because of socially constructed gender differences in care giving roles, access to evacuation incentives, exposure to risk and perceived risk. We find, in part, that women are more likely to evacuate because, compared to men, they live at greater exposure to risk and have a heightened perception of risk. Yet, those men who are at greater risk, and do perceive heightened risk are more likely to evacuate than women with comparable risk exposure and perception. Future studies of disaster response should distinguish clearly between the intention to evacuate and the capacity to do so.

Julie M. Bateman and Bob Edwards, Department of Sociology, *East Carolina University*

## Riding Out the Storm: The Experiences of the Physically Disabled During Hurricanes Bonnie, Dennis, and Floyd

We examine the experiences during Hurricanes Bonnie, Dennis, and Floyd of households in eastern North Carolina which include a member with a physical disability, and contrast them with those of other households. We utilize data from two phone surveys - one of households after Hurricanes Bonnie and Floyd, the second of households after Floyd. We also draw from interviews with physically disabled persons, family members, and informants from county and emergency management agencies. We find households with physically disabled members were less likely to evacuate than others. Reasons for not evacuating were directly attributable to a lack of or perceived lack of access to services and assistance. Households with a disabled member were more likely to have experienced damages to their homes in both seasons and to see their homes condemned after Floyd. Damage costs represented a greater proportion of the incomes of households with a disabled member. These data underscore the need for attention by emergency management personnel to three issues: communication and coordination of services, evacuation planning and assistance, and the provision of accessible shelter.

Marieke Van Willigen, Bob Edwards, Ken Wilson, John Maiolo, Department of Sociology and John Whitehead, Department of Economics, *East Carolina University*

## Effects of the Flood: Students Report

About six months after Hurricane Floyd hit the area, a random sample of East Carolina University students was surveyed by phone to determine the extent to which they had been affected by the flooding brought on by Hurricane Floyd. The intent of the survey was also to determine the proportion of students still being affected by this natural disaster, to determine how students felt the university responded, and to determine whether students still had unmet needs. Survey results revealed that while most students were affected by the flooding, a smaller proportion actually experienced property loss-- 11% lost personal property, 9% had their

homes flooded, and 5% had their cars flooded. Almost half of the students who responded reported experiencing difficulty getting to school and work. Two out of five respondents reported having academic concerns as a result of the flood, one in five experienced financial problems, and 6% experienced health problems. At the time of the survey, 4% of respondents reported continued financial and/or emotional concerns and 2% were still experiencing academic difficulties. Generally speaking, students were satisfied with responses from university administrators and faculty, and many students sought help through the University's Flood Relief Resource Center. Six months after Hurricane Floyd, very few of the respondents reported any lingering issues related to the flood. An interesting outcome of the survey process was that while students reported little lingering issues, the qualitative data suggested students still needed to process their experiences. Additionally, the qualitative and quantitative responses were somewhat incongruent. Students who had not experienced property loss tended to discount the impact that the disaster had on them personally and they expressed feelings of guilt both for not experiencing loss and for experiencing stress as a result of their experiences. ECU students' lives were changed as a result of this natural disaster, but with the university response, the community response, and the response of peers, students have dealt with the consequences. Most respondents reported the changes in their lives as both positive and negative. Students felt stronger connections to the institution and the community and reported that their personal relationships had been strengthened. The university response appears to have been helpful and appropriate to meet the needs of the student population.

Kris M. Smith, Planning and Institutional Research, and Valerie Q. Glass, Research, Assessment and Testing, *East Carolina University*

### How Extreme Weather Events Affect Student Test Performance

During the 1999-2000 school year, North Carolina faced two extreme weather systems: Hurricane Floyd in the fall and a winter storm in January. Given the national attention to school accountability it is important to understand how such events can adversely affect student performance on end-of-year tests. We use data on student test results to determine the effect of these events on student learning. Using four years of data on roughly 1600 public elementary schools, we determine that the percentage of students meeting Level III proficiency ("passing the test") in the affected area was almost one percentage point lower than if Floyd had not occurred. Furthermore, we estimate that approximately thirty-four elementary schools in the affected area would have met "Expected Growth" if not for Floyd.

George Mark Holmes, Department of Economics, *East Carolina University*

### Part III. Public, Individual, and Mental Health

*Disasters can be devastating for personal, public, and mental health. Experts in these fields summarize the broad understanding of how disasters affect each of these dimensions of human health. More specific reports describe the effects of the hurricane disasters on elementary school and college students, the promise of telemedicine to help respond to distant disasters, and the potential for climate warming to have a detrimental effect on public health in North Carolina.*

#### Mental Health and Disasters

Disasters produce both individual and collective trauma, so behavioral health concerns are

present in nearly all aspects of preparedness, response, and recovery. Several characteristics of traumatic events have a powerful influence on how individuals and communities respond. These include surprise, threats to physical well-being, intentional harm, injury, or death, exposure to the grotesque, the sudden violent death of a loved one, and the scope and uncertain duration of the event. Impacts on communities hinge on the extent of community disruption, the stability of families and the community prior to the disaster, and the role of community leadership. Emerging challenges to the field of disasters and mental health involve global epidemics, traditional terrorism, cyber-terrorism, and the use of biological, nuclear, and chemical agents for terrorist attacks. Compared to natural disasters, the psychological effects of terrorist events are more serious, complex, and long-term.

Among the challenges confronting improved understanding of the mental health effects of disasters are the scarcity of good research on risk and protective factors, the scarcity of good intervention research, training, and the lack of consistency of reporting service experience. Continuing areas of controversy involve the roles of professionals and non-professionals, treatment versus crisis counseling, rivalries between disciplines, professions, and organizations, and duration of efforts to mitigate the mental health aspects of disasters.

Professionals in the field have learned that assigning blame for the event is a predictable response; that there is an expectation of immediate gratification and relief; that those at the social and economic margins are disproportionately affected by disasters; and that there continues to be widespread ignorance about mental health. However, the human spirit, reinforced by religious belief, symbolism, and ritual, is resilient.

RADM Brian W. Flynn, Assistant Surgeon General, U.S. *Public Health Service*

## Public Health Consequences of Disasters

The World Health Organization defines a disaster as a sudden ecologic phenomenon of sufficient magnitude to require external assistance. At the community level this can be defined operationally as any community emergency that seriously affects people's lives and property and that exceeds the capacity of the community to effectively respond to that emergency. The objective of disaster management from a public health perspective is to assess the needs of disaster-affected populations, match available resources to those needs, prevent further adverse health effects, implement disease control strategies for well-defined problems, evaluate the effectiveness of disaster relief programs, and improve contingency plans for various types of future disasters. Proper planning and execution of disaster medical aid programs requires knowledge of the types of disasters that might occur, the morbidity and mortality that might result, and the consequent medical care needs. Therefore, emergency responders should be expert on how to handle the type of disaster most prevalent in their own community, since each type of disaster is characterized by different morbidity and mortality patterns and has different health care requirements. For example, hospitals in North Carolina should plan for hurricanes, while those in California should plan for earthquakes.

Floods are the most common natural disasters. They affect more people worldwide and cause greater mortality than any other type of natural disaster. They occur in almost every country, but 70 percent of all flood deaths occur in India and Bangladesh. In the United States, floods

cause more deaths than any other natural disaster, with most fatalities resulting from flash floods. From a public health viewpoint, floods may disrupt water purification and sewage disposal systems, cause toxic waste sites to overflow, or dislodge chemicals stored above ground. In addition, makeshift evacuation centers with insufficient sanitary facilities may become substantially overcrowded.

Sound epidemiologic knowledge of the causes of death and the types of injuries and illnesses caused by disasters is clearly essential when determining what relief supplies, equipment, and personnel are needed to respond effectively in emergency situations. The overall objective of disaster management is to assess the needs of disaster-affected populations, to match resources to needs efficiently, to prevent further adverse health effects, to evaluate relief program effectiveness, and to plan for future disasters.

Eric K. Noji, MD, MPH, *National Center for Infectious Diseases,  
Centers for Disease Control, Atlanta, Georgia*

## Death by Degrees, The Health Threats of Climate Change in North Carolina

Based on the newest projections made by the Intergovernmental Panel on Climate Change, temperatures worldwide could increase 2.5 to 10.4 degrees F. by 2100. Temperatures in North Carolina could change equally dramatically. While projections look to the future, global warming appears to be influencing climate now. Heat stress days and nights have increased throughout the state over the past fifty years. More heat brings more cases of heat cramps, heat exhaustion, and heat stroke. In addition, heat can cause death and tends to exacerbate the death rate from other medical conditions. The elderly, infirm, children, and infants will likely suffer the most.

Climate change means extremes. Greenhouse gas concentrations increase heat and moisture in the atmosphere. Heat and water vapor create instability, leading to more frequent and possibly more severe weather activity, including thunderstorms, lightening strikes and floods. Increased precipitation could lead to more flooding.

North Carolina's air quality will likely deteriorate due to climate change. The pollutants emitted from cars and power plants that burn fossil fuels include carbon dioxide, which causes global warming, and other pollutants. These pollutants help to create ground-level ozone. The amount of ozone, the primary component of smog, commonly rises on hotter days. High ozone levels exacerbate asthma and other respiratory illnesses. In addition to asthma attacks, exposure to elevated ozone levels can cause shortness of breath, pain when breathing, lung and eye irritation, and greater susceptibility to respiratory illness, such as bronchitis and pneumonia. As it stands, 17 North Carolina counties fail to meet federal air pollution standards.

Water quality and availability may also be compromised as the climate changes. Global warming also may change the chemical composition of water that fish and shellfish inhabit, causing the amount of life-sustaining oxygen on the water to decline, while dangerous pollution and salt levels increase.

Climate change may also increase the cases of vector-borne disease that occur in the state. Warming and other climate changes expand the habitat and infectivity of disease-carrying

insects, increasing the potential for transmission of the diseases they carry. Temperature is a limiting factor with respect to transmission of a viral agent by a vector, such as a tick or mosquito. In North Carolina, diseases spread by ticks include Lyme disease, Rocky Mountain Spotted Fever and ehrlichiosis. Mosquitoes already flourish in North Carolina, and some carry different forms of encephalitis and West Nile virus, a dangerous disease that recently spread to the state. If conditions become warmer and wetter, mosquito populations could increase, thereby increasing the risk of transmission of these diseases.

The sea level along North Carolina's coast falls within that stretch of U.S. coast most vulnerable to rising seas. Therefore, much of the state's 3,375 miles of tidally influenced shoreline, consisting of the barrier islands, salt marshes, and tidal freshwater marshes are at risk from erosion. Studies by EPA and others have estimated that along the Atlantic coast, a one foot (30 cm) rise in sea level is likely by 2050 and could occur as soon as 2025. In the next century, a two foot rise is most likely, but a four foot rise is possible. Such a rise could dramatically increase storm surges and lead to coastal erosion, particularly along the barrier islands, including the Outer Banks. In addition salt water intrusion could affect drinking water supplies. North Carolina needs to be deeply concerned about the potential health impacts of global warming on its population. Only precautions taken now can avert the potential health problems of the future.

Kent J. Bransford, MD, *Physicians for Social Responsibility*

Edited and reprinted by permission from, *Death By Degrees – The Health Threats of Climate Change in North Carolina*, Physicians for Social Responsibility, Washington, DC, (March 2001).

### A Global Telehealth Resource Center

The Global Telehealth Resource Center (GTRC) seeks to build working relationships with disaster relief organizations, provide medical needs assessment and rapid response methods that can be rapidly deployed in response to disasters across the world. The effective use of these technologies includes training clinicians and responders in the effective use of telemedicine technologies and in diverse telehealth strategies for disaster and post-disaster events. A key part of that task is to develop and provide low-cost deployable environmental and biosensor technologies.

David C. Balch, Telemedicine Center, *Brody School of Medicine, East Carolina University*

### Hermeneutic Investigation of Students' Lived Experiences of the Flood of the Century

Objective: The flood that followed Hurricane Floyd in September 1999 created an emergency in eastern North Carolina that quickly reached disaster proportions. Little is known about the personal experiences of students who witnessed this crisis. The purpose of this study is to fill the knowledge gap about university students' lived experiences with a major flood.

Design: the University Institutional Review Board approved the study. This qualitative study used Van Maanen's hermeneutic phenomenologic approach to researching lived experience (1990). For Van Maanen, the insight into the essential meaning of a phenomenon involves a process of reflection. In reflecting on the lived experience, the structural or thematic aspects of a phenomenon are analyzed. These themes are the structures of the experience. In analyzing the students' written accounts of their flood experience, the following steps in Van Maanen's

phenomenologic reflection were used: uncovering thematic aspects; composing linguistic transformation; and determining incidental and essential themes. The essays were typed by one of the researchers. All researchers read the narratives several times and hand coded the data into themes. Essential statements were highlighted and themes discussed by all the researchers. The essays were further analyzed by using a qualitative analysis program.

**Sample:** The sample consisted of 67 student essays maintained in the Special Collections Section of Joyner Library on the campus of East Carolina University. Students wrote these essays in October 1999 as part of the recovery process related to the flood experience. The writers were enrolled in English and History courses.

**Concepts:** The researchers adopted the Heideggerian viewpoint that a person cannot be understood apart from their world. Rogers' Science of Unitary Human Beings (1970) was used as the orienting framework. The irreducibility and integral nature of man and the environment as described by Rogers (1970) are consistent with the Heideggerian perspective.

**Findings & Conclusions:** The analysis of the essays revealed 70 distinct codes that were grouped into four essences: awareness/sensory experience, response to the storm, storm damage/description and seeking safety. A Student's Lived Experience Model was developed that describes the disaster stress experienced by these students.

John J. Kane, RN, MS, MSN, James X. Stobinski, RN, MPA, MSN,  
Marie E. Pokorny, RN, PhD, School of Nursing, *East Carolina University*

### Flood Talk: A Community Response to Mental Health Needs

In response to the unmet mental health needs of Grifton's flood survivors, a group of community residents and volunteer health professionals combined forces to organize Flood Talk. Flood Talk is a volunteer staffed counseling service that provides supportive care, emotional support, and some direction on navigation through the bureaucracy of flood relief efforts. Saturday "clinics" were held at a local church; outreach work is recognized as a critical element of the success of this effort. Between December 1999 and May 2001, 24 sessions were held to serve over 180 clients. Fifty volunteer providers and 32 community volunteers were involved with a total of 533 encounters. Positive impact, resulting from this grassroots community project, on individual cases and community relationships will be highlighted.

Sandra Hardee, Betty Howes, *Brody School of Medicine, East Carolina University*

### Impacts of the Hurricane Floyd Flood on a Pediatric Clinic Population

**Introduction:** This presentation examines the social and health impacts of the Hurricane Floyd flood on children and families from a university pediatric clinic.

**Setting and Methods:** During a one-week period in February of 2000, we asked families who attended the clinic to complete a brief survey pertaining to the flood.

**Results:** Of 458 families seen in the clinic, 252 (55%) returned surveys. About two-thirds of all families (68%) were affected by the flood. More than one-third (37%) reported that their homes were flooded. Over a quarter reported that their home furnishings (26%), personal belongings (27%), and automobiles (36%) were damaged or lost. Economic losses stemming from temporary unemployment (43%) and job loss (8%) were common. Families also reported disruptions in their normal routines. Fifteen percent of families took flood victims into their

home, and 8% reported that their child had to change schools because of the flood. Families affected by the flood faced new barriers to health care. Eighteen percent lost medications or medical devices during the flood. After the flood, 17% had trouble finding time for clinic visits, and 12% had problems paying for medical care. A considerable number of affected families also reported health problems. In 13% of families, a member of their household experienced a new flood-related health problem, while 9% of families experienced exacerbations of pre-existing conditions.

**Conclusions:** Children and families from the clinic experienced major social problems that may have negative, long-term effects on their health. Health care providers should continue to assess the social well-being and health status of children and families who were affected by the flood and provide support as needed.

Matthew D. Curry, MA, Christopher J. Mansfield, PhD, Kathleen D. Leonardo, BSN, RN, Center for Health Services Research and Development, *East Carolina University*, and Pamela G. Larsen, DrPH, DNSc, FNP, Department of Pediatrics, *East Carolina University*

### Prevalence Of Posttraumatic Stress Disorder In Children After Hurricane Floyd

**Introduction:** The purpose of this study was to report on the prevalence of the post-traumatic stress symptoms in children following Hurricane Floyd and the catastrophic flooding that followed. The affected children in this study were attending an elementary school, located in eastern North Carolina that was completely destroyed by floodwater. Thirty-seven (37) percent of these children reported their homes to be flooded as well.

**Subjects:** Data was collected from a cohort of 218 fourth grade students. Sixty-nine percent (69%) or 150 children with completed assessments and signed child and parent/guardian informed consents were included in the analyses. Demographics of the children indicated 57% female, and 43% percent male. Ages of the children were nine years 46%, ten years 45%, eleven years 8%, and twelve years 1%. The ethnic background of the children was reported as African American 63%, Caucasian 33%, and Hispanic American 4%.

**Methodology:** In March of 2000 approximately 6 months following the flood, all fourth grade children were assessed by classroom using the child version of Posttraumatic Stress Reaction Index (Frederick, Pynoos, and Nader, 1992). The validity of this instrument has been reported from correlation studies as .91 in children and .95 in adults with clinically confirmed cases of PTSD (Shannon, Lonigan, Finch & Taylor, 1994).

**Results:** Data analyses (n=150) indicate that 5.3% of the children had doubtful symptoms of PTSD while 24% had mild symptoms, 36% had moderate symptoms, 25.3% had severe symptoms, and 9.3 % had very severe symptoms. The mean CPTSD-RI score was 34.4 (+/-15.6). Children reporting that their homes were flooded were three times more likely to report symptoms than those not flooded (m=39.1 +/- 16.1 n=57 p<.003). Females were twice as likely as males to report symptoms (m=37.5 +/- 16.4 n=85 p<.005).

**Discussion:** Children in this study were experiencing significant symptoms of PTSD six months post trauma. According to DSMIV-TR, studies conducted in the community indicate

an 8% prevalence of PTSD in the U.S. adult population (American Psychiatric Association, 2000) at any given time. In a population based investigation, Lonigan, Anthony, & Shannon (1998) found that 5.5% were experiencing significant symptoms. Vernberg, LaGreca, Silverman, and Prinstein (1996) found that in 3 elementary schools "severely affected" by Hurricane Andrew, 86% of the children reported mild symptoms and more than 55% moderate to severe symptoms. In comparison, this study found that 95% of the children reported at least mild symptoms and 71% moderate to very severe symptoms. This study demonstrates that symptoms of PTSD persist well beyond the initial trauma and require professional attention and intervention.

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C. Russoniello, T. Skalko, J Beatley, D. Alexander, K. O'Brien & S. McGhee, Department of Recreation and Leisure Studies, *East Carolina University and Pattillo Elementary School*

#### Hurricane Floyd Effects on Ethnic Help-Seeking Choices

This paper explores ethnic differences in the types of health resources sought for emotional and unexplained somatic problems. Ethnic differences in comfort with participating in support groups is also examined. The effect of a large natural disaster, Hurricane Floyd, on these help-seeking choices is described. Results are based on a telephone survey of a representative random sample (n=1118) in rural eastern North Carolina. Respondents are given choices of sources of health care consultation for overwhelming stress and emotional problems and for physical symptoms like headache, rapid heart beat, or dizziness for which a family physician had already failed to find a physical cause. Demographic variables that could help explain differences between ethnic groups were examined as were response differences between those surveys before and after Hurricane Floyd.

The population made a sharp distinction between somatic symptoms and emotional symptoms. This distinction seemed more pronounced for European-Americans than for African-Americans. Both African-Americans and European-Americans overwhelmingly selected physician help for unexplained somatic symptoms before and after Floyd. For emotional symptoms both groups selected help from self and friends most often. For both types of symptoms, African-Americans, more often than European-Americans, selected help from clergy. This dif-

ference increased for unexplained somatic symptoms after Hurricane Floyd. African-Americans showed markedly increased comfort with support groups after Floyd, while European-Americans showed no changes in comfort with support groups as a function of Floyd. The effects of Hurricane Floyd on African-Americans are interpreted as reflecting an increased salience of community support for African-Americans, significantly through the Baptist Church.

Richard M. Bloch, MD and Yekeen A. Aderibigbe, MD, Department of Psychiatric Medicine, Brody School of Medicine, East Carolina University

## **Part IV. Summary and Major Themes**

*Future disaster mitigation must come from a combination of planning, land-use design, effective state and local regulations, long-term economic incentives, and close working relationships between all levels of government, non-profit organizations, the faith community, and the private sector. These recommendations are captured in the presentation by Michael Armstrong, former Associate Administrator for Mitigation in the Federal Emergency Management Administration (FEMA), and those offered by conference participants.*

### **Building Disaster Resistant Communities**

Migration to vulnerable areas like flood plains and the increased intensity of weather events have resulted in dramatically increased economic costs of hazards over the past two decades. Some 44 disasters in the United States have exceeded \$1 billion each in costs, costs that are borne disproportionately by the poor. There is an urgent national need to focus on hazard prevention, reduction, and mitigation. Three factors shape the ability of communities to mitigate natural hazards; the location of development; the design and enforcement of local regulations; and the use of economic incentives. The goal should be to locate dwellings, plants, and community infrastructure outside high risk areas like flood plains. There must be strong partnerships between federal, state, and local governments, as well as business, insurance, and developers to design and enforce regulations. Leaders must understand that disasters impose tremendous economic burdens on their citizens, that major savings come from investments in mitigation, and that the appearance of short-term economic gains may be devastated through major disaster losses. Consequently, long-term economic development must be closely tied to planning. The goal is to break the cycle of disaster-rebuild-disaster by planning, risk assessment, code enforcement, and economic incentives. Success requires a climate that supports decision-makers in efforts to enforce land-use and building regulations, land-use planning, and the participation of government, community, non-profit, and private sector organizations as advocates for disaster-resistant communities. Local, state, and federal agencies have specialized but complementary roles to play in providing the policies, incentives, resources, training, and funding to establish a nation of disaster-resistant communities.

Michael J. Armstrong, Esq., Former Associate Director of Mitigation,  
*Federal Emergency Management Administration*

## **Conference Summary and Recommendations**

### **I. It Is Never Over: Discrete Events but Continuous Planning**

Although hurricanes and other climatic events do not occur with entirely predictable regularity, they are predicted to come with enough frequency and intensity to warrant continuous activity, either recovering from the last one or preparing for the next one. Combined with global warming, sea level rise, and the movement of human populations to the coasts, adapting to these circumstances will require new social institutions.

## Recommendations

- Reduce subsidies at all levels for the development of infrastructure in hazard zones; increase incentives for the removal or avoidance of such infrastructure
- Include both public and private (non-governmental) organizations and constituents in the planning process

## II. Harnessing Individualism. Democracy and Community

We must take advantage both of the strength of individuals and the bonds of community. Democratic institutions, particularly at the state and local level, will only provide the necessary framework if supplied with good information and full participation.

### Recommendations

- Provide for better documentation and evaluation of response and recovery efforts for use in adaptive management
- Increase support and capacity for local community involvement in planning, mitigation, and recovery

## II. The Biophysical Environment: Restoring the Land- and Seascape

The biophysical environment is more resilient than many had thought, although the jury is still out regarding many important biophysical variables in climatic events. We must realize the extent of human alterations of these land- and seascapes; work to restore as much natural function as possible; and design human institutions to preserve those functions.

### Recommendations

- Promote the development of better baseline data and continuous monitoring programs for both natural and social scientific variables
- Develop an ethic of community and environmental sustainability

## IV. Reduce Vulnerability, Increase Capacity

The tools exist, with proper financial and human capital, to turn vulnerability into capacity. Cultural differences, for example, often yield cultural strengths. Human communities must reach out to each other, with mutual respect and mutual support. If impact is local, so must be capacity. We must evolve from a reactive, defensive framework to a proactive one that emphasizes the need for attention to all aspects of the relationship between a healthy Human Ecology and a healthy Biophysical Ecology.

### Recommendations

- Regularize dedicated funding and training sources for integrated response, recovery, mitigation and planning at the federal, state and local levels
- Recognize and provide for the different circumstances and needs of the different cultures of the coastal plain

## V. Information, Communication and Education

Many of the details of human perception and behavior, and of the workings of the biophysical environment, in situations of stress and crisis are still not well known or well documented. Social and natural scientific research can provide more knowledge. This knowledge must be transmitted to a variety of audiences, from school children to adults, in a variety of communications media. Full advantage should be taken of state-of-the-art technology.

#### Recommendations

- Encourage the further involvement of the college and university community with primary, secondary and continuing adult education, and with the provision of information and expertise to policy makers
- Take advantage of digital technology to link human and information networks



