Hurricane Debris Management Workshop

Sponsored by:

Alachua County Solid Waste and Emergency Management

University of Florida Hinkley Center for Solid and Hazardous Waste

April 9, 2008
Agenda

9:45-10:00  Refreshments

10:00-10:30  **Introduction and Opening Remarks**

  John Schert, Director
  Hinkley Center for Solid and Hazardous Waste, University of Florida

  Karen Deeter, Assistant Public Works Director
  Alachua County Waste Management

  David Donnelly, Director
  Alachua County Emergency Management

  Charles Kibert, Ph.D., P.E., Principal Investigator
  M.E. Rinker Sr., School of Building Construction, University of Florida

10:30-11:30  **HAZUS-MH: Part I: Hurricane Simulation and Debris Assessment:**

  “Charley, Frances and Ivan”

  K.R. Grosskopf, Ph.D. and Eric Kramer, Ph.D.
  M.E. Rinker Sr., School of Building Construction, University of Florida

11:30-12:00  Lunch (provided)
### Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| 12:00-12:30 | **HAZUS-MH: Part II**  
Hurricane Simulation and Debris Assessment: “Katrina”  
K.R. Grosskopf, Ph.D. and Eric Kramer, Ph.D.  
M.E. Rinker Sr., School of Building Construction, University of Florida |
| 12:30-1:15 | **Applying for FEMA Disaster Assistance: Eligible and Non-Eligible Debris**  
Phil W. Worley, State Debris Coordinator  
Florida Division of Emergency Management (FDEM) |
| 1:15-1:30  | **Break**                                                              |
| 1:30-2:15  | **Special Discussion Topics**                                         |
| 2:15-2:30  | **Closing Remarks**                                                   |
HAZUS-MH: Hurricane Simulation and Debris Assessment

K.R. Grosskopf, Ph.D and Eric W. Kramer, Ph.D
M.E. Rinker Sr., School of Building Construction
University of Florida
April 9, 2008
Introduction

► 2004 storms generated ~ 75M yd$^3$ of C&D and vegetative debris in six weeks, as much as would normally be seen statewide in three years

► ~350 major staging areas; 4,000 acres

► Debris
  • Clean waste: recycled, energy generation
  • Commingled (mixed) waste: burned, landfill

► “Storm chasers”
  • Out-of-state workforce
Overview

► What is HAZUS-MH?

► Hurricane Simulation and Debris Assessment, PART I
  • Charley, Frances & Ivan (2004)

► Hurricane Simulation and Debris Assessment, PART II
  • Category 5 “Katrina” scenario
Overview

![Graph showing correlation between peak windspeed (mph) and building damage (%). The R² value is 0.9765.]

![Map showing urban and conservation areas in Florida, comparing 2005 and 2060.]

*Urban Conservation*

![Aerial view of a flooded area with damaged buildings.]

![Image of a dry area with sound building structures.]

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7
HAZUS-MH: A Decision Support Tool for Disaster Preparedness and Emergency Management

► HAZUS – Natural hazards loss estimation tool in GIS

Characterized by:

• Geographically sensitive, risk-based approach
• Validated scientific methodology to estimate damages, losses, and mitigation benefits
• Interactive visual display and identification of hazards and vulnerability
• Assistance with decision-making and comprehensive approach to hazards

ArcView – Desktop GIS for Mapping, Data Integration, and Analysis
HAZUS-MH Data

► Over 200 default layers
  • General Inventory
  • Building profiles and occupancy
  • Essential facilities
  • Demographics

► Hazard Specific Inventory
  • Terrain, elevation, storm tracks

► User supplied data
  • Updated building inventory, local critical facilities
HAZUS scenario outputs

- Outputs include maps, reports, and tabular data

### HAZUS-MH Models

<table>
<thead>
<tr>
<th>Direct Damage</th>
<th>Earthquake</th>
<th>Flood</th>
<th>Hurricane</th>
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<tbody>
<tr>
<td>Ground Motion Ground Failure</td>
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<tr>
<td>General Building Stock</td>
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<td>Essential Facilities</td>
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<td>High Potential Loss Facilities</td>
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<td>Transportation Facilities</td>
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<tr>
<td>Lifelines</td>
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</table>

| Induced Damage                     |            |       |           |
| Fire Following                     |            |       |           |
| Hazardous Materials Sites          |            |       |           |
| Debris Generation                  |            |       |           |

| Direct Losses                      |            |       |           |
| Cost of Repairs/Replacement        |            |       |           |
| Income Loss                        |            |       |           |
| Crop Damage                        |            |       |           |
| Casualties                         |            |       |           |
| Shelter and Recovery Needs         |            |       |           |

| Indirect Losses                    |            |       |           |
| Supply Shortages                   |            |       |           |
| Sales Decline                      |            |       |           |
| Opportunity Costs                  |            |       |           |
| Economic Loss                      |            |       |           |

**Earthquake**
- Ground Motion
- Ground Failure

**Flood**
- Frequency
- Depth
- Discharge Velocity

**Hurricane**
- Winds
- Pressure
- Missile
- Rain
HAZUS wind model methodology

► “Hazard-load-resistance-damage-loss” methodology
HAZUS limitations

► HAZUS at present cannot model:
  • Storm surges, wave damage, or wind damage to transportation, utility networks, tree damage to buildings

► Wind and Flood models are independent
  • No ability to model floods caused by hurricane rains or flooding by urban storm water runoff; Potential for duplication of damage/losses

► Low intensity storms and winds are difficult to model
  • Hurricanes Frances and Jeanne in Alachua County

► HAZUS does not account for events that precede the scenario
  • Soil saturation, sequential storm strikes, etc.

► Scale and accuracy
  • Regional scale scenarios give most accurate damage and loss estimates
Examples of HAZUS scenarios

► 2007 Alachua and Nassau County Hurricane Simulation and Damage Assessment

• 5 scenarios, including:
  – 2004 storms
  – Historical 1896, 1898 storms
  – Worst case event
  – Probabilistic storms
  – 100 year flood event

► Scenario development

• Storm parameters
  – NWS assistance to review and adjust deterministic scenarios
    • NOAA H*Wind post-storm analyses
HAZUS scenario outputs

Wind speeds

- Peak and max sustained winds
HAZUS scenario outputs

► Wind speeds
  • Peak and max sustained winds
HAZUS scenario outputs

Building damage and economic losses

Severe damage: Failure of >50% roof cover >20% window 10-20 impacts
HAZUS scenario outputs

- Building damage and economic losses

Nassau County Hurricane Simulation and Damage Assessment
Scenario: 1898 Hurricane

Residential Loss
HAZUS scenario outputs

► Essential facility damage

NASSAU COUNTY HURRICANE SIMULATION AND DAMAGE ASSESSMENT
Scenario: 1898 Hurricane

Schools - Severe Damage
SEVERE (probability)
- < 0.01
- 0.01 - 0.20
- 0.20 - 0.39
- 0.39 - 0.58
- 0.58 - 0.77
- 0.77 - 1.00

Schools
HAZUS scenario outputs

► Shelter requirements

MAP: Nassau County Hurricane Simulation and Damage Assessment
Scenario: 1898 Hurricane

Displaced Households
HAZUS scenario outputs

► Debris

Nassau County Hurricane Simulation and Damage Assessment
Scenario: 1898 Hurricane

Debris: Brick/Wood
BRICK AND WOOD (tons/acre)
- 0.00
- 0.01 - 0.07
- 0.08 - 0.13
- 0.14 - 0.26
- 0.27 - 2.81
- 2.82 - 5.77
- 5.78 - 17.75

Miles
HAZUS scenario outputs

Quick Assessment Report
November 10, 2006

Study Region: Nassau HU
Scenario: Nassau_1896_hist_Sandrik
Scenario Description: User Defined
Peak Gust Wind Speed (mph): 171

Regional Statistics

Area (Square Miles) 667
Number of Census Tracts 5
Number of People in the Region 57,663

General Building Stock

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Building Count</th>
<th>Dollar Exposure ($ M)</th>
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<td>Commercial</td>
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## Scenario Results

### Number of Buildings Damaged

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<tr>
<th>Damage State</th>
<th>Residential</th>
<th>Commercial</th>
<th>Other</th>
<th>Total</th>
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<td>10</td>
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<tr>
<td>Moderate</td>
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<tr>
<td>Severe</td>
<td>5,600</td>
<td>80</td>
<td>20</td>
<td>5,600</td>
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<tr>
<td>Destruction</td>
<td>5,800</td>
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<td>&lt;10</td>
<td>5,800</td>
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<td><strong>Total</strong></td>
<td><strong>19,000</strong></td>
<td><strong>100</strong></td>
<td><strong>30</strong></td>
<td><strong>19,000</strong></td>
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</tbody>
</table>

### Shelter Requirements

- Displaced Households (# Households): 11,000
- Short Term Shelter (# People): 2,500

### Economic Loss ($ Millions)

- Capital Stock: 2,163
  - Residential Property: 1,893
  - Commercial Property: 193
  - Other Property: 76
- Business Interruption (Income): 346

**Total Direct Economic Loss**: 2,509
HAZUS scenario outputs

► Flood model

- Digital Elevation Model

Inflow / outflow conditions affect scenarios
HAZUS scenario outputs

► Flood model

- 100 Year event

Direct damage
Induced damage
Direct losses
**Indirect losses

Nassau County Hazus Flood Results

Legend
100 Year Flood Water Height (ft)
High: 14.30
Low: 0
HAZUS scenario outputs

► Flood model
  • Bridge Damage

Nassau County Hazus Flood Results

Legend
- Affected Bridges
HAZUS scenario outputs

► Flood model

- Total Economic Loss

Nassau County
Total losses: $440 Million
33% Business Interruption
50% Residential

Legend
All Occupancy Economic Loss
Total Loss ($1000)
1 - 1783
1784 - 5235
5236 - 11677
11678 - 25095
25096 - 63075
HAZUS scenario outputs

Flood model

- Residential Economic Loss
HAZUS scenario outputs

▶ Flood model

- Debris
- Total

152,000 tons
38% Finishes
29% Structures
33% Foundations
Hurricane Simulation and Debris Assessment, PART I

Charley, Frances & Ivan (2004)
Hurricane Debris Modeling for 2004 Storms

Scenarios to model debris for 2004 hurricanes:
- Charley
- Frances
- Ivan

Impact on 5 urban coastal and rural inland counties:
- Charlotte and De Soto
- St. Lucie and Okeechobee
- Escambia
Hurricane Debris Study: Validation

Actual debris data (2004 storms)

- Difficulty in obtaining accurate data
  - Counties impacted by multiple storms; clean-up not complete before next storm strike
  - Cross-county staging areas, regional transfer stations, etc.
  - Private contractors
Hurricane Debris Study

▶ HAZUS Debris Estimates

- Census tract level
- Building inventory and vegetation
- Storm hazards (wind vs. flood) may affect results
Hurricane Charley scenario: Charlotte County

Storm parameters

• NOAA H*wind post-storm analyses

User Defined Storm Track Input Data

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Time Step (hour)</th>
<th>Radius To Max Winds (miles)</th>
<th>Max. Sustained Wind Speed (mph @ 10m)</th>
<th>Central Pressure (mBar)</th>
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<td>31.21</td>
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<td>23.00</td>
<td>85.10</td>
<td>994.00</td>
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Landfall

[Map of Charlotte County, Florida Hurricane Simulation and Damage Assessment]
Hurricane Charley scenario: Charlotte County

Winds

Gusts >125 mph
Hurricane Charley scenario: Charlotte County

Max sustained >100 mph
Hurricane Charley scenario: Charlotte County

Damage and loss estimates

<table>
<thead>
<tr>
<th>Scenario Results</th>
<th>Residential</th>
<th>Commercial</th>
<th>Other</th>
<th>Total</th>
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<tr>
<td><strong>Number of Buildings Damaged</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Minor</td>
<td>23,000</td>
<td>200</td>
<td>80</td>
<td>23,000</td>
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<tr>
<td>Moderate</td>
<td>14,000</td>
<td>200</td>
<td>80</td>
<td>14,000</td>
</tr>
<tr>
<td>Severe</td>
<td>4,800</td>
<td>200</td>
<td>70</td>
<td>5,100</td>
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<tr>
<td>Destruction</td>
<td>2,100</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>2,100</td>
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<tr>
<td><strong>Total</strong></td>
<td>44,000</td>
<td>600</td>
<td>200</td>
<td>45,000</td>
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</table>

**Shelter Requirements**

- Displaced Households (# Households): 6,500
- Short Term Shelter (# People): 1,600

**Economic Loss ( $ Millions )**

- Capital Stock: 1.784
- Residential Property: 1.402
- Commercial Property: 275
- Other Property: 106
- Business Interruption (Income): 379
- Total Direct Economic Loss: 2,163
Hurricane Charley scenario: Charlotte County

- Debris estimates
  - Brick, wood, and other
  - Concrete and steel
  - Eligible tree debris
  - Total tree debris
Hurricane Charley scenario: Charlotte County

► Debris estimates

- Brick, wood, and other
- Concrete and steel
- Eligible tree debris
- Total tree debris
Hurricane Charley scenario: Charlotte County

- Debris estimates
  - Brick, wood, and other
  - Concrete and steel
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  - Total tree debris
Hurricane Charley scenario: Charlotte County

► Debris estimates

- Brick, wood, and other
- Concrete and steel
- Eligible tree debris
- Total tree debris
Comparative debris summary, 2004 storms

HAZUS Debris Estimates for 2004 Storms, by County

- Okeechobee
- DeSoto
- St. Lucie
- Escambia
- Charlotte

- Tons (thousands)

Hazardous materials categories:
- Reinf. Concrete & Steel
- Brick, Wood & Other
- Eligible Tree Debris
- Subtotal w/out ineligible
- Ineligible Tree Debris
- Total
Estimated Debris from 2004 Storms

Debris grand total

Tons per acre

- 1.2
- 1.3
- 1.4 - 1.6
- 1.7 - 2.0
- 2.1 - 2.2
Estimated Debris from 2004 Storms

Concrete & Steel Debris

Tons per acre

- 0.0045
- 0.0046 - 0.0050
- 0.0051 - 0.0061
- 0.0062 - 0.012
- 0.013 - 0.042
Estimated Debris from 2004 Storms

Brick, Wood & Other Debris

Tons per acre

- 0.05
- 0.06 - 0.16
- 0.17 - 0.31
- 0.32 - 0.38
- 0.39 - 0.63
Estimated Debris from 2004 Storms

Eligible Tree Debris

Tons per acre

- 0.049
- 0.050 - 0.061
- 0.062 - 0.17
- 0.18 - 0.25
- 0.26 - 0.34
Estimated Debris from 2004 Storms

Debris subtotal (excluding ineligible trees)

Tons per acre

<table>
<thead>
<tr>
<th>Range</th>
<th>Tons per acre</th>
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<tr>
<td>0.11</td>
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<tr>
<td>0.12 - 0.23</td>
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<td>0.24 - 0.49</td>
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<tr>
<td>0.50 - 0.73</td>
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<td>0.74 - 0.92</td>
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![Map showing debris distribution](image)
Estimated Debris from 2004 Storms

Ineligible Tree Debris

Tons per acre

- 0.67
- 0.68 - 1.1
- 1.2 - 1.1
- 1.2 - 1.4
- 1.5
Estimated Debris from 2004 Storms

Debris grand total

Tons per acre

- 1.2
- 1.3
- 1.4 - 1.6
- 1.7 - 2.0
- 2.1 - 2.2
Session Break
Hurricane Simulation and Debris Assessment, PART II

Category 5 “Katrina” Scenario
Part II: HAZUS-MH Hurricane Simulation and Debris Assessment: Worst case “Katrina” storm

► Model the impacts that a hypothetical category 5 storm would have on the five counties

► Each scenario builds on the 2004 storm tracks, ramped up to strong category 5, a "worst case" scenario
Worst case category 5 scenario: Escambia

Storm parameters:

- Storm path remains same as Ivan
- Assistance from NWS meteorologists

User Defined Storm Track Input Data

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Landfall
Worst case category 5 scenario: Escambia

Winds

Gusts > 160 mph
Worst case category 5 scenario: Escambia

Max Sustained
>127 mph
### Worst case category 5 scenario: Escambia

#### Damage and loss estimates

<table>
<thead>
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<th>Scenario Results</th>
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<tbody>
<tr>
<td><strong>Number of Buildings Damaged</strong></td>
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<td>Severe</td>
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<td>Destruction</td>
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<td><strong>Total</strong></td>
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<table>
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<th>Shelter Requirements</th>
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<td><strong>Displaced Households (# Households)</strong></td>
</tr>
<tr>
<td><strong>Short Term Shelter (# People)</strong></td>
</tr>
<tr>
<td><strong>Economic Loss ( $ Millions )</strong></td>
</tr>
<tr>
<td><strong>Capital Stock</strong></td>
</tr>
<tr>
<td><strong>Residential Property</strong></td>
</tr>
<tr>
<td><strong>Commercial Property</strong></td>
</tr>
<tr>
<td><strong>Other Property</strong></td>
</tr>
<tr>
<td><strong>Business Interruption (Income)</strong></td>
</tr>
<tr>
<td><strong>Total Direct Economic Loss</strong></td>
</tr>
</tbody>
</table>
Worst case category 5 scenario: Escambia

Debris estimates

- Brick, wood, and other
- Concrete and steel
- Eligible tree debris
- Total tree debris

Escambia County, Florida Hurricane Simulation and Damage Assessment

Scenario: Worst Case Category 5

Debris (tons/acre)
Brick and wood
- 0.39 - 1.98
- 1.99 - 12.54
- 12.55 - 21.15
- 21.16 - 27.46
- 27.47 - 35.08
- 35.09 - 40.87
- 40.88 - 52.99

Worst Case Cat 5
Worst case category 5 scenario: Escambia

Debris estimates

- Brick, wood, and other
- Concrete and steel
- Eligible tree debris
- Total tree debris
Worst case category 5 scenario: Escambia

Debris estimates

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- Total tree debris
Worst case category 5 scenario: Escambia

Debris estimates

- Brick, wood, and other
- Concrete and steel
- Eligible tree debris
- Total tree debris
Estimated Debris - Worst Case Cat 5 Storms

HAZUS Debris Estimates for Category 5 Worst Case Storms, by County

- Gkeechobee
- DeSoto
- St. Lucie
- Escambia
- Charlotte

- Reinf. Concrete & Steel
- Brick, Wood & Other
- Eligible Tree Debris
- Subtotal w/out ineligible
- Ineligible Tree Debris
- Total

Tons (in thousands)
Estimated Debris - Worst Case Cat 5 Storms

Debris grand total
Tons per acre
- 5.0
- 5.1 - 5.0
- 5.1 - 13
- 14
- 15 - 14

IVAN
CHARLEY
FRANCES
Estimated Debris - Worst Case Cat 5 Storms

Concrete & Steel Debris

Tons per acre

- 0.26
- 0.27
- 0.28 - 0.62
- 0.63 - 1.2
- 1.3 - 1.5

St. Lucie
Worst case: 300x Frances
Estimated Debris - Worst Case Cat 5 Storms

Brick, Wood & Other Debris

Tons per acre

- 1.3
- 1.4
- 1.5 - 5.7
- 5.8 - 7.2
- 7.3 - 9.7

St. Lucie
Worst case:
>30x Frances
Estimated Debris from Worst Case Cat 5

Eligible Tree Debris

Tons per acre

- 0.13
- 0.14
- 0.15 - 0.52
- 0.53 - 0.71
- 0.72 - 1.1
Estimated Debris - Worst Case Cat 5 Storms

Debris subtotal (excluding ineligible trees)

Tons per acre

- 1.7
- 1.8
- 1.9 - 7.4
- 7.5 - 9.1
- 9.2 - 12
Estimated Debris - Worst Case Cat 5 Storms

Ineligible Tree Debris

Tons per acre
- 2.0
- 2.1 - 3.2
- 3.3
- 3.4 - 5.2
- 5.3 - 5.4
Estimated Debris - Worst Case Cat 5 Storms

Debris grand total

Tons per acre
- 5.0
- 5.1 - 5.0
- 5.1 - 13
- 14
- 15 - 14

IVAN
CHARLEY
FRANCES
Trend Analyses and Future Activities

![Graph showing trend analysis]

- Building Damage vs. Total Units
  - R² = 0.9765

![Maps showing urban conservation changes from 2005 to 2060]

- Urban
- Conservation
Trend Analyses

Trend analyses were prepared to determine the extent of damage to buildings and debris generation associated with intensity of peak and sustained wind speeds.

Results indicate that little building damage occurs until peak wind speeds exceed approximately 90 mph. Beyond this point, the increase in damage and building debris generation increases exponentially with respect to increases in peak wind speed.

However, significant damage to buildings from fallen trees and, significant vegetative debris generation is likely at sub-hurricane wind speed.
Trend Analyses – Building Damage

![Graph showing the relationship between peak windspeed (mph) and building damage (% Total Units). The graph has a trend line with an R² value of 0.9464.]
## Trend Analyses – Building Damage

<table>
<thead>
<tr>
<th>CAT</th>
<th>Destroyed</th>
<th>Severe</th>
<th>Moderate</th>
<th>Minor</th>
<th>Total Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT &lt;1</td>
<td>0.0%</td>
<td></td>
<td></td>
<td></td>
<td>100.0%</td>
</tr>
<tr>
<td>CAT 1</td>
<td>10.0%</td>
<td></td>
<td></td>
<td></td>
<td>90.0%</td>
</tr>
<tr>
<td>CAT 2</td>
<td>20.0%</td>
<td>30.0%</td>
<td>40.0%</td>
<td></td>
<td>70.0%</td>
</tr>
<tr>
<td>CAT 3</td>
<td>30.0%</td>
<td>40.0%</td>
<td>50.0%</td>
<td></td>
<td>60.0%</td>
</tr>
<tr>
<td>CAT 4</td>
<td>40.0%</td>
<td>50.0%</td>
<td>60.0%</td>
<td></td>
<td>50.0%</td>
</tr>
</tbody>
</table>

The chart illustrates the distribution of building damage across different categories, showing the percentage of units affected by each damage level.
Trend Analyses – Debris

**Wind Speed**
- Total Debris (tons) vs. Max Sustained Windspeed (mph)
  - $R^2 = 0.7875$
- Total Debris per Capita (tons) vs. Peak Windspeed (mph)
  - $R^2 = 0.6672$

**Population**
- Total Debris (tons) vs. Max Sustained Windspeed (mph)
  - $R^2 = 0.6545$
- Total Debris per Capita (tons) vs. Peak Windspeed (mph)
  - $R^2 = 0.8049$

**Buildings**
- Total Debris per Building (tons) vs. Peak Windspeed (mph)
  - $R^2 = 0.6545$
- Total Debris per Square Mile (tons)

**Land Area**
- Total Debris (tons) vs. Max Sustained Windspeed (mph)
Trend Analyses – Debris

R² = 0.9265
Trend Analyses – Debris

![Graph showing the relationship between Total Debris per Urban Density (tons/capita/sq mile) and Max Sustained Windspeed (mph). The graph has a linear trend line with an R² of 0.9264. The equation is: Total Debris = 0.0003 * Max Sustained Windspeed + 3.4689.](image-url)
Trend Analyses – Debris

[Bar chart showing the breakdown of debris by category (CAT) and type (Tree (ineligible), Tree (eligible), Building)]
Trend Analyses - Debris

- Hurricane Debris Estimating Model
  - Developed by the U.S. Army Corps of Engineers
  - Based on actual data from Hurricanes Frederic, Hugo and Andrew and has a reported accuracy of +/- 30%
  - Assumes approximately 30% of the debris will be clean woody wastes; remaining 70% assumed to be mixed (C&D) debris
  - Of the 70% mixed C&D, 42% is assumed to be burnable after sorting, 5% is soil, 15% are metals and 38% landfill
Trend Analyses - Debris

Hurricane Debris Estimating Model

\[ Q = H \times C \times V \times B \times S \times Z \]

where:
- \( Q \) = the quantity of hurricane-generated debris, \( \text{yd}^3 \)
- \( H \) = the estimated number of households impacted
- \( C \) = a storm category factor, \( \text{yd}^3 \)
- \( V \) = a vegetation characteristic multiplier
- \( B \) = a commercial/business/industrial use multiplier
- \( S \) = a storm precipitation characteristic multiplier
- \( Z \) = percentage of land area impacted
## Trend Analyses - Debris

<table>
<thead>
<tr>
<th>Hurricane Category</th>
<th>Value of “C” Factor (yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetative Cover</th>
<th>Value of “V” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.1</td>
</tr>
<tr>
<td>Medium</td>
<td>1.3</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.5</td>
</tr>
</tbody>
</table>
## Trend Analyses - Debris

<table>
<thead>
<tr>
<th>Commercial Density</th>
<th>Value of “B” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.0</td>
</tr>
<tr>
<td>Medium</td>
<td>1.2</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Precipitation Characteristic</th>
<th>Value of “S” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>None to Light</td>
<td>1.0</td>
</tr>
<tr>
<td>Medium to Heavy</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Trend Analyses – Debris

HAZUS vs Corps of Engineers (FEMA Pub 325)
Trend Analyses – Debris

**Simulation vs Actual**

**Hurricane Ivan, 2004**

- **HAZUS**: 928,515 tons
- **COE (FEMA)**: 1,393,961 tons
- **Actual**: 1,519,747 tons
Trend Analyses

► Variance in damage and debris output increases significantly with increase in storm intensity

► Ratio of building vs. tree debris increases significantly with increase in storm intensity

► Slightly higher correlation of building damage and debris to maximum sustained wind
  • Cycle fatigue and progressive failure vs. catastrophic failure
Future Activities

Service

- HAZUS simulations (state, regional and county)
  - Building damage
  - Debris generation
  - Displaced populations and shelter requirements
  - Emergency services impacts
  - Flooding and storm surge (SLOSH)
  - Economic loss

- Alachua, Charlotte, DeSoto, Escambia, Nassau, Okeechobee, St. Lucie
Future Activities

► Research

• Building mitigation
  – Property appraiser data
  – Manufactured housing
    • Improvements to 1994 HUD Code and 1999 FAC 15-C
    • 2002 FBC add-on structures
  – Site-built housing and commercial buildings
    • Improvements to 2002 FBC and (Miami-Dade) PAS
      • Roof coverings and sheathing attachment
      • Door and window impact resistance

• Infrastructure
  – Transportation, utilities, etc.
Future Activities

►Research (con’t)

• Landscape design
  – Satellite tree survey, type and distribution of vulnerable species

• Land use planning
  – 2020 and 2050 state comp plans and future growth
  – Climate change
    • Storm intensity and frequency (ASCE-07 wind zones)
    • Sea level rise

• Injury and fatality simulations
  – Flood, storm surge, population density, socioeconomics, etc.
  – USAR and first response
  – Clean-up and recovery workers
HAZUS Resources

► www.HAZUS.org
► www.HAZUS.org/SEHUG
► www.flhug.HAZUS.org

► For more information about the Florida Hurricane Simulation and Damage Assessment project, contact:
  • Kevin R. Grosskopf: kgro@ufl.edu
  • Eric W. Kramer: ekramer@ufl.edu
Discussion

Questions and comments?
References

