Assessing Storm Damage in Urbanized Landscapes: Preparation, Response & Recovery

David Bloniarz, USDA Forest Service
Why Prepare?
Tornados

Thunderstorms & Wind

Snow
Any Time, Any Place....
1997 April Fool’s Day Blizzard

March 31 - April 1, 1997

Snowfall (inches)

NESIS = 2.29
Category 1
1997 April Fool’s Day Blizzard

- 700,000 customers Lost Electricity
- Nearly 13% of New England lost power
- Boston's greatest April 24-hr snowfall
1998 Northeast Ice Storm Storm
FEMA Disaster Aid

[Map showing areas affected by ice and flooding damage in January 1998, with states such as ME, NH, VT, and NY prominently displayed.]
Tree Damage
Transmission tower outside Montreal
Urban Core Impacts

Downtown Montréal
Landscape Scale Damage

Central Vermont - January 1998
Historical Tracks of US Hurricanes
Isabel 2003: “A Storm of Trees”

COPING WITH ISABEL: WHAT YOU NEED TO KNOW

1.8 million Dominion customers lost power
Northern end of Hatteras Village decimated
At least 17 in four states reported dead

SWEPT AWAY

The Virginian-Pilot

THE IMPACT
"Catastrophic" damage done to power grid, officials say

APPEARANCE
From downed lines to water, problems Isabel left behind

Hatteras Village isolated after hurricane cuts island in half

The Virginian-Pilot

Saturday, September 20, 2003

12 YEARS OF SPECIAL COVERAGE INSIDE: TIP, CLUES AND TACTICS TO USE AND WHERE TO GET HELP.

Tornado Watch in effect until 11 p.m. for the Outer Banks, including Hatteras Island. A tornado warning is active for the Outer Banks and Wrightsville Beach until 4 p.m.

N. Carol., VA: Power outages, fires, and more

A power outage has been reported in the Hatteras area.

The storm has caused widespread power outages in the Outer Banks area.

At least 17 deaths have been reported in four states.

Hatteras Island, NC: Evacuations, power outages

Evacuations have been ordered in Hatteras Island, NC due to the storm.

Power outages are widespread in the area.

The storm has caused significant damage to power lines.

Isabel 2003: “A Storm of Trees”

Hurricane Isabel
September 18, 2003 12:30 PM

Coping with Isabel:
What you need to know

1.8 million Dominion customers lost power
Northern end of Hatteras Village decimated
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Isabel 2003: “A Storm of Trees”
Isabel 2003: “A Storm of Trees”

- Affected Maryland and Washington, DC
- $945 million (2003 USD, ($1.13 billion 2011 USD)
- Highest Sustained Winds 60 MpH
- Over 2 million households/businesses lost power
Isabel “wreaked havoc on the forest of urban and suburban trees… Many of them are so big that, when blown over by tropical storm-force winds, they’re likely to find a power line that was once thought safely distant.”

- Pat Michaels
  Virginia State Climatologist
Katrina: Beyond the Trees

- $81 Billion in damage
- 1,836 fatalities
- 80% New Orleans submerged
- 3 million without electricity
- 90,000 sq miles declared disaster
Katrina: Beyond the Trees
Katrina: Tree Loss


- 5 million acres affected
- 320 million trees lost
Western/Central Massachusetts
June 1, 2011 Tornado
Western/Central Massachusetts
June 1, 2011 Tornado
On the ground response and action
On the ground response and action
Storms Over The Urban Forest
Planning, Responding and Regreening--A Community Guide to Natural Disaster Relief

Tree Emergency Plan Worksheet
For Urban and Community Foresters, Conservationists, Community Leaders, Public Works Departments, Planners, Councils, and other Public Officials

1. Early Warning System/Weather Forecasting Service...etc.
2. Local Emergency Manager... etc.
3. Public Relations Coordinator... etc.

An Initial Storm Damage Assessment Protocol for Urban and Community Forests
January 2001
Developed by
USDA Forest Service
Northeast Center for Urban and Community Forestry
University of Massachusetts, Amherst
Amherst, MA 01003

Urban Tree Risk Management:
A Community Guide to Storms and Ice Storms
The Development of Ice Storm-Resistant Urban Tree Populations

TREES AND ICE STORMS
PUBLIC OFFICIALS

Developed by
Community Forestry Education Project
Consultative Extension of Monroe County
Rochester, NY

August 2000

Supported by a grant from
USDA Forest Service, Northeastern Region
through the Northeast Center for Urban and Community Forestry
Amherst, MA
Chapter 1  Introduction
Chapter 2 Coping with Natural Disasters
Chapter 3 Preparing for Natural Disasters
Chapter 4 Natural Disaster Alert, Response and Recovery
Chapter 5 Regreening the Community
Chapter 6 Approaches to Working With Disaster Relief Organizations
Chapter 7 Tornado Releaf - A Case Study
Chapter 8 Notes from Hurricane Andrew
Chapter 10 References
Chapter 11 Appendix - Key Words

http://www.na.fs.fed.us/urban
Tree Emergency Plan Worksheet
For: Urban and Community Foresters, Community Leaders, Public Works and Parks Departments, Planners, Councils, and other Public Officials.

1. Early Warning System/Weather Forecasting Service — Use an early warning procedure to enhance mitigation: communicate with the National Weather Service, a consulting meteorological firm, a designated television weather channel, or the local police department. With a procedure in place, you should have at least three hours of lead time before most tree damaging weather strikes.

   Staff Lead: ____________________________  
   Contact Name: ____________________________  
   Address: ____________________________  
   Phone: ____________________________  
   Mobile: ____________________________  
   FAX: ____________________________  
   Email: ____________________________  
   Web Site: ____________________________  

   Description of services provided:

2. Local Emergency Manager — Lead contact for a community and responsible for emergency planning and response activities.

   Name: ____________________________  
   Phone: ____________________________  
   Mobile: ____________________________  
   Role(s): ____________________________  

3. Public Relations Coordinator — This is the individual responsible for primary public relations, media contacts, citizen information and communications about the natural disaster. (Must have full knowledge of damage, community issues and capabilities, and be able to make decisions.)

   Name: ____________________________  
   Phone: ____________________________  
   Mobile: ____________________________  
   Alternate(s): ____________________________  
   Name: ____________________________  
   Phone: ____________________________  
   Mobile: ____________________________  
   Name: ____________________________  
   Phone: ____________________________  
   Mobile: ____________________________  

http://www.na.fs.fed.us/urban
Tree Emergency Plan Worksheet

http://www.na.fs.fed.us/urban
Tree Emergency Plan Worksheet

11. Procedure for Debris Staging and Removal
   - Identify several sites for debris staging and processing areas. Establish a contract or agreement securing each site. Choose a processing site that is large, flat, well-drained, and accessible to roads that can sustain truck weights of at least 30 tons per area. Ensure that the site is located at least 100 feet away from residential areas. Identify multiple sites. Annually reevaluate access and availability to those sites. Make sure the site is large enough for safety considerations and can accommodate large truck movements. (Spring debark is also possible; identify sites that can be accessed for debarking.)

Site 1 - Location: ___________________________
   Contact name/role: _______________________
   Phone: ________________________________
   Mobile: ______________________________

Site 2 - Location: ___________________________
   Contact name/role: _______________________
   Phone: ________________________________
   Mobile: ______________________________

Site 3 - Location: ___________________________
   Contact name/role: _______________________
   Phone: ________________________________
   Mobile: ______________________________

12. Debris and Brush Removal from Private Property
   - Identify how you will address this issue. A major storm makes it difficult for public property owners to remove brush and debris. Make a decision to address this issue immediately for debris collection and disposal. Review the city's debris collection guidelines for residents and businesses. Specify the types, amounts, and pricing arrangements for the quantities of materials that you will avoid. Cities can also assist private property owners by contracting with private companies for debris collection and removal by preparing a list of companies that are licensed, professionally insured, and insured.

Person Responsible: _______________________
   Phone: ________________________________
   Mobile: ______________________________

Major Storm Policy:

Minor Storm Policy:

Listing of available low-rate companies:

http://www.na.fs.fed.us/urban
An Initial Storm Damage Assessment Protocol for Urban and Community Forests

January 2001

Developed by
USDA Forest Service
Northeastern Forestry Institute
Amherst, MA 01003

Additional Resource:
Donnelly Resource Group
600 N Hicks Road
Naples, NY 144512

Urban Tree Risk Management:
A Community Guide to Program Design and Implementation
Estimating Storm Damage Costs
What is i-Tree?

A suite of tools to assess urban vegetation and their ecosystem services and values

i-Tree™ Eco
i-Tree™ Streets
i-Tree™ Storm
i-Tree™ Species
i-Tree™ Vue

v. 3.0 programs
Public-Private Partnership

- USDA Forest Service
- Davey Tree Expert Co.
- National Arbor Day Foundation
- Society of Municipal Arborists
- International Society of Arboriculture
- Casey Trees
Goals

- Simple and low-cost tools and methods to aid in forest planning and management
- Complete process – start to finish
i-Tree Version 4.0

- 5 New or Enhanced Tools
How Does Storm Work?

- Context of Use
- Sampling
- Data Collection
- PDA & Desktop Features
Context of Use

Planning
- Framed by overall natural disaster plan
  - FEMA funding: Pre-Disaster Mitigation Program
  - Tree Emergency Plan Worksheet (Burban)

Recovery
- First 24-36 hours
- Response to state emergency agency
The SDAP Process

An Initial Storm Damage Assessment Protocol for Urban and Community Forests

i-Tree Storm

Random Plots

Pre-Storm Sample Survey

Estimating Engine

Post-Storm Survey

Final Damage Estimate
Components

i-Tree Storm

Data Collection - Paper

Data Collection - PDA

Plot Generator

Data Storage & Processing

Sampling Tools

Reporting
Sampling Methods

- 2-3% of blockside mileage
  - Blockside = street segment between road/street corners or ends

- Manual Method or Computerized Process
  - Random selection
  - 10 blockside minimum needed for analysis
Sampling Methods
Manual Sampling Method
The Smarter Way

Example: Hornell, NY
TIGER/Line Files, Redistricting Census 2000

Content Citation:
Title of Content: TIGER/Line Files, Redistricting Census 2000
Type of Content: Downloadable Data
Content Publisher: U.S. Bureau of the Census
Publication Date: 2000-02-01

Content Description:
Content Summary: The Redistricting Census 2000 TIGER/Line files are an extract of selected geographic and cartographic information from the TIGER data base. The geographic coverage for a single TIGER/Line file is a county or statistical equivalent entity, with the coverage limited to 2000 legal boundaries. A complete set of Redistricting Census 2000 TIGER/Line files includes all counties and statistically equivalent administrative areas, including States and Puerto Rico. The Redistricting Census 2000 TIGER/Line files consist of line segments representing physical features and administrative boundaries.

Content Purpose: In order for others to use the information in the Census TIGER data base in a geographic information system (GIS) and for other geographic applications, the Census Bureau releases to the public extracts of the data base in the form of TIGER/Line files.

Content Themes: Administrative and political boundaries

Source of TIGER/Line data as shape files
Map of Sample Plots
Components

i-Tree Storm

Sampling Tools

Data Collection - Paper

Data Collection - PDA

Data Storage & Processing

Reporting
Data Collection

Data Collection- Paper

Data Collection- PDA
Using i-Tree Storm

- Examples of Applied Use
- Success Stories
- Other Points
Data Collection

**Form 5A**

**POST-Storm Field Data Collection Sheet (Populated Areas)**

<table>
<thead>
<tr>
<th>Community Name</th>
<th>Plot Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Street</td>
<td>To Street</td>
</tr>
<tr>
<td>Date</td>
<td>Plot Length (ft)</td>
</tr>
<tr>
<td>ROW Width (ft)</td>
<td>Collected by</td>
</tr>
</tbody>
</table>

Start of plot description:

End of plot description:

<table>
<thead>
<tr>
<th>ROW Trees ONLY</th>
<th>ROW + 50' Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree Removal</strong></td>
<td><strong>Tree Pruning</strong></td>
</tr>
<tr>
<td><strong>DBH Range</strong></td>
<td><strong>Total Trees</strong></td>
</tr>
<tr>
<td>6-12</td>
<td>3.2</td>
</tr>
<tr>
<td>13-18</td>
<td>5.1</td>
</tr>
<tr>
<td>19-24</td>
<td>7.7</td>
</tr>
<tr>
<td>25-30</td>
<td>9.2</td>
</tr>
<tr>
<td>31-36</td>
<td>12.5</td>
</tr>
<tr>
<td>37-42</td>
<td>19.4</td>
</tr>
<tr>
<td>43+</td>
<td>29.0</td>
</tr>
</tbody>
</table>

**Total** | 721-800 |

1. Flat is measured during setup. Note any trees and plot number.
2. Trees are assumed to be at least 10 feet from the edge or right-of-way.
3. Cuts are assumed to be used at 40 cubic yards for the total plot.
4. For park larger than 500 ft, report average cubic yards per total cubic yards.
5. Average = Total + number of 100-feet intervals (in centimeters).

**i-Tree Storm**

[Image of i-Tree Storm software interface on a handheld device]
Overview: Pre-storm setup

- Create random sample
  - Before emergency!
  - Use electronic or manual means
- Measure **tree density and size class**
  - Within ROW
  - Also 50’ back from ROW edge
- Take final steps
  - Pre-Storm report form: useful estimate
  - Storage for future use
Data collection: paper forms

- In disaster work, good reason to keep paper as option
  - Electricity not a concern
  - Damage possibility minimal
  - Reduces training needed
- Forms for many different situations
- Copies in User’s Manual, or on web
POST-Storm Field Data Collection Sheet (Non-linear Maintained Areas)

Community/Facility Name:
Survey Area Location:
Collected by:
Date:

Measurements to relocate the plot center:
Net point:
Compass bearing:
Distance:

Plot extent post-center marker (Y/N):
Marker Type:
Other:

Maintained Trees:

<table>
<thead>
<tr>
<th>Tree Diameter</th>
<th>Stems Per</th>
<th>Total Stems</th>
<th>Total Hours</th>
<th>Total Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per Tree</td>
<td>Removal</td>
<td>Per Tree</td>
<td>Removal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td></td>
<td>3.2</td>
<td>5.10</td>
<td></td>
</tr>
<tr>
<td>10-18</td>
<td></td>
<td>5.1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>18-24</td>
<td></td>
<td>6.1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>24-30</td>
<td></td>
<td>5.1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>30-40</td>
<td></td>
<td>5.1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>40+</td>
<td></td>
<td>5.1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL:

Completion Date:

TOTAL:

Cent: Cubic Yards:

NOTE:
- Fill in the total area under the table and the percentages at the top of the column.
- Include all dead and removed trees.
- Include woody debris and fallen branches.
- Include all areas affected by the storm.
Data collection: data entry

- Paper forms only
- Easiest to use Excel’s entry form
  - Highlight top row of headers
  - On menu, click Data → Form
- Can also just start typing at cell A1
Data Collection: Desktop Interface

- Manage Users
- Community Values
- Reference Data
  - TIGER
  - manual
- ROW Info
- Export Data
Data Collection: Desktop Interface

Setup Questions: i-Tree Storm

1. What is your cost per CuYd for total debris management?

2. Tree removal  Hourly rate?  $55.00

3. Tree pruning  Hourly rate?  $55.00

4. What is the street mileage of all roads you manage?  8.0

5. What was the source of your tree density numbers?

6. What sampling method did you use?

7. How did you get your post-storm information?

8. How many hours does it take to remove and prune a tree for each size class?

<table>
<thead>
<tr>
<th>DBH class</th>
<th>Removal Hours</th>
<th>Pruning Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-12</td>
<td>3.70</td>
<td>0.75</td>
</tr>
<tr>
<td>13-18</td>
<td>5.10</td>
<td>1.00</td>
</tr>
<tr>
<td>19-24</td>
<td>7.70</td>
<td>1.50</td>
</tr>
<tr>
<td>25-30</td>
<td>10.20</td>
<td>2.00</td>
</tr>
<tr>
<td>31-36</td>
<td>12.50</td>
<td>3.00</td>
</tr>
<tr>
<td>37-42</td>
<td>20.40</td>
<td>4.00</td>
</tr>
<tr>
<td>43+</td>
<td>28.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Rural (All Trees)</td>
<td>6.20</td>
<td>2.50</td>
</tr>
</tbody>
</table>
Setup Questions: i-Tree Storm Hurricane Adaptation (Beta)

1. What is your cost per CuYd for total debris management?
2. Will you calculate tree removal separately from debris?
3. Will you calculate tree pruning separately from debris?
4. What is the street mileage of all roads you manage?
5. Which debris rate do you want to use?
6. How many hours does it take to remove and prune a tree for each size class?

<table>
<thead>
<tr>
<th>DBH class</th>
<th>Removal Hours</th>
<th>Pruning Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-12</td>
<td>3.70</td>
<td>0.75</td>
</tr>
<tr>
<td>13-16</td>
<td>5.10</td>
<td>1.00</td>
</tr>
<tr>
<td>19-24</td>
<td>7.70</td>
<td>1.50</td>
</tr>
<tr>
<td>25-30</td>
<td>10.20</td>
<td>2.00</td>
</tr>
<tr>
<td>31-36</td>
<td>12.50</td>
<td>3.00</td>
</tr>
<tr>
<td>37-42</td>
<td>20.40</td>
<td>4.00</td>
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<td>5.00</td>
</tr>
<tr>
<td>Rural (All Trees)</td>
<td>6.20</td>
<td>2.50</td>
</tr>
</tbody>
</table>
PDA Setup Interface

- Management of process, data and applications
- Simple, intuitive

![PDA and Software Interface](image)
Overview: Post-storm work

- Revisit sample segments
  - Storm or Hurricane: choose estimation method
    - Indirect by average crown loss class
      - 0-25%, 26-50%, etc.
      - Loss category images available from FS
    - All trees within 50’ of ROW
    - Direct as CY of debris
  - Only trees within ROW
    - Hazard pruning by size class
    - Hazard removal by size class
- Enter data, report results
Overview: Validity

- Peer reviewed sampling protocols
- Also: storm type factor
  - Tested for ice storms
    - Low variance
    - 2% sample got within 5% of true value in field test
  - Not tested for wind storms
    - Larger variance
    - May affect required sample size
- Area of ongoing i-Tree research
Estimating Engine

# i-Tree Storm

**Community:** Burlington

**Report Date:** 22-Jul-09

This report was generated by i-Tree Storm v3.0.

**Source:** [http://www.treetools.org](http://www.treetools.org)

<table>
<thead>
<tr>
<th>Component</th>
<th>Estimate</th>
<th>± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removals</td>
<td>94,240</td>
<td>53</td>
</tr>
<tr>
<td>Total Removal Hours</td>
<td>94,240</td>
<td>10,852</td>
</tr>
<tr>
<td>Total Removal Cost</td>
<td>5,183,174</td>
<td>550,986</td>
</tr>
<tr>
<td>Hazard Prune</td>
<td>7,100</td>
<td>665</td>
</tr>
<tr>
<td>Total Pruning Hours</td>
<td>14,769</td>
<td>1,407</td>
</tr>
<tr>
<td>Total Pruning Cost</td>
<td>5812,322</td>
<td>377,397</td>
</tr>
<tr>
<td>Total Debris cu yds</td>
<td>272,285</td>
<td>73,195</td>
</tr>
<tr>
<td>Total Debris Cost</td>
<td>4,084,273</td>
<td>407,325</td>
</tr>
</tbody>
</table>
Data collection: PDA

- Pocket PC only
- Installed on handheld through Start menu
- Data uploaded automatically during synchronization
Reference data (plots)

- **TIGER**
  - Can upload sample TIGER/Line data
  - Same process as described before

- **Manual**
  - Can do own sample from map
  - Must be random

- **For both, recommended**
  - 2% of blocksides
  - 30 minimum (maximum?)
Estimating Costs

### i-Tree Storm

**Community:** Burlington  
**Report Date:** 22-Jul-09

<table>
<thead>
<tr>
<th>Component</th>
<th>Estimate</th>
<th>± SE *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removals</td>
<td>94,240</td>
<td>832</td>
</tr>
<tr>
<td>Total Removal Hours</td>
<td>$4,240</td>
<td>10,852</td>
</tr>
<tr>
<td>Total Removal Cost</td>
<td>$5,183,174</td>
<td>$596,865</td>
</tr>
<tr>
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<td>7,100</td>
<td>665</td>
</tr>
<tr>
<td>Total Pruning Hours</td>
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<td>1,407</td>
</tr>
<tr>
<td>Total Pruning Cost</td>
<td>$812,322</td>
<td>$77,397</td>
</tr>
<tr>
<td>Total Debris cu yds</td>
<td>272,285</td>
<td>27,156</td>
</tr>
<tr>
<td>Total Debris Cost</td>
<td>$4,084,273</td>
<td>$407,325</td>
</tr>
</tbody>
</table>

* SE of Total Debris cu yds is calculated only on direct CY estimates; crown loss estimates are ignored.

### COMMUNITY VALUES

<table>
<thead>
<tr>
<th>Street Miles</th>
<th>Removal Cost/hr</th>
<th>Pruning Cost/hr</th>
<th>Brush Cost/cu yd</th>
<th>Based on Sample Data</th>
<th>Precision Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>125.0</td>
<td>$55.00</td>
<td>$55.00</td>
<td>$15.00</td>
<td>Tree density per 100' (ROW + 50')</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>7L</td>
<td></td>
<td></td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DETAILED POST-STORM CALCULATION: Hazard Removal and Pruning

<table>
<thead>
<tr>
<th>DBH Class (inches)</th>
<th>Total of Removal Trees</th>
<th>Removal Time per Tree</th>
<th>Total Hours for Removal</th>
<th>Total Hours ±SE</th>
<th>Total of Prune Trees</th>
<th>Hazard Prune Time per Tree</th>
<th>Total Hours for Hazard Prune</th>
<th>Total Hours ±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-12</td>
<td>9</td>
<td>3.70</td>
<td>33.3</td>
<td>±19.11</td>
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<td>0.75</td>
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</tr>
<tr>
<td>13-18</td>
<td>29</td>
<td>5.10</td>
<td>147.9</td>
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<td>1.00</td>
<td>26.0</td>
<td>±5.76</td>
</tr>
<tr>
<td>19-24</td>
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<td>7.70</td>
<td>192.5</td>
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<td>1.50</td>
<td>35.0</td>
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<td>25-30</td>
<td>31</td>
<td>10.20</td>
<td>316.2</td>
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<td>2.00</td>
<td>46.0</td>
<td>±10.02</td>
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<tr>
<td>31-36</td>
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<td>12.50</td>
<td>300.0</td>
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<td>12</td>
<td>3.00</td>
<td>35.0</td>
<td>±9.36</td>
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<tr>
<td>37-42</td>
<td>12</td>
<td>20.40</td>
<td>244.8</td>
<td>±103.76</td>
<td>12</td>
<td>4.00</td>
<td>45.0</td>
<td>±11.48</td>
</tr>
<tr>
<td>43+</td>
<td>9</td>
<td>28.00</td>
<td>252.0</td>
<td>±59.33</td>
<td>7</td>
<td>5.00</td>
<td>35.0</td>
<td>±8.73</td>
</tr>
<tr>
<td>All Rural</td>
<td>0</td>
<td>6.20</td>
<td>0.0</td>
<td>±0.00</td>
<td>0</td>
<td>2.50</td>
<td>0.0</td>
<td>±0.00</td>
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<tr>
<td>Totals</td>
<td>139</td>
<td>1496.7</td>
<td>112</td>
<td>233.0</td>
<td>822.20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Precision Level indicates overall reliability of input data (see User's Manual).
Storm User's Manual
Storm User’s Manual

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Set-up questions
What kinds of storms do you anticipate? Ice storms, hurricanes and floods, smaller-scale disasters?

Different disaster types present different damage and debris profiles, requiring some adjustment to the use of Storm.

Ice Storms: Ice storms tend to have relatively widespread and uniform damage, and the debris is almost exclusively vegetative. Furthermore, the ice-laden debris usually remains at its initial landing place and is not moved around by natural forces. These characteristics permit quick, accurate estimates of potential and actual damage and costs from a small random sample.
Hurricanes and floods: Hurricanes and many floods also produce widespread damage, and Storm will work well to produce a quick estimate of actual damage and costs. A Hurricane Adaptation has been incorporated into Storm that makes use of actual data and practices from a 10% random sample of communities in Florida following the 2004-2005 hurricane seasons. For pre-storm assessments, the Hurricane Adaptation version (beta) predicts average vegetative debris loads based on street mileage and a choice of three damage levels. Because general averages are used, the estimates tend to be more accurate at the larger scale than at the very local level.

What Type of Storm?
Smaller-Scale Disasters: Smaller-scale disasters, including tornados, derechos (straight-line storms associated with thunderstorms), and some floods, present sampling problems since they affect smaller areas. To estimate the damage caused by smaller-scale disasters, the following procedure may be used:

Determine the rough geographic area affected by the disaster. It may be necessary to assess this based on a quick survey of the area, for example, by driving toward the area from different directions and noting where the damage begins, or by using aerial data if available.

Draw a boundary around the affected area on a street map or in the GIS file used for sampling.

Determine the total street miles in the affected area using the scaled map or standard GIS tools.

Establish a suitable sample of the street segments in the area.
Hurricane Adaptation users must also decide: Will you separate estimates for tree removal and tree pruning from estimates of debris removal?

The data collection protocol differs slightly depending on whether you will bid out emergency work in a lump sum for debris (including pruning and removal), or instead break it up by handling the emergency tree pruning and/or removal with a different contract.
Does your community include rural (unpopulated) roads?

Data collection for rural roads differs slightly from data collection in populated areas. This is mainly because in populated areas FEMA will reimburse costs for debris that can be hauled to the curbside by residents, so trees 50 ft beyond the right-of-way are included in estimations of potential debris. There are manual forms specifically for rural areas and rural plots can be identified in the plot list and PDA.
Will you collect data using (a) the i-Tree Storm PDA tool, (b) paper forms for manual data entry, or (c) a non-i-Tree platform?

The Storm software package includes a PDA application for use in data collection. Significant updates have been made for i-Tree v. 3.0, and the PDA application now works seamlessly from within Storm. The program will work with Pocket PC devices running Window’s Mobile 2003 (or later).

If your community lacks funding to support the use of PDAs or you simply prefer to use an alternate method, that’s no problem. Data collection can be conducted using the paper forms in the Appendix, spreadsheets, etc. If you use the paper forms, data can later be entered directly into Storm’s Excel Template. If you would like to use a non-i-Tree platform, look over the data requirements on the forms to get an idea of what is needed. It’s a good idea to have the paper forms ready no matter what your decision, as storm-related power outages are likely.
Springfield Massachusetts
June 1, 2011 Tornado
Tornado Damage Quick Facts
Impacts on Springfield’s Street Trees

On June 1, 2011 a series of three tornadoes ripped through Western Massachusetts, including the second strongest tornado ever recorded in Massachusetts, with wind speeds estimated at 136 to 143 mph, according to the National Weather Service. The most severe tornado was the EF-3, on the Enhanced Fujita Damage Classification Scale, that carved a half-mile-wide path for 10 miles from Westfield to Charlton, killing three people and injuring 200. In Springfield, the tornado impacted city’s north and Big Concourse, East Forest Park and Summer Acres neighborhoods.

In the neighborhoods of Springfield affected by the storms, damage to the street trees was extensive, destroying or severing many of the public trees growing in these areas. A team of U.S. Forest Service and City of Springfield personnel conducted a preliminary review of the storms in those neighborhoods, and an initial summary of the storm impacts was developed.

A preliminary review of the storm damage to Springfield public street trees follows here:

- 87% of the 440 total miles of city streets were impacted by the storms.
- 14.1% of Springfield’s streets showed some damage to the public trees growing on them.
- 31.6 miles (8%) of the 416 street trees, growing in the impacted areas, were destroyed or severely damaged, accounting for 38% of Springfield’s street trees.
- Immediate impacts include the reduction of carbon dioxide by 1,949,512 pounds.
- Reduced storage of 7,220,000 gallons of water.
- Approximately 200,000 pounds of tree snags and branches have been lost.

For more information please contact:

David E. Bloemers
U.S. Forest Service Northern Research Station
Ann Arbor, MI

Alessandro R. Spatafora
City of Springfield
Assistant City Forester
aspetoro@ci.spfld.ma.us
### Annual Loss in Benefits of Springfield’s Street Trees

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Quantity</th>
<th>Impact Zone Value</th>
<th>Loss Value</th>
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<tbody>
<tr>
<td><strong>Energy Saved</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Electricity (MWh)</td>
<td>360.6</td>
<td>$18,393</td>
<td>$4,598</td>
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<tr>
<td>Natural Gas (therms)</td>
<td>129,018.6</td>
<td>$85,439</td>
<td>$29,903</td>
</tr>
<tr>
<td>Total ($)</td>
<td></td>
<td>$103,832</td>
<td>$34,501</td>
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<tr>
<td><strong>Carbon Dioxide</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO$_2$ Sequestered (lbs)</td>
<td>946,377</td>
<td>$3,123</td>
<td>$1,093</td>
</tr>
<tr>
<td>CO$_2$ Released (lbs)</td>
<td>-244,714</td>
<td>-$808</td>
<td>-$283</td>
</tr>
<tr>
<td>CO$_2$ Avoided (lbs)</td>
<td>1,086,259</td>
<td>$3,585</td>
<td>$1,255</td>
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<tr>
<td>Total (lbs, $)</td>
<td>1,787,922</td>
<td>$5,900</td>
<td>$2,065</td>
</tr>
<tr>
<td><strong>Air Quality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoided pollutants* (lbs)</td>
<td>4954</td>
<td>$21,451</td>
<td>$7,508</td>
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<tr>
<td>Deposited pollutants**</td>
<td>4264</td>
<td>$22,958</td>
<td>$8,035</td>
</tr>
<tr>
<td>BVOC emitted (lbs, $)</td>
<td>-1,140</td>
<td>-$2,634</td>
<td>-$922</td>
</tr>
<tr>
<td>Total (lbs, $)</td>
<td>8,078</td>
<td>$41,775</td>
<td>$14,621</td>
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<tr>
<td><strong>Storm Water</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall intercepted (gal)</td>
<td>6,983,576</td>
<td>$555,872</td>
<td>$19,555</td>
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<tr>
<td><strong>Aesthetic/Other</strong></td>
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<tr>
<td>Added Property Value</td>
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<td>$140,569</td>
<td>$49,199</td>
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<tr>
<td><strong>TOTAL VALUE</strong></td>
<td></td>
<td>$347,948</td>
<td>$121,782</td>
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</table>

*NO 2, SO 2, VOC, PM10  **O 3, NO 2, PM10, SO 2
Canopy Analysis of Springfield Tornado Zone
i-Tree Canopy Analysis of Springfield Tornado Zone

- Based on initial estimates, over 13,000 trees were destroyed or severely damaged;
- Immediate impacts include the reduction of rainwater interception by over 7.5 million gallons per year;
- Reduced storage of over 30 million pounds of carbon annually;
- Approximately 1.4 million pounds of sequestered CO2 has been lost.
Micro-climate Changes in Springfield’s Tornado Zone

The June 2011 Massachusetts tornado profoundly altered the landscape over a wide geographic area.

On June 1, 2011 a series of tornadoes ripped through western Massachusetts, and included the second strongest tornado ever recorded in Massachusetts, with wind speeds estimated at 136 to 146 mph, according to the National Weather Service. The most severe tornado was the EF-3 on the Enhanced Fujita Damage Classification Scale, that carved a half-mile-wide path for 59 miles from Westfield to Chariton, killing three people and injuring 126. In Springfield, the tornadoes impacted city’s South End, Upper Hill, Metro Center, Six Corners, East Forest Park and Sodan Acres neighborhoods.
Micro-climate Changes in Springfield’s Tornado Zone
Micro-climate Changes in Springfield’s Tornado Zone
Micro-climate Changes in Springfield’s Tornado Zone

<table>
<thead>
<tr>
<th></th>
<th>Tornado</th>
<th>Non-tornado</th>
<th>Forest</th>
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<tr>
<td>% canopy cover</td>
<td>0.8</td>
<td>44.2</td>
<td>99.7</td>
</tr>
<tr>
<td><strong>Morning (0800 hrs)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>18.2</td>
<td>17</td>
<td>16.6</td>
</tr>
<tr>
<td>%RH</td>
<td>95.4</td>
<td>96</td>
<td>99.4</td>
</tr>
<tr>
<td><strong>Afternoon (1600 hrs)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>26.4</td>
<td>24.6</td>
<td>22.9</td>
</tr>
<tr>
<td>%RH</td>
<td>64.3</td>
<td>67.1</td>
<td>80</td>
</tr>
<tr>
<td><strong>Midnight</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>17</td>
<td>17.1</td>
<td>17</td>
</tr>
<tr>
<td>%RH</td>
<td>97.2</td>
<td>95.2</td>
<td>97.6</td>
</tr>
</tbody>
</table>
Figure 2. Daily street-side temperatures (ºC) by time of day, East Forest Park, Springfield, MA, 30 Aug – 26 Sep 2011.

Daily morning (0800 hrs) temperature (ºC), by tornado effect, 31 Aug - 25 Sep 2011

Daily afternoon (1600 hrs) temperature (ºC), by tornado effect, 30 Aug - 25 Sep 2011

Daily midnight temperature (ºC), by tornado effect, 31 Aug - 25 Sep 2011
June 1, 2011: Springfield in Nature’s Crosshairs

On June 1, 2011 a series of three tornadoes ripped through Western Massachusetts, and included the second strongest tornado ever recorded in Massachusetts, with wind speeds estimated at 275 to 285 mph, according to the National Weather Service. The most severe tornado was the EF-3, on the Enhanced Fujita Damage Classification Scale, that carved a half-mile-wide path for 39 miles from Westfield to Charlton, killing three people and injuring 200.

The main path of the storm followed a track through the city of Springfield, MA impacting many of its neighborhoods including the South End, Ha Corners, O’Hill, Upper Hill, East Forest Park and Sixteen Acres neighborhoods. The tornado resulted in major damage to city infrastructure including many buildings and dwellings, power lines, and public shade trees. In the neighborhoods of Springfield affected by the storms, damage to the street trees was extensive, destroying or severely damaging many of the public trees growing in these areas.

The tornado has left a mark on the City of Springfield that will take many years to erase. This is no more evident than with the loss of the tree resource within the impact zone. The landscape will never be the same as before the storm and it will take many years to recover the canopy cover lost in some areas. While this loss is a tragedy, with reforestation efforts and proper management, the urban forest in these areas can be healthier than it ever has been. There is a great opportunity to apply the latest knowledge and professional practice of urban forestry to ensure healthy and vigorous trees will once again line the streets of the neighborhoods affected.

With your help, Springfield will be able to regreen the devastated neighborhoods and restore its urban forest canopy. Please join in the effort by planting a tree in your own yard, helping to plant trees along our streets and in our parks, or donate your time or funds to neighborhood regreening efforts. With your help, Springfield’s urban forest will be restored... one tree at a time.
Wrap-Up

- Questions
- Discussion
- Other Points