Urban Forests in Florida: Storm Damage Assessment Utility for Estimating Hurricane-Caused Tree Debris[1]

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Why estimate post-hurricane tree debris?

Hurricane events present substantial challenges to Florida cities and counties when responding to storm damage and removing debris. Calculating urban forest debris can help cities improve both their pre-hurricane planning and their post-hurricane response. The ability to plan for potential debris rates before a wind storm and to measure tree debris and other tree-related costs quickly and accurately after a wind storm facilitates the Federal Emergency Management Agency (FEMA) reimbursement process and may indirectly impact communities' relationships with FEMA throughout recovery operations.

A few methods exist for estimating urban forest debris following storms, including models developed by the United States Army Corps of Engineers (USACE), FEMA, and Broward County, Florida. While helpful, these models include assumptions that sometimes render them less helpful and have many limitations as pointed out by Escobedo *et al* (2009). A standardized method for estimating ice storm damage and debris costs is available as the Storm Damage Assessment Protocol (SDAP), or i-Tree Storm, a component of the USDA Forest Service i-Tree program (http://www.itreetools.org). To better estimate debris from trees after hurricanes, in 2008 the University of Florida adapted the SDAP specifically for hurricanes using actual tree debris, windspeed, and landcover data from Florida, and the new hurricane tool, called i-Tree Storm Hurricane Adaptation Utility, is now available on the itreetools Web site. This fact sheet will explain how this tool can be used to better estimate tree debris amounts and cleanup costs for pre-hurricane planning purposes and post-hurricane response.

What are debris estimates based on?

The Hurricane Adaptation Utility has been developed to calculate tree debris caused by storms in Florida (Escobedo *et al*. 2009). The Hurricane Adaptation Utility uses data reported from a random sample of 43 hurricane-impacted Florida communities from the 2004 and 2005 hurricane seasons. Some of the communities were sampled more than once based upon the incidence of two or more hurricane strikes within the 2004–2005

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hurricane seasons. (See fig. 1 and table 1).This Florida-specific debris assessment protocol can estimate potential damage before a storm and report tree debris and damage after a storm. The Hurricane Adaptation Utility is based on data collected from a random sample of communities affected by Hurricanes Charley, Francis, Ivan and Jeanne in 2004 and Dennis, Katrina and Wilma in 2005 (See table 1).

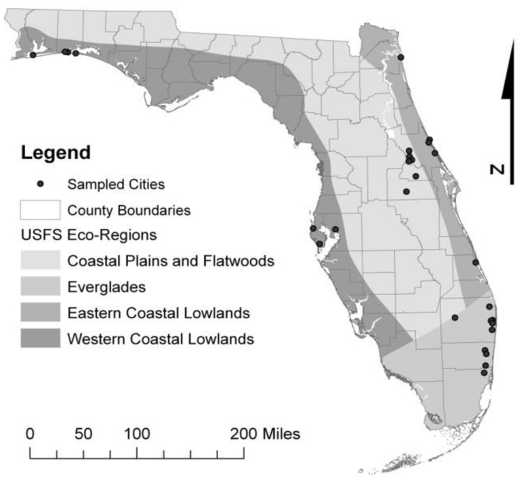

Figure 1. Locations of sampled communities in Florida and delineation of Eco-Regions as defined by the USDA Forest Service.

Average debris totals and costs were determined based on information collected from sampled communities' project worksheet records from 2004 to 2005 (Staudhammer *et al*., 2009). Total debris management costs for all regions averaged $21.50 per cubic yard (CY) for every 100 feet of street in the sampled communities. For the purposes of estimating the volume of downed tree debris, a cubic yard is 100 linear feet of street right of way. Rates of debris production ranged widely according to the strength of the storms. According to its capacity to generate debris, each hurricane was categorized as a low, moderate, or high damage storm. The tree debris averages per 100 feet of street segment were 0.77 CY for low-damage storms, 4.44 CY for moderate-damage storms, and 22.85 CY for high-damage storms. Reported unit tree removal and pruning costs (where available) averaged $447 per individual tree removal and $147 for individual hazard tree pruning. Data from central Florida indicated that the hourly rate for a fully equipped tree crew was $50. These values may be used as defaults for the Hurricane Adaptation Utility, however locally known costs can be substituted in the Utility to calculate a more accurate result.

How debris estimates are made:

The Hurricane Adaptation Utility is an Excel™-based debris spreadsheet and is now available as the i-Tree Storm Hurricane Adaptation Utility (http://itreetools.org/storm/index.php). It uses information commonly available from state, urban, and community forestry coordinators as well as online sources such as Nowak and Greenfield (2009) which provide tree density, storm category, population, tree canopy, and urbanized land cover information for debris calculations. To estimate debris using the tool, users provide data in response to 5 standardized prompts, namely: 1. Costs for debris disposal, 2. If tree removal costs are separate from debris removal costs, 3. If tree pruning costs are separate from debris removal costs, 4. Miles of public streets and, 5. A debris rate of high, medium or low. Specific details can be found in the i-Tree Storm User's Manual (i-Tree 2010). Existing debris rates in the i-Tree Storm Hurricane Adaptation Utility are default values based on state-wide averages reported to FEMA in Florida during the 2004 and 2005 hurricane seasons (Escobedo *et al*., 2009; Staudhammer *et al*., 2009).

How this information can be used:

Values from Table 1 can be used to better understand potential tree debris rates from different hurricane intensities and for pre-hurricane planning purposes. Also, default estimates in the i-Tree Storm Hurricane Adaptation Utility can be improved by adjusting default values with the region-specific data from Table 1. Users can compare their community to other communities with similar population densities, geographic locations, ecoregions, percent tree cover and tree density, and then find the closest match in Table 1 for their forecasted storm in order to estimate the appropriate debris rate to enter in the tool. Advanced users can substitute values from Table 1 for the default debris rate values in "DamageBrush" Tables in the "Codes" worksheet and use Staudhammer *et al.*'s article, "Patterns of urban tree debris from the 2004 and 2005 Florida hurricane season: A technical note" (2009) to adjust debris removal costs for more region-specific values (See i-Tree, 2010 for specific details).

The benefits of improved debris estimation for Florida cities and counties:

Accurate tree debris estimates may improve a community's pre-storm planning and post-storm response. Examples of improvements to storm preparedness may include:

- Development of pre-hurricane planning and post-hurricane response management systems
- Identification of staging sites and development of debris work contracts
- Procurement of contractors and enlistment of additional human resources
- Development of municipal policies and ordinances that improve community effectiveness in the face of future hurricane events
- Improvement of interagency coordination and communications with emergency management agencies.

Estimating hurricane-caused tree debris can be challenging because hurricanes are such complex and varied storms. While the i-Tree Storm Hurricane Adaptation Utility cannot entirely eliminate this complexity, it can improve our ability to estimate hurricane-tree debris generation and assist in storm preparation and response among Florida cities and counties. The tool is currently available and can be downloaded for free as part of the i-Tree suite of urban and community forestry software (www.itreetools.org).

Additional Literature

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Escobedo F., R. Northrop, and W. Zipperer. 2007. Developing an urban forest management plan for hurricane-prone communities. University of Florida- IFAS, EDIS FOR 121/FR176. http://edis.ifas.ufl.edu/document_fr176

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Nowak D.J. and Greenfield E.J. 2009. Urban and Community Forests of the Southern Atlantic Region. USDA Forest Service, Northern Research Station, General Technical Report NRS-50. 90p. http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs50.pdf

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Table 1. Descriptive statistics for a sample of communities affected during the 2004 and 2005 Florida hurricane seasons. Communities generating less than 50 cubic yards per mile for individual hurricanes are not included. Some communities appear more than once due to multiple hurricane landfalls.

Eco-region/city	Hurricane (sustained wind speed; mi/hour*)	% Tree cover**	% Developed land**	% Tree cover in developed areas**	Population density year 2000 (#/mi^2)	Vegetation debris (yards^3/mi)
Eastern Coastal Lowlands						
Atlantic Beach	Frances (54)	26	71	27	3584	160.9
Daytona Beach Shore	Frances (54)	30	41	13	1093	245.4
Edgewater	Frances (54)	33	63	21	1872	374.8
Fort Pierce	Frances (54)	10	81	5	2545	276.6
Port Orange	Charley (68)	28	66	16	1855	973.4
Average	*All storms*	*25.4*	64.4	16.4	2189.8	406.22
Everglades						
Atlantis	Wilma (70)	13	92	11	1463	1573.9
Belle Glade	Jeanne (45)	4	72	2	3206	236.4
Belle Glade	Wilma (70)	4	72	2	3206	1225.2
Golf	Wilma (70)	20	94	19	277	2142.9
Greenacres	Wilma (70)	6	96	4	5918	316.5
Lauderdale Lakes	Wilma (70)	4	95	3	8832	512.3
North Lauderdale	Katrina (52)	9	89	5	8319	54.5
Opa-locka	Wilma (70)	2	95	1	3452	796
Palm Beach Gardens	Frances (54)	23	38	8	630	164.9
Palm Springs	Frances (54)	3	96	2	7261	699.8
Pembroke Pines	Katrina (52)	7	75	4	4466	128.6
Average	*All storms*	*9.1*	84.2	5.9	4382.4	713.73
Coastal Plains & Flatwoods						
Belle Isle	Jeanne (45)	31	63	25	2873	633.8
De Land	Charley (68)	34	63	19	1317	86.4
Debary	Frances (54)	40	46	19	853	475.6
Deltona	Frances (54)	28	68	16	1943	388.2
Orange City	Charley (68)	41	57	18	1091	187.4
Oviedo	Charley (68)	43	47	14	1739	1396.3
Average	*All storms*	*36.2*	57.3	18.5	1636	527.95
Western Coastal Lowlands						
Clearwater	Jeanne (45)	10	91	6	4302	99.6
Destin	Ivan (51)	15	85	13	1477	696.5
Destin	Dennis (64)	15	85	13	1477	119.1
Fort Walton Beach	Ivan (51)	18	95	17	2683	1131.1
Fort Walton Beach	Dennis (64)	18	95	17	2683	714.3
Gulf Breeze	Ivan (51)	45	46	27	1192	3204.5
Gulf Breeze	Dennis (64)	45	46	27	1192	1190.5
Gulf Breeze	Katrina (52)	45	46	27	1192	137.7

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Eco-region/city	**Hurricane (sustained wind speed; mi/hour*)**	% **Tree cover****	% **Developed land****	% **Tree cover in developed areas****	**Population density year 2000 (#/mi^2)**	**Vegetation debris (yards^3/mi)**
Gulf Port	Frances (54)	11	94	9	4422	97.5
Mary Esther	Dennis (64)	26	81	18	2635	182.9
Tampa	Frances (54)	22	78	11	2707	122.8
Average	*All storms*	*21*	81.4	14.4	2774.0	699.7

* Maximum sustained wind speeds at landfall obtained from:http://www.nhc.noaa.gov/tracks/2004atl.gif and http://www.nhc.noaa.gov/tracks/2005atl.gif; **Source: Nowak and Greenfield.