Summary of Methods and Results for SDAP-FL

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Introduction

The current Storm Damage Assessment Protocol (SDAP) is one component of the USDA Forest Service's suite of software and urban forest management tools know as i-Tree. The version of SDAP in i-Tree was developed by the USDA (Dave Bloniarz) and Davey Resource Group (Christopher J. Luley and Jerry Bond) in 2001, with subsequent modification by Jerry Bond while at Davey. Documentation on this history is available on the i-Tree website (www.itreetools.org).

The SDAP version in i-Tree was developed for use primarily for reporting debris and tree damage from ice storm events, although the basic street sampling methods and statistical summaries to estimate damage levels presented in SDAP should also work for wind events. However, ice storm events produce debris and tree damage that is significantly different from wind events in both etiology and distribution. Therefore, the development of hurricane specific data for estimating debris and tree damage appeared warranted.

This project was initiated to obtain debris and tree damage estimates that could be integrated into the current version of SDAP i-Tree with the purpose of developing an SDAP specifically based on and appropriate to Florida hurricanes. The project was initiated in January 2008 and was concluded at the end of March 2008 after approximately 400 man-hours of labor.

Methods

Hurricanes Sampled

All data for the SDAP Florida Hurricane Adaptation were obtained from the 2004-05 hurricane seasons in Florida, and included Jeanne, Ivan, Frances, and Charley from 2004 and Katrina, Dennis and Wilma from 2005 (see the Project CD for "Florida Hurricanes 2004-05 " for all hurricanes for 2004-05). Meteorological summaries of these hurricanes from NOAA are provided in "NOAA reports on the 2004-05 hurricanes" folder located on the Project CD.

Pilot Sample

A pilot sample of hurricanes was selected manually from coastal and inland communities to determine the utility of using Project Worksheets (PW's) for quantifying debris and tree damage and costs for the project. PW's are compiled by each community requesting federal reimbursement for hurricane damage after the declaration of a national emergency by the President of the United States. PW's are categorized by the type of damage involved and are also submitted to the Florida Division of Emergency Management (FDEM), from which they were obtained for this project. Of interest is

Category A, the debris damage category, which also contains data for hazard tree pruning and removal reimbursement when available, and G, the general category that includes Categories A-F.

The pilot sample included two communities from each of the above hurricanes in the 2004-05 hurricane seasons. These communities included Navarre and Santa Rosa (Dennis), Aventura and Miami Gardens (Katrina), Jupiter and Belle Glade (Wilma), Port Charlotte and Orlando (Charley), Stuart and Lakeland (Frances), Pensacola and Milton (Ivan), and Port St. Lucie and Fort Meade (Jeanne). These communities were also contacted by phone to determine if they could provide additional tree damage data (removal and hazard pruning) for the project. The raw data from this pilot sample are provided in the "Pilot sample" spreadsheet located on the Project CD.

Sample Selection

Based on the pilot sample, it was determined that PW's would likely provide adequate debris data but only minimal tree pruning and removal data. Based on this result, a random 10% sample of communities reporting Category A or G (which included A) to the FDEM (see the contents of the folder "Hurricane applicants" for the entire list of communities from which those reporting Category A or G damage category, and "Debris Data---raw" for communities selected for the 10% sample). Because PW's appeared to have limited tree removal and hazard pruning data, selected communities were also called in an attempt to obtain these data directly--without great success as the data are extremely difficult to locate.

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Exclusions

Counties sampled for each hurricane were limited to those highly impacted following FEMA's maps (see contents of the folder "Highly impacted communities by hurricane"). Entities other than communities (e.g., counties, tribes, official departments, hospitals, etc.) were excluded from the sample. Stump removal, for which insufficient data were available, was excluded from the data collection.

Data Acquisition

PW's from the communities in the sample were obtained from FDEM (see Project CD "FEMA Project Worksheets for the sample communities" for PW's). Data for debris and tree damage amounts and costs were taken from the PW's and entered into a spreadsheet (See "Debris Data---raw" on the Project CD). Where applicable, costs deemed not directly related to removal and reduction of debris were included with debris costs in an "other" category. Cost in the other category covered a wide range of items, such as debris monitoring, and were annotated in the spreadsheet as to their source. It should be noted that these PW's vary in terms of both what is reported and how it is reported, rendering data acquisition somewhat time-intensive and data integrity among the communities somewhat compromised.

Tree removal and hazard pruning data reported in the PW's were recorded along with debris in the spreadsheet ("Debris Data---raw"). Tree data were further summarized and characterized as to usefulness by further evaluation of the data presented in PW's (See "Tree work unit cost" on the Project CD for data and summary). A summary of the results of calling communities for tree data is also provided (see "Tree Data -- raw " on the Project CD).

Data Analysis

Debris data from PW's was evaluated after collection and data deemed usable was summarized (see "Summary of debris for sample communities " on Project CD). In the summary, debris data were converted to a total cost per cubic yard, and estimates of debris generation per unit street length were made. Street mileage was obtained using i-Tree's Sample Street Segment Generator with the US Census Bureau's TIGER/Line data in a GIS, and is summarized for the sample communities (see "Street miles for sample " on the Project CD).

Community street tree density data were unavailable to us, so we used whole community tree density as the best available proxy. Relationships between community tree density and debris amounts collected from streets were investigated. Tree density for each community was obtained from Dave Nowak of the USDA Forest Service, Northern Research Station, Syracuse, NY 13210 (see "Florida places tree density " on the Project CD). These data are based on USDA's assessment of tree density using aerial photography analysis. The RPA data set provided a percent canopy coverage for each community. This was converted to tree density by using a nationwide standard of 476.9 trees/ha provided by the USDA (Dave Nowak, email communication, March 6, 2008).

Maximum sustained wind speed data were obtained from tabular data reported for selected communities by NOAA (see "Florida hurricanes 2004-05 " and the contents of the folder "NOAA reports on the 2004-05 hurricanes" on the Project CD). Where wind speed data were not available for a sample community, wind speeds were assigned to sample communities based on nearest community with a recorded windspeed.

Correlations, simple and multiple regressions were made between CY debris per street mile and tree density and maximum sustained wind speed (see "Summary of debris for sample communities " and "Regressions" (PDF) on the Project CD).

Results

Data Collection

Data included in PW's from 68 communities were collected and assessed for debris amounts and cost, and tree hazard pruning and removal information (See "Debris Data -- raw " on the Project CD). From these data, we obtained usable debris amounts and cost data from 41 communities (See "Summary of debris for sample communities" on the Project CD). Tree pruning and removal data were considerably less available, and only 11 communities referenced tree work in their PW's and of these only 5 communities provided usable pruning and removal data for unit cost estimates (See "Tree Data -- raw" on the Project CD). In addition, data provided by email from the City of Winter Park were used in unit cost estimates (cmeeks@cityofwinterpark.org; March 19, 2008; 9:58 am).

No usable data were obtained from any PW for community for tree removal or pruning rates (removal or pruning quantities/total tree population). Data was obtained from calling communities from the contractor Beck Disaster Recovery, Inc. (Orlando) for Pensacola for hurricane Ivan, and for the 2004-05 hurricane seasons from Winter Park.

Debris Removal Costs and Production

Total debris management costs averaged $21.47 for the 41 communities that provided usable data (See "Summary of debris for sample communities " on Project CD). This cost factor for CY debris is presented as a default value in SDAP (rounded to $21.50), a significant increase from the current default value of $6.

Correlations with between maximum sustained wind speeds and debris per street mile from these communities was R = 0.54 and for tree density was R = 0.23 (See "Summary of debris for sample communities " on Project CD). Simple regression equations between wind speeds or tree density were significant, but multiple regressions with both variables showed only the wind speed variable as significant (See "Regressions" on Project CD).

Given the relatively weak correlations and regression using wind speed and tree density, we chose to use the average debris production for damage estimates in SDAP, rather than attempt to develop a predictive model using such uncertain relations. Debris production rates were divided into low, moderate, and high categories, and the average debris production for each was used in the new SDAP Template. These averages were 0.77 CY per 100 feet for low damage, 4.42 per 100 feet for moderate damage, and 24.42 per 100 feet for high damage levels (See "Summary of debris for sample communities " on Project CD).

Tree Removal and Hazard Pruning Costs and Rates

Unit tree removal and pruning costs were obtained from a small number of communities (5) and averaged $447 for tree removals (rounded to $450 for use in SDAP) and $147 for hazard pruning (rounded to $150 for use in SDAP, see "Unit cost calculations " on Project CD). Cost data were unavailable for hourly breakdowns by tree size classes, and the default rates used in SDAP i-Tree 2.0 were used. Data from Orlando (Andy.Kittsley@ci.orlando.fl.us; March 27, 2008; 8:08 am) indicated a per-man hour rate for a fully equipped tree crew was currently $50 per man-hour. This is similar to the $55 per man-hour rate currently suggested for use in SDAP so the current values were not altered.

Street tree removal and pruning rates after hurricanes used in SDAP were derived from Pensacola (See "Pensacola tree work after Ivan" on the Project CD) and Winter Park data (cmeeks@cityofwinterpark.org; March 19, 2008; 9:58 am). Removal rates averaged 0.65% for Pensacola and 3.6% for Winter Park (total removals percentage/3 for the three hurricanes that season) for an overall average of 2%. Pruning rates averaged 34% for Pensacola and 23% for Winter Park (total hazard prune percentage/3 for the three hurricanes that season) for an overall average of 28%. A removal rate of 3% and a pruning rate of 30% are now used for SDAP for hurricane pre-storm estimations based on these limited results. Clearly, it would be desirable to find additional data such as these so that more robust numbers may be used for vegetative debris estimation.

Discussion

A significant difference between ice storm damage clean up and hurricane storm damage clean up appears to be the use of unit costing for tree removals and pruning, or the inclusion of tree removal and pruning costs in debris clean costs. This is suggested by the absence of reported tree removal and pruning data in PW's, the absence of itemized (by diameter class) data for these costs found when calling communities, and more common use of a unit costing approach in PW's.

Although we have concluded based on our limited sample and contact with communities, that itemization of costs for each tree pruned or removed is rare for hurricanes in Florida, FEMA still requests this approach be used in all their formal documentation (See FEMA 325). In fact, many federal reviewers in PW's noted that communities failed to provide photographic documentation of reimbursable costs, and FEMA has recently changed its PW reporting form to emphasize more consistent quantification and unit costing.

There was extremely limited data reported in PW's or available from communities directly to develop any relationships between tree removal and hazard pruning rates and wind speed. In fact, we only obtained usable data from a two communities (Pensacola and Winter Park) that had recorded removal and pruning data by tree as required by FEMA. Therefore, this represents a large area of improvement needed for SDAP for hurricanes. Given the propensity of communities to apparently use unit costing or report removal and pruning costs with debris cleanup, these data will be more difficult to obtain than debris removal estimates. However, knowledge of communities that have tree inventories before hurricanes occurred, and contacting them as potential sources of itemized tree data is one possible method to obtain better data in the future.

End-user Products

The Florida Hurricane Adaptation is based upon the Storm Damage Assessment Protocol, released with i-Tree 2.0 in February 2008. Because of the results of the new research, many large and small differences exist between the new version and the original. The following table summarizes the major changes made to each of the components of the i-Tree version.

Table 1. Major alterations in the Florida Hurricane Adaptation

Component	Alterations
Interface	• Main page revised for increased legibility • Community values page completely redone • VB code altered for new values and template
Template	• Parameters reset for Florida hurricanes • User access greatly improved • Help documents added • Estimates facilitated
User's Manual	• Crown loss method removed • Tree density removed • New installation instructions added • Introduction on storm types rewritten
Paper forms	• Errors corrected • Crown loss and tree density removed • Footnotes revised • Pages restructured for legibility
PDA software	• Not altered

APPENDIX I: Contents of the Project CD

Overview

* Project letter (PDF)
* Summary Methods (PDF)

Applications and Documents

* Template -- Florida (Excel)
* Template -- Florida (Excel 2007)
* Interface -- Florida (Access)
* Paper forms -- Florida (PDF)
* User's Manual -- Florida (PDF)

Data

* Debris data -- raw (Excel)
* Florida hurricanes 2004-05 (Excel)
* Florida places tree density (Excel)
* Street miles for sample (Excel)
* Pensacola and Winter Park tree work (Excel)
* Pilot sample (Excel)
* Summary of debris for sample communities (Excel)
* Regressions (PDF)
* Tree work data -- raw (Excel)
* Tree work unit cost (Excel)

Supporting Documents

* Hurricane applicants (folder)
* Highly impacted communities by hurricane (folder)
* NOAA reports on the 2004-05 hurricanes (folder)
* FEMA Project Worksheets for the sample communities (folder)
* FEMA C&D debris policy 2004-05 (PDF)

APPENDIX II: Regression of debris rate on wind speed

Regression Summary
Veg Rate vs. Windspeed kt

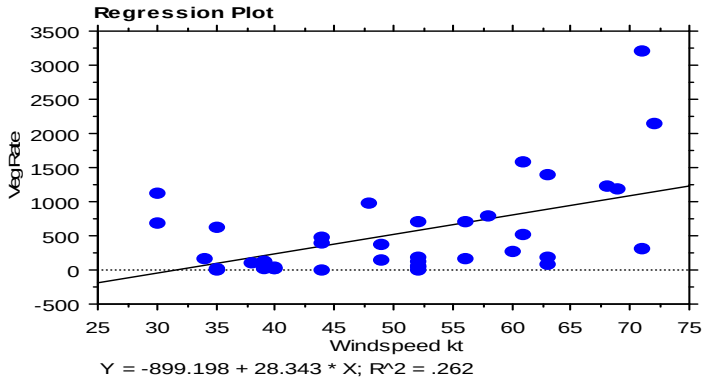
Count	39
Num. Missing	34
R	.512
R Squared	.262
Adjusted R Squared	.243
RMS Residual	590.322

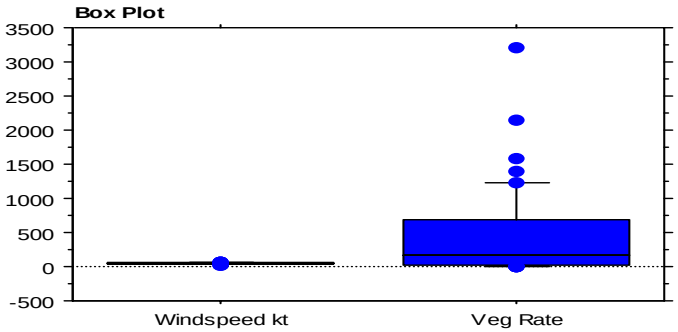
ANOVA Table
Veg Rate vs. Windspeed kt

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	4588011.310	4588011.310	13.166	.0009
Residual	37	12893743.155	348479.545		
Total	38	17481754.465			

Regression Coefficients
Veg Rate vs. Windspeed kt

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-899.198	403.015	-899.198	-2.231	.0318
Windspeed kt	28.343	7.811	.512	3.628	.0009





Descriptive Statistics

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
Windspeed kt	50.171	11.954	1.867	41	30.000	72.000	32
Veg Rate	450.756	647.082	95.407	46	0.000	3204.507	27

Regression Summary
CY per foot vs. 2 Independents

Count	43
Num Missing	2
R	.554
R Squared	.307
Adjusted R Squared	.272
RMS Residual	.116

ANOVA Table
CY per foot vs. 2 Independents

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	2	.239	.119	8.840	.0007
Residual	40	.540	.013		
Total	42	.779			

Regression Coefficients
CY per foot vs. 2 Independents

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-.188	.076	-.188	-2.478	.0175
Sustained Windspeed kt	.005	.002	.433	3.201	.0027
Tree Density # per acre	.001	.001	.260	1.921	.0618