In the United States, it is not a question of whether a severe storm will affect a community, but when it will happen. Large-scale or regional storms that cause excessive tree damage can cripple communities, compromise public safety and typically result in a state of emergency declared at the state or federal level. State emergency management agencies often require communities to submit an initial damage estimate within 12 hours of the end of the storm, even if they have not yet declared a state of emergency. This estimate of storm damage should be realistic and credible, and is necessary in order to initiate the reimbursement process. The question for most community foresters is how to collect reliable information and prepare an initial report in the 12-hour window required by some state emergency management agencies.

The initial estimate of costs related to storm-damaged trees can vary widely between communities, even if the amount or type of damage to the communities is similar. A survey of 14 western Massachusetts communities following a severe winter storm in April of 1997 reported initial estimates of tree damages ranging from $1,000 to $100,000 per community for like amounts of damage.

During a storm emergency, municipal officials often complete the initial damage assessment while involved in crisis management. Communication with emergency response personnel or quick visual surveys of impacted areas are common damage-assessment procedures, but in most cases these are poor indicators of what the storm's total cost will be. Municipalities, trying to manage a crisis, often overlook costly tree problems. Having a storm damage assessment procedure in place before the storm strikes—and a qualified damage assessor assigned to complete the assessment—provides a level of preparedness that will allow municipal officials to concentrate on the emergency-response activities. Once the assessment is completed, it can be forwarded to the proper agencies with little interruption to the municipal storm cleanup process.

Communities have differing needs and resources. Depending on the size of each community, budget and staff, communities will vary in their ability to plan for and respond to natural disasters. This prototype is designed to be adaptable to communities regardless of size, physical layout or level of technology used by a municipality. The result will be a simple, credible and immediate assessment of a community's storm-damaged, street-side trees. The following benefits may also be realized by implementing this procedure:

♦ A damage assessment plan may help set priorities for emergency-response decisions by identifying areas within the community susceptible to tree damage.
♦ An accurate assessment of damage early in the crisis will increase the potential for state/federal reimbursement.
♦ Using a standardized method for assessing tree damage may speed up the reimbursement process.
♦ The entire planning process encourages communication and involvement among municipal departments in planning for storm emergencies.
♦ Communities statewide or regionally can be compared and tallied.

Basic requirements

In order to guarantee effectiveness for this process, the municipality needs to prepare a plan and have it accepted before a storm ravages the area. This storm damage assessment procedure is designed to be adaptable to all types of communities, regardless of size or available technology. Two basic requirements are necessary to set up the planning stage of this process. The first is an accurate base map of the community. This could be as simple as a real estate map or as advanced as Geographical Information System (GIS) data. Other options include topographical maps, aerial or orthophotographs, or a completed street tree inventory in map form. The second requirement is a thorough knowledge of the municipality's road system and community forest. The community forester needs to collect this information and should get the community's municipal departments and emergency managers involved in this planning process.

Getting started

Using the base map, determine the total miles of road in...
the community. This information is readily available from the public works department. Next, locate and mark on the map those roads that have trees growing alongside or near them. This should include all publicly and privately owned trees that could impact public roads during a storm. Those roads that are not under the municipality’s jurisdiction, or do not have potentially damaging trees along them, should not be marked on the map since they normally are not a factor in cleanup efforts by the municipality and are not eligible for state and federal aid. Identifying the roads susceptible to storm damage can be accomplished using aerial photographs, a street tree inventory map, or a windshield survey of the road system. Once identified and marked, estimate the miles of tree-lined roads. This number will be a percentage of the total road miles and will be used when determining sample size.

The key to this system is to establish permanent sample plots that may be surveyed prior to a storm. The sample plots should be randomly chosen from the susceptible areas marked on the base map. The recommended plot size is a 1/10-mile along the road. This distance is easily walked and accurately measured with a vehicle’s odometer. The width of the plot should encompass both sides of the street and be measured as far from the road as necessary to include all trees that may impact the road during a storm. The data collected in each plot will consist of the number of trees, species, height, DBH and proximity to the road. In most cases, a 100 percent inventory can be accomplished.

The sample size will be a percentage of the total of tree-lined streets in the community—divided into numerous sample plots. Ideally, the sample size should be large enough to represent the community’s urban forest, but more importantly, it must be small enough so all the plots can be surveyed in several hours. This sample survey will provide an initial assessment of the storm-damaged trees, rather than the complete tree inventory of a community. Since the plot inventoried 100 percent of the trees that could affect the street, following the storm the assessor can inspect each plot and establish the amount of damage. The intent is to use an established, plausible method to initiate the damage assessment and reimbursement process—something more reliable than a quick windshield damage survey taken immediately following a storm. The results of this assessment are the foundation for a more thorough survey taken in the days after a storm.

**Plot inventory**

The inventory of street-side trees in the sample plots for the storm damage assessment method is similar to a standard street tree inventory, since the trees’ locations, species and size are recorded. It differs from an inventory because it only lists the trees that can affect the street during a storm, and in certain situations, the plot data can be generalized. The objective is to assess how the trees in the sample plot could impact the immediate area during a storm, rather than to determine the exact species, height and DBH of the trees for management purposes. For example, if a plot area is 1/10 mile long and heavily wooded on both sides, tree height and DBH can be estimated, and the trees classified by the type of stand.
Table 1

Priority Rating System

Road System: Set priorities according to use and importance to public safety
Example:
High Priority - main thoroughfares and emergency routes
Medium Priority - secondary roads; residential streets
Low priority - unpaved roads; dead ends; private streets

Land Use: Set priorities according to commercial and residential features such as housing, population and land use.
Example:
High Priority - populated, high-density urban residential areas
Medium Priority - residential neighborhoods; populated rural areas
Low priority - institutional land; private property; low population areas

Street-Side Trees: Set priorities according to the likelihood of trees affecting the street during a storm. Consider the trees' density, height, and proximity to the road.
Example:
High priority - many large trees near the road in a populated area
Medium priority - secondary roads with trees near the street
Low priority - no trees that can affect the road system, private or institutional lands or unpopulated areas (no sample plots will be in low priority areas)

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use</td>
<td></td>
</tr>
<tr>
<td>Area type:</td>
<td></td>
</tr>
<tr>
<td>Industrial/retail</td>
<td>0</td>
</tr>
<tr>
<td>Rural/business district</td>
<td>1</td>
</tr>
<tr>
<td>Suburban residential</td>
<td>2</td>
</tr>
<tr>
<td>Urban residential/emergency facilities</td>
<td>3</td>
</tr>
<tr>
<td>Roads:</td>
<td></td>
</tr>
<tr>
<td>Unpaved dead end</td>
<td>0</td>
</tr>
<tr>
<td>Rural/paved/unpaved</td>
<td>1</td>
</tr>
<tr>
<td>Secondary/neighborhoods</td>
<td>2</td>
</tr>
<tr>
<td>Main thoroughfares/emergency access routes</td>
<td>3</td>
</tr>
<tr>
<td>Street-Side Trees</td>
<td></td>
</tr>
<tr>
<td>Density (spaced along road):</td>
<td></td>
</tr>
<tr>
<td>No trees</td>
<td>0</td>
</tr>
<tr>
<td>Low (&lt;31 m (100 ft) apart)</td>
<td>1</td>
</tr>
<tr>
<td>Med. (15 m (50 ft) to 31 m (100 ft))</td>
<td>2</td>
</tr>
<tr>
<td>High (&lt;15 m (50 ft))</td>
<td>3</td>
</tr>
<tr>
<td>Height:</td>
<td></td>
</tr>
<tr>
<td>Less than 5 m (15 ft)</td>
<td>0</td>
</tr>
<tr>
<td>5 m (15 ft) to 8 m (25 ft)</td>
<td>1</td>
</tr>
<tr>
<td>7 m (25 ft) to 12 m (40 ft)</td>
<td>2</td>
</tr>
<tr>
<td>Over 12 m (40 ft)</td>
<td>3</td>
</tr>
<tr>
<td>Proximity to street:</td>
<td></td>
</tr>
<tr>
<td>Over 15 m (50 ft) away</td>
<td>0</td>
</tr>
<tr>
<td>12 m (40 ft) to 15 m (50 ft)</td>
<td>1</td>
</tr>
<tr>
<td>6 m (20 ft) to 12 m (40 ft)</td>
<td>2</td>
</tr>
<tr>
<td>Less than 6 m (20 ft)</td>
<td>3</td>
</tr>
</tbody>
</table>

Priority Ratings

High Priority (13-15 points): These areas are essential for public safety and susceptible to storm damage.

Medium Priority (6 to 12 points): Not critical to public safety but susceptible to storm damage. Most areas within the community will be in this category.

Low Priority (0 to 5 points): These areas should not be sampled or considered in the damage assessment.

Example: 110 mixed hardwoods, 15 to 20 inch DBH, 30 to 40 feet high and 10 to 20 feet from the road.

Following are the steps required for inventorying each sample plot:

Step 1

Locate and mark the plots' locations in the field.
It is advisable to begin each plot at a road intersection, and use a permanent marker at the opposite end of the plot. Being able to find the plot markers after a storm is more important than placing a marker at exactly 1/10 mile. If a permanent landscape feature such as a mailbox, tree or utility pole is close to the 1/10-mile measurement, it can be used as a marker. Other permanent markers could include paint, stakes or a Global Positioning System (GPS) coordinate. Consider low visibility and adverse conditions during the damage assessment when choosing a plot marker. (Photo #5)

If an end marker is lost or destroyed, re-measuring from the plot's starting point will suffice. In certain urban areas, city blocks can be used as sample plots—as long as they are relatively uniform in distance.

Step 2

Record data.

Inventorying the trees in each plot prior to the storm will provide information for the damage assessment so the assessor can compare pre-storm and post-storm conditions. It might be advisable to take photographs of each sample plot before and after a storm. This information can be used to better delineate the community's urban forest and how it was affected by the storm. An added benefit of this stage of the process is that it allows communities to identify areas that may be more susceptible to tree damage on roadways that are critical to public safety. This is accomplished by prioritizing an area according to the likelihood of potential tree damage—and its impact on public safety. A rating system (Table 1) can assist this process and can be implemented when identifying the community's tree-lined streets at the beginning of this process. Following is the recommended data that should be recorded for each sample plot:

- The plot location and sample direction
- The tree type or type of stand
The number of trees in the plot
- Tree density, measured by the spacing between the trees
- Estimated height and DBH range of the individual trees or stand of trees
- The proximity of the trees to the street

Implementation

Assessor qualifications

Damage assessor(s) could be part of a municipality's forestry staff or may be contracted from the private sector to perform the task. If a municipality decides to establish sample plots using in-house staff and contract out the actual damage assessment, the person doing the assessment must be briefed ahead of time on the location and content of the sample plots. Dependable communications with the local storm center or crisis coordinators and a reliable vehicle (four-wheel drive in winter storm conditions) are advisable, due to the potential dangers involved.

Whoever does the assessment should not be obligated to participate in emergency response and clean-up efforts. They should also reside locally (or be available on short notice), be familiar with the area and possess the following qualifications:
- Experienced in estimating tree work. For example, retired tree wardens, commercial or consulting arborists or retired utility arborists
- Able to determine equipment needs for hazard mitigation and cleanup efforts
- Be familiar with storm-damaged trees and related hazardous conditions
- Knowledgeable of the damage assessment process and plot locations

Response

Once the storm has passed, the damage assessor needs to survey the plots as soon as possible. The assessor should follow a pre-planned, efficient route between plots, but should be aware of other routes in the event that the planned route is blocked.

For each plot surveyed, the assessor will record hours on a damage-assessment form, the amount and type of damage, the equipment needed for removing hazards and debris, and the time required of equipment and crew. Once all plots have been surveyed, the data can then be used to estimate the total resources needed for addressing the rest of the community's tree damage. (Fig. 1)
Case Study: Amherst, Massachusetts

This case study was conducted in Amherst, Mass., during August 1998. Meetings with the Department of Public Works supervisor, tree warden and a town engineer revealed that Amherst has approximately 100 miles of road of which 75 miles have trees located near enough to affect them during a severe storm. A windshield survey and a study of aerial photographs of Amherst's road system and street-side trees confirmed this.

In order to pilot test this assessment procedure, the total distance of tree-lined streets was based on the percent of streets in Amherst that have trees growing next to or near them; in this case approximately 75 of 100 miles of road. This study used a 2 percent sample of the total tree-lined streets and consisted of 15, 1/10 mile-long plots. Public roads susceptible to tree damage were marked on the base map and 15 sample plots were randomly chosen along these streets throughout the community.

Once the plots were established, it took about four hours to re-visit each plot in optimal weather conditions, or about 15 minutes per plot. A larger sample size for this community could pose a time constraint on post-damage assessment procedures, and was not recommended.

The sample data noted below are examples intended for illustrative purposes, since no severe storms have occurred since the start of this study. The following is an outline of the process used to set up and implement the initial damage assessment for Amherst.

**Five steps to estimating total damage based on sample plot data.**

1. Determine the total miles of tree-lined streets
2. Calculate the number of total sample miles
3. Record the total damage for all plots
4. Set up a formula to estimate for entire community
5. Estimate the required resources needed to clean up after storm

**Data from Amherst, Mass. (Aug. 1998)**

**Step 1**
100 miles of roads x 75% tree-lined = 75 miles total tree-lined roads

**Step 2**
Two percent sample size x 75 miles tree-lined roads = 1.5 sample miles. (Fifteen plots of 1/10 mile each were chosen in high and medium priority areas.)

**Step 3**
Total plot damage (fictitious): Crew / equipment hours for 15 plots or 1.5 miles of road were estimated at 12 crew hours

**Step 4**
Set up the formula

\[ \frac{12 \text{ hrs.}}{2 \text{ hrs. / mile} \times 75 \text{ miles}} = 600 \text{ crew hours for entire 1.5 miles community clean-up} \]

**Step 5**
Determine the resources needed (ten crews are available)

10 crews, 11 hours a day = 110 crew hrs./day

\[ \frac{600 \text{ crew hrs.}}{5.45 \text{ days of clean up time}} \]

110 crew hrs./day

or

600 crew hrs. @ $ ____/crew/equip. hrs. = $ __________ Initial damage est.

---

**DAMAGE ASSESSMENT DATA FORM**

<table>
<thead>
<tr>
<th>Assessor</th>
<th>Plot Location</th>
<th>Plot No.</th>
<th>Plot Length</th>
<th>Plot Direction</th>
<th>Date</th>
</tr>
</thead>
</table>

**DAMAGE SUMMARY: # Limbs Down ____ % Crown Loss ____ # Uprooted ______ # of Trees Down ____

**ESTIMATED TIME AND EQUIPMENT:**

<table>
<thead>
<tr>
<th>Required Equipment</th>
<th>Number</th>
<th>Crew Hours</th>
<th>Total Crew/Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucket truck with chipper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chipper truck with chipper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log loader</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front end loader</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dump truck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total $ _____

**NOTES:**

---

Figure 1. Each plot should have a separate Damage Assessment Data Form that corresponds to the Sample Plot Data Form. The Damage Summary section will provide information on the type and amount of damage that may be useful for future management strategies.
Discussion

What became very apparent during the northern New England and New York ice storm of 1998 was that a uniform method for measuring community tree damage immediately following a severe storm was needed. In the 1998 storm, each state used its own system to estimate the amount of tree damage present, which made it difficult for federal disaster teams to accurately estimate the total damage. This project proposes a methodology that can give arborists and emergency management officials a system that effectively provides municipal, state and federal officials with a uniform estimate of damage and projected costs within a 12-hour window required for completing the initial damage assessment by the Federal Emergency Management Agency (FEMA).

This damage assessment method represents a preliminary model and is intended to provide an initial overview of tree-related storm damage during the normally confusing hours immediately after a severe storm. The sampling method and accuracy need to be tested in actual storm conditions, and adjustments to the methodology for choosing sample size and plot locations may be necessary. Currently, the USDA Forest Service's Northeastern Center for Urban and Community Forestry, in cooperation with the states of New York, New Hampshire, Vermont and Maine, is working on the development of a standardized damage assessment protocol. The Davey Resource Group has been awarded a grant to begin preliminary work on this protocol.

This storm damage assessment system could be a useful tool in an emergency, but its strength lies in the planning stage of emergency response. Once established, municipal and emergency response officials can focus on emergency management and public safety during and after a storm. The often neglected task of providing the initial damage assessment to state and federal emergency management agencies will become less of a distraction and more of an asset to a community's emergency preparedness and response operations.

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