

TREES
AND
ICE
STORMS

THE
DEVELOPMENT
OF
ICE STORM-
RESISTANT
URBAN TREE
POPULATIONS





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Richard J. Hauer, Mary C. Hruska, and Jeffrey O. Dawson. 1994. Trees and ice storms: The development of ice storm-resistant urban tree populations. Special Publication 94-1, Department of Forestry, University of Illinois at Urbana-Champaign. Urbana, IL 61801. 12pp.

Funding for this publication was provided by the technology transfer program of the USDA Forest Service Urban Forestry Center for the Midwestern States.

Graphic Designer: Lynn Hawkinson Smith

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Technical Editor: Molly Bentsen

Photo credits: Cover—Reprinted with permission of Joel Dexter; pages 2, 5, 6, 7, 10, 11—Michael R. Jeffords; page 4—(l. to r.) Mary Hruska, Joel Dexter, Michael Brunk, Jim Skiera; pages 8, 9, 12—Lynn Hawkinson Smith



The authors gratefully thank Robert Brush, Gina Childs, Robert Miller, and George Ware for their constructive reviews and comments.



SUMMARY

Severe ice storms occur every year in the United States, particularly in the midwestern and eastern regions, resulting in millions of dollars in monetary losses. Tree species vary in their resistance to ice accumulation. Certain characteristics, such as “included” bark, dead and decaying branches, a broad crown, and fine branching, increase a tree’s susceptibility to ice storm damage. Planting trees resistant to ice storms and performing regular tree maintenance to remove structural weaknesses will reduce damage caused by severe ice storms. Management plans for urban trees should incorporate information on the ice storm susceptibility of trees to limit potential ice damage, to reduce hazards resulting from ice damage, and to restore urban tree populations following ice storms. Susceptibility ratings of species commonly planted in urban areas are presented for use in developing and maintaining healthy urban tree populations.

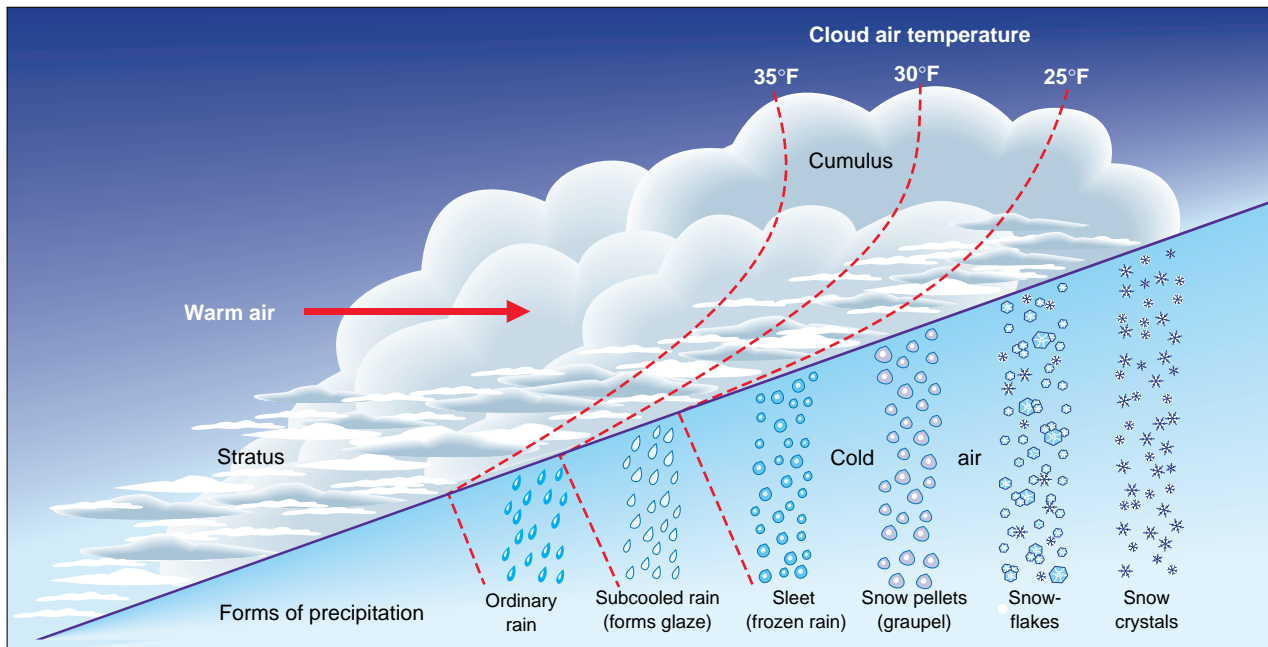


Figure 1. Forms of precipitation that result when a winter warm front slowly advances into ground layer air at or below 0°C and the relationship to cloud air temperature (from Lemon, 1961).

INTRODUCTION

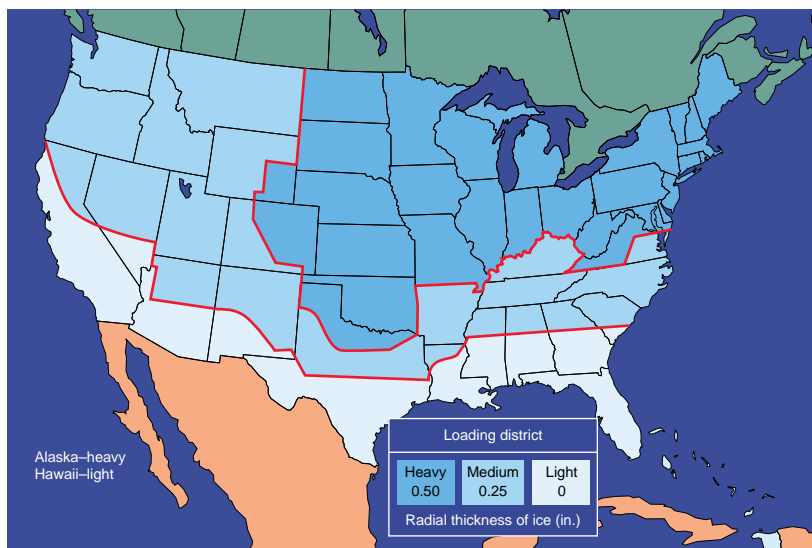
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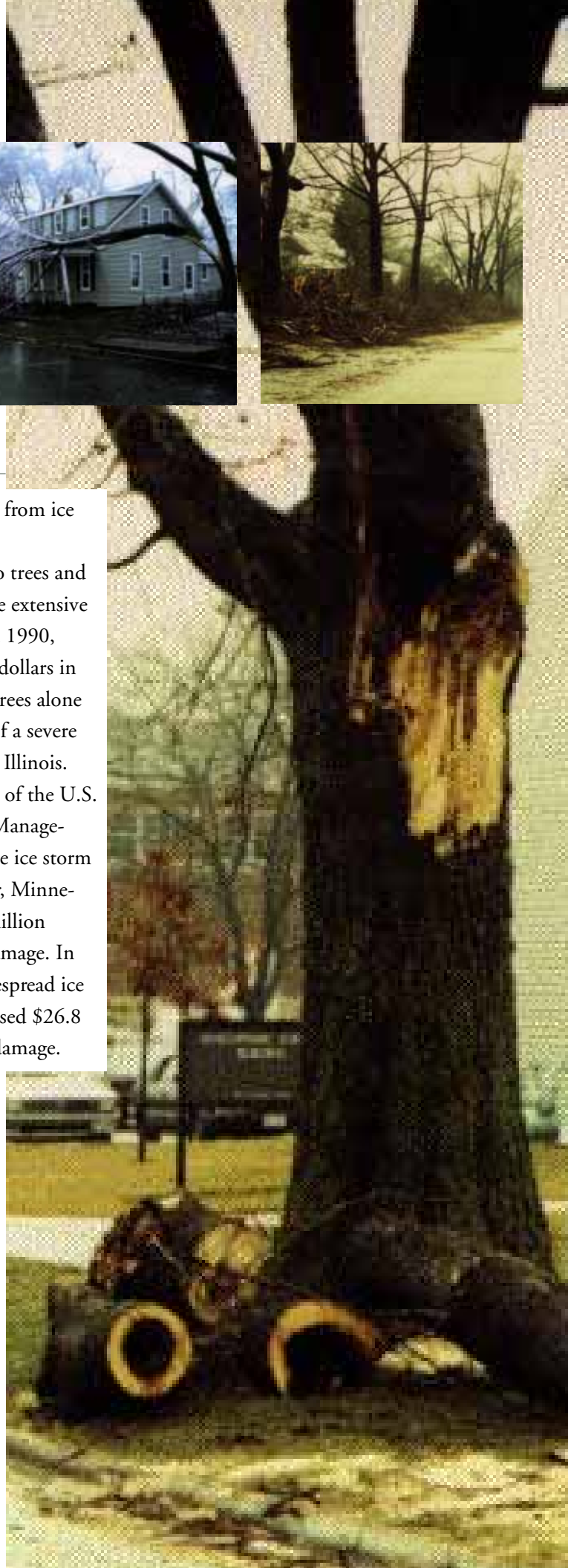
ce storms, also referred to as glaze storms, cause considerable damage every year to trees in urban and natural areas. They vary considerably in their severity and frequency.

Ice storms are a result of the ice formation process, which is influenced by general weather

patterns. Ice accumulates when supercooled rain freezes on contact with surfaces, such as tree branches, that are at or below the freezing point (0°C). This generally occurs when a winter warm front passes through an area after the ground-level temperature reaches or falls below freezing (Figure 1). Rain falls through layers of cooler air without freezing, becoming supercooled. Periodically, other climatic events, including stationary, occluded, and cold fronts, also result in ice storms. Conditions that result in ice storms are most prevalent in the midwestern and eastern parts of the United States, as illustrated by the ice-loading districts shown in Figure 2.

Figure 2. Ice-loading districts in the United States for ice accumulation on surfaces (from National Bureau of Standards, 1948).





Accumulations of ice can increase the branch weight of trees by 30 times or more. Ice formation generally ranges from a trace to 1 inch in additional stem diameter. Accumulations between 1/4 and 1/2 inch can cause small branches and weak limbs to break, while 1/2-inch to 1-inch accumulations can cause larger branches to break, resulting in extensive tree damage. Branch failure occurs when loading from the weight of ice exceeds wood resistance or when constant loading further stresses a weakened area in a branch (Figure 3). Strong winds substantially increase the

potential for damage from ice accumulation.

Monetary losses to trees and other property can be extensive after an ice storm. In 1990, more than a million dollars in damage to parkway trees alone occurred as a result of a severe ice storm in Urbana, Illinois. According to records of the U.S. Federal Emergency Management Agency, a severe ice storm in 1991 in Rochester, Minnesota, caused \$16.5 million worth of property damage. In the same year, a widespread ice storm in Indiana caused \$26.8 million in property damage.

Figure 3. Included bark and woody decay enhance branch breakage and tree damage when ice accumulates on trees (photo by Jim Skiera).

HISTORICAL ACCOUNTS

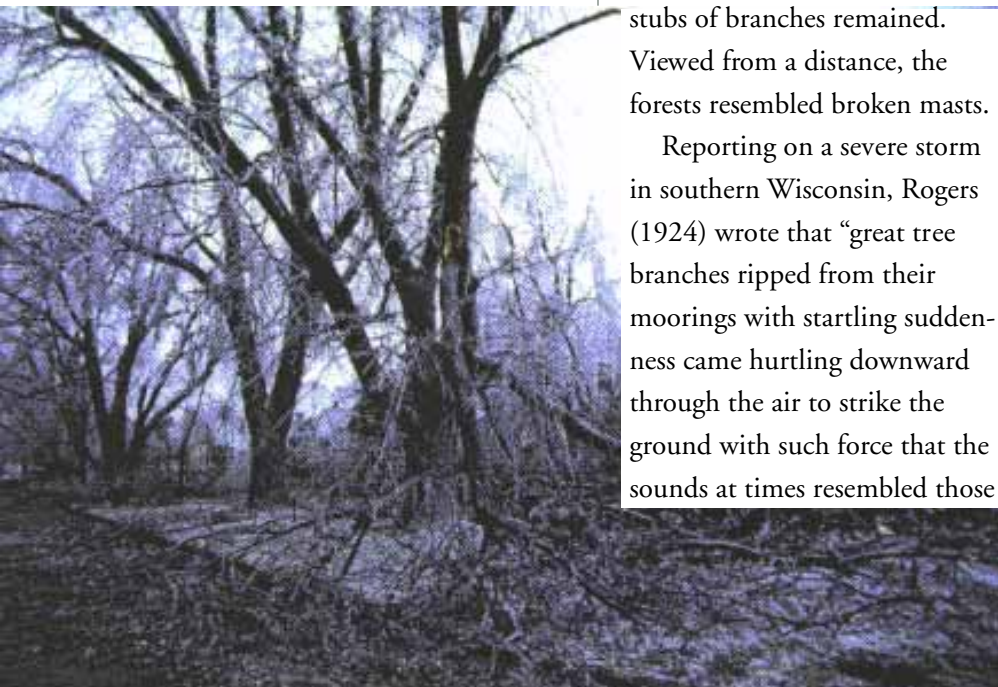
The air was filled for hours with the rifle report of snapping branches followed by the crash of ice-laden branches smashing to the ground.

In one of the earliest documented accounts of an ice storm in the United States, Harshberger (1904) reported that there were two exceptionally destructive ice storms around Philadelphia in 1902. One storm was accompanied by high winds and did irreparable damage to numerous fruit, forest, and shade trees. The other deposited more ice, but because of the lack of wind there was less damage. Twelve years later in eastern Pennsylvania and western New Jersey, an area of approximately 600 square miles was damaged by an ice storm (Illick, 1916). Actual counts of damaged trees indicated that 90 percent of the forest trees either had their crowns broken off entirely or were damaged so badly that only stubs of branches remained.

Viewed from a distance, the forests resembled broken masts.

Reporting on a severe storm in southern Wisconsin, Rogers (1924) wrote that “great tree branches ripped from their moorings with startling suddenness came hurtling downward through the air to strike the ground with such force that the sounds at times resembled those

of a thunderstorm. Pedestrians kept to the middle of the thoroughfares and many people remained indoors rather than risk the uncertainties of the public streets.” He also reported that where trees had stood close together, streets became completely blocked and passageways had to be chopped out with axes. Abell (1934) reported that forests of the southern Appalachian area had been repeatedly damaged by ice storms. Referring to a storm in western North Carolina in 1932, he quoted a mountaineer to have said, “By two o’clock Sunday morning there was no sleeping at all for the noise of breaking timber.” More recently, on Valentine’s Day 1990, a severe ice storm in Urbana, Illinois, damaged at least 26 percent of the city’s parkway trees (Hauer et al., 1993). About 5 percent were severely damaged and required immediate removal or repair. The air was filled for hours with the rifle report of snapping branches followed by the crash of ice-laden branches smashing to the ground. Most of the city was without power, for as long as eight days.



The wood strength of sound branches matters less than the ability of a tree to withstand breakage at branch junctures.

TREE FEATURES INFLUENCING ICE STORM SUSCEPTIBILITY

A

number of characteristics increase a tree species' susceptibility to ice storms: "included" bark, decaying or dead branches, increased surface area of lateral branches, broad crowns, and imbalanced crowns (Figure 4). Included bark (inset) results from in-grown bark in branch junctures. This weak connection enhances a tree's susceptibility to

breakage under ice-loading conditions. For example, 'Bradford' pear branches often break during ice storms where there is included bark in branch junctures. In contrast, the 'Aristocrat' pear has few branches with included bark and sustains less damage during ice storms.

Decaying or dead branches are already weakened and have a high probability of breaking when loaded with ice. The surface area of lateral branches increases as the number of branches and the broadness of the crown increase. With an increased surface area, more ice can accumulate on lateral branches; the greater ice load results in greater branch failure. Contrary to popular belief, the wood strength of sound branches matters less than the ability of a tree to withstand breakage at branch junctures and the presence of fine branching or a broad crown that enhances ice accumulation.

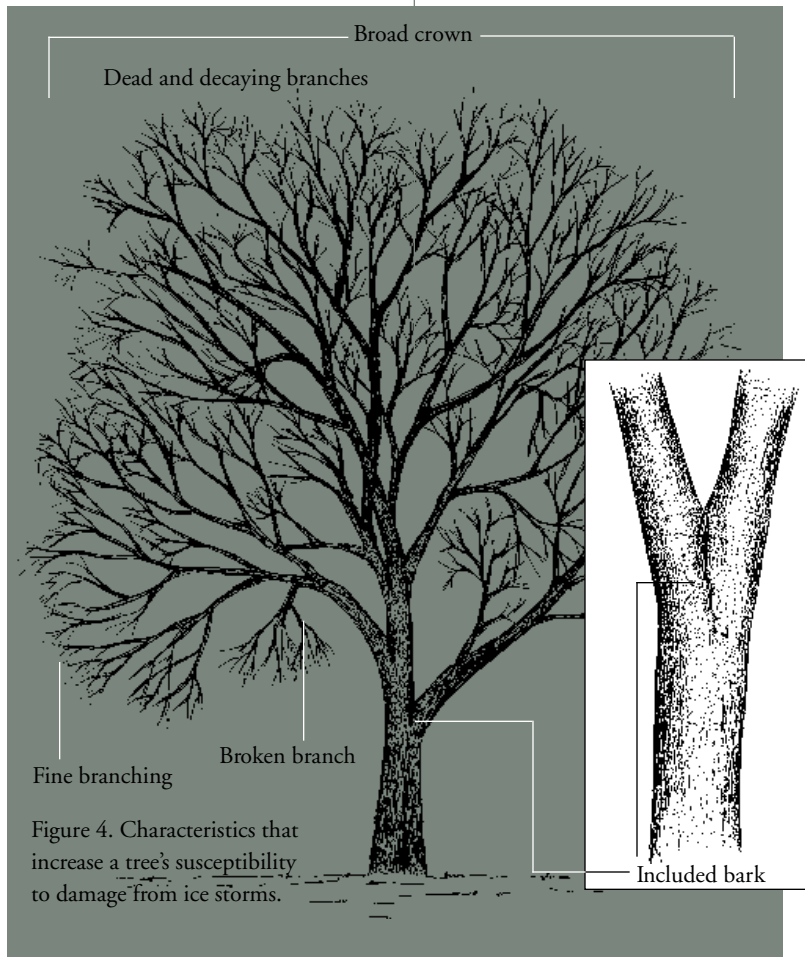
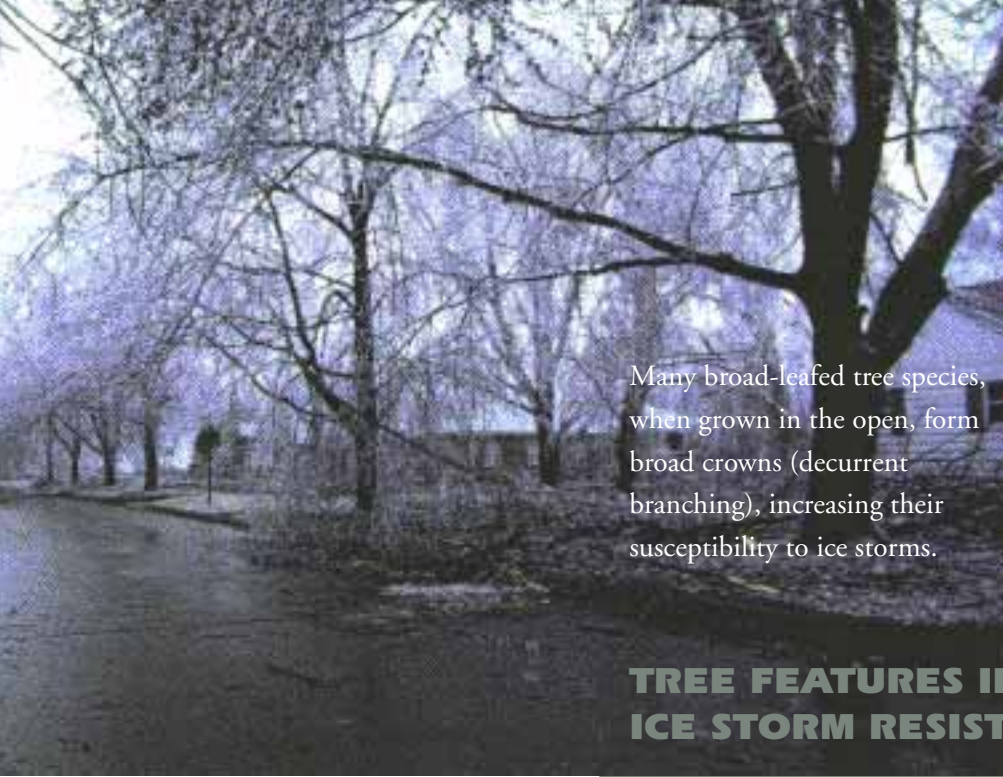


Figure 4. Characteristics that increase a tree's susceptibility to damage from ice storms.





Many broad-leaved tree species, when grown in the open, form broad crowns (decurent branching), increasing their susceptibility to ice storms.

Examples include Siberian elm, American elm, hackberry, green ash, and honey locust. Trees with imbalanced crowns are also more susceptible to ice damage.

TREE FEATURES INFLUENCING ICE STORM RESISTANCE

Juvenile and mature trees that have excurrent (conical) branching patterns, strong branch attachments, and low surface area of lateral branches are generally resistant to ice storms (Figure 5). Many conifers have an excurrent branching pattern,

and many resist ice storm damage. Some tree species, such as sweet gum, have an excurrent growth habit when young but develop a decurrent growth habit later in life. These species are more resistant to breakage when young than broadleaf trees that do not exhibit a juvenile

excurrent branching pattern. Some tree species that typically exhibit a decurrent branching pattern have clones with an excurrent form, which should have greater resistance to ice storm damage. Tree species with strong branch attachments have greater resistance to breakage than those with included bark. Trees with coarse branching patterns (fewer, thicker branches) and, as a consequence, lateral branches with reduced surface area, such as Kentucky coffee tree, black walnut, and ginkgo, accumulate less ice and typically have little breakage from ice storms. Forest understory tree species such as ironwood and blue beech and trees that mature at small heights, such as amur maple, are also relatively resistant to ice storm damage.

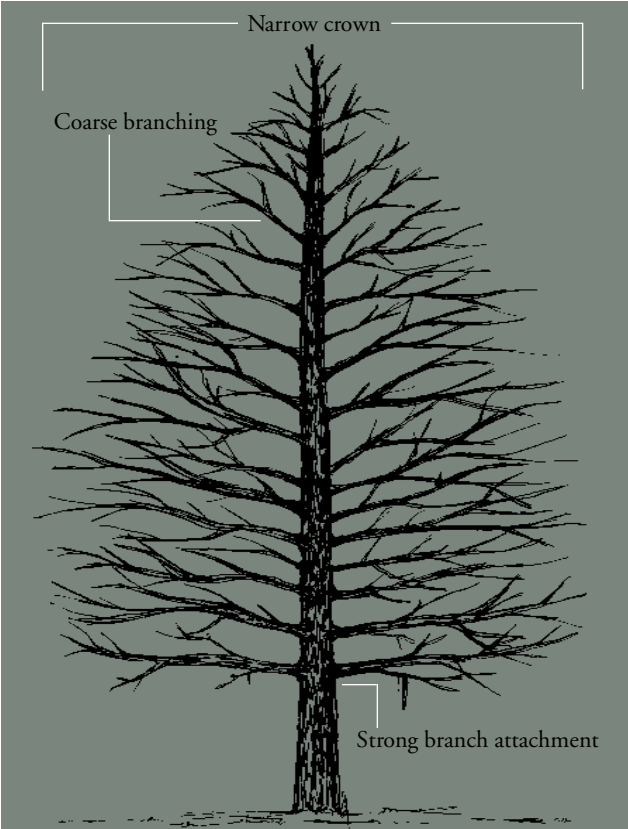


Figure 5. Characteristics that reduce a tree's susceptibility to damage from ice storms.

ICE STORM DAMAGE IN WOODED AREAS

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rees in forests, greenbelts, and other natural areas are also damaged by ice storms. The location of a tree within a stand often influences its susceptibility. Edge trees tend to have large, imbalanced crowns with longer and lower branches on the open side. Interior trees, which must compete for light, have small crowns and fewer lower limbs and typically show less damage than edge trees. Edge trees accumulate more ice on the open side, which can result in major branch failure, crown breakage, and uprooting of entire trees. Species with

shallow root systems, such as red oak, are more prone to tipping during ice storms than deep-rooted species, such as white oak and bur oak. Streams or rivers that dissect forests are often lined with edge trees with much of their crowns over the water. During the 1990 Valentine's Day ice storm in central Illinois, there was extensive edge tree damage on the Middle Fork of the Vermilion River in Vermilion County. Whole trees uprooted by the weight of accumulated ice were stacked up to four deep at every bend of the river.





ICE STORM DAMAGE MANAGEMENT AND PREVENTION

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ree species resistant to ice damage can be planted to reduce tree and property damage from ice storms. Ice storm susceptibility should not be the sole criterion for selecting trees for urban planting, but the numbers of susceptible trees should be limited, particularly in regions with high frequencies of damaging ice storms. Ice storm resistance ratings based on the authors' research and a review of published reports on

commonly planted urban trees are presented in Table 1.

For species not included in Table 1, resistance to ice accumulation can be estimated based on general tree characteristics. Tree species and cultivars genetically prone to forming included bark and those having decurrent branching patterns and large branch surface area will be more susceptible to damage. In contrast, species and cultivars with coarse branching

Table 1. Ice Storm Susceptibility of Tree Species Commonly Planted in Urban Areas

Susceptible	Intermediate resistance	Resistant
American elm	Bur oak	American sweetgum
American linden	Eastern white pine	Arborvitae
Black cherry	Northern red oak	Baldcypress
Black locust	Red maple	Black walnut
Bradford pear	Sugar maple	Blue beech
Common hackberry	Sycamore	Catalpa
Green ash	Tuliptree	Eastern hemlock
Honey locust	White ash	Ginkgo
Pin oak		Ironwood
Siberian elm		Kentucky coffee tree
Silver maple		Littleleaf linden
		Norway maple
		Silver linden
		Swamp white oak
		White oak

Adapted from Hauer et al. (1993).



Proper tree placement and pruning on a regular cycle will reduce property damage and decrease a tree's susceptibility to ice storms.

patterns and excurrent branching and those that lack included bark and other structural weaknesses will generally be more tolerant to ice storms. However, ratings based directly on measurements and observations of ice-storm-related tree damage are more reliable when available.

Proper tree placement and pruning on a regular cycle will reduce property damage and decrease a tree's susceptibility to ice storms. Property damage from trees broken by ice accumulation can be reduced by locating trees where they can do the least damage. Trees should not be planted in locations where their growth will interfere with above-ground utilities—branches that grow into power lines and fail during ice storms create power outages and safety hazards. Those trees located near homes and other structures should be pruned and monitored

for hazards. Trees pruned regularly from a young age should be more resistant to ice storms as a result of removal of structurally weak branches, decreased surface area of lateral branches, and decreased wind resistance. Professional arborists can install cables and braces to increase a tree's tolerance to ice accumulation in situations where individual trees must be stabilized to prevent their failure.

After storm damage has occurred, hazardous trees and branches require immediate removal to ensure safety and prevent additional property damage. Trees that can be saved should have broken branches properly pruned to the branch collar; stubs and flush-cut pruning result in weakly attached sprouts and future insect and disease problems. Loose bark should be cut back only to



The impact of ice storms can be minimized through planning, tree selection, and tree maintenance.

where it is solidly attached to the tree. A split fork can be repaired through cabling and bracing.

Where severe ice storms occur, disaster plans should be developed to assist in recovery. Guidelines available from the Forest Service (Andresen & Burban, 1993) can assist with planning for and mitigating the impact of natural disasters in urban forests. The impact of ice storms can be minimized through planning, tree selection, and tree maintenance as out-

lined in this brochure. Assistance in planning and carrying out programs to lessen the impact of future ice storms is available from governmental and private agencies concerned with urban and community forestry. Concerted action over many years is needed to minimize ice storm damage. Sustained efforts will undoubtedly reduce fatalities, injuries, monetary losses, tree damage, and cleanup costs to individuals and communities in regions where ice storms occur.



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