United States
Department of
Agriculture

Forest Service

Tree Survival and Growth Following Ice Storm Injury

Walter C. Shortle, Kevin T. Smith, and Kenneth R. Dudzik
USDA Forest Service, Northeastern Research Station, Durham, New Hampshire

Introduction

Nearly 25 million acres of forest from northwestern New York and southern Quebec to the south-central Maine coast were coated with ice from a 3-day storm in early January 1998. This storm was unusual in its size and the duration of icing. Trees throughout the region were injured as branches and stems broke and forks split under the weight of the ice. These injuries reduced the size of tree crowns and exposed wood to infection that can lead to wood decay.

In addition to regional assessments[1], forest managers need to know how much damage to expect in the years following the storm due to loss of wood quality, loss of tree growth, or tree death. The purpose of this study was to determine tree survival, stem growth, and response to infection following injury to major hardwood tree species from the 1998 ice storm.

[1]Miller-Weeks, M.; Eagar, C. 1999. **Ice Storm 1998—A Forest Damage Assessment for New York, Vermont, New Hampshire, and Maine.** Concord, NH: North East State Foresters Association and USDA Forest Service, Northeastern Area State and Private Forestry. 32 p.

Northeastern Research Station

Research Paper NE-723
May 2003

www.fs.fed.us/ne

Tag and Track Study

A 5-year "tag and track" study was initiated to determine the effects of the storm on injured trees of species initially identified as being at high risk of loss of utilization value. This report focuses on:

- tree survival
- stem growth
- wound closure

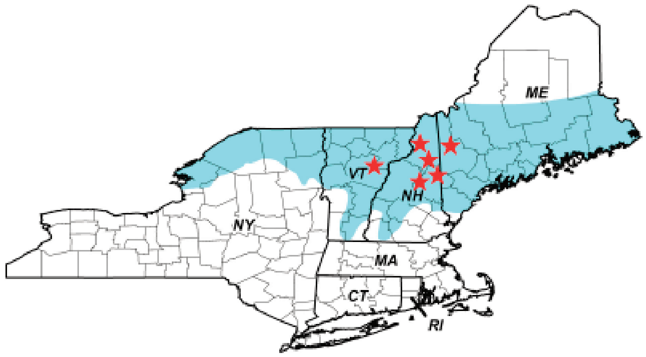

Figure 1.—Area affected by the 1998 ice storm (shaded) and study locations (stars).

At six locations within the region impacted by the 1998 ice storm (Fig. 1), surviving northern hardwood trees were permanently tagged and classified in October 1998 to represent three classes of crown loss due to the storm. The frequency of comparable categories in 22,000 trees examined in a regional assessment of storm impact[1] are given in parentheses:

- Class A trees had crown loss of less than one-half (79 percent occurrence in the storm area).
- Class B trees had crown loss of one-half to three-quarters (9 percent occurrence).
- Class C trees had crown loss of more than three-quarters (12 percent occurrence).

Table 1.—Number of sample trees in study.

	Crown loss class		
Tree species	A	B	C
Sugar maple	64	41	29
Red maple	24	16	12
Yellow birch	42	40	32
Paper birch	—	19	21
White ash	18	18	24

At each location, as many Class B and C trees as possible were tagged, along with a comparable number of Class A trees. Even in the heavily impacted areas, Class A trees usually were more common than those in Classes B and C. The final tagged sample of 400 trees was of large poles and sawtimber, 9-18 inches in diameter at breast height, that formed the canopy of these northern hardwood stands (Tables 1 and 2).

Table 2.—Average diameter at breast height in inches (and number of years to add one inch of tree diameter at prestorm growth rates).

	Crown loss class		
Tree species	A	B	C
Sugar maple	13 (10)	13 (11)	12 (10)
Red maple	11 (10)	12 (10)	11 (10)
Yellow birch	12 (12)	12 (12)	13 (14)
Paper birch	—	14 (18)	12 (16)
White ash	12 (6)	14 (10)	12 (10)

Methods

In October 1998, tagged trees were wounded at breast height by drilling a hole 3/8 inch in diameter to a depth of 2 inches. This treatment provided a uniform injury to evaluate wound closure. From 1999-2001, the tagged trees were visually assessed in July for tree survival and in October for wound closure.

The effect of crown loss on radial growth was determined from increment cores taken from each tagged tree 3 years after storm injury. To allow for natural year-to-year variation in growth, the mean annual ring width for the 3 years after the 1998 storm (growth increments for 1998-2000) was compared for the mean annual ring width for the 10 years before the storm, 1988-1997.

The effect of crown loss on wood quality from the injury and the tree response to injury and infection was determined through the dissection of a subsample of the tagged trees 4 years after storm injury.

Results

Tree survival

All tagged sugar maple, red maple, and white ash from all crown injury classes were alive after 4 years. After 4 years for yellow birch, one Class B and two Class C trees had died, yielding survival rates of 95 percent and 94 percent, respectively. After 4 years for paper birch, five Class B and 12 Class C trees had died, yielding survival rates of 74 percent and 38 percent, respectively. Dissection of dead birch trees revealed the presence of Armillaria root disease which was well established prior to the 1998 storm (Fig. 2).

Stem growth

The average prestorm growth rate (years to increase 1 inch in diameter) (Table 2) was derived from the mean ring width for the 10 years before the 1998 storm. The percent reduction of stem growth is based on a comparison of the post-storm rings of 1998-2000 to the pre-storm ring widths of 1988-1997 (Fig. 3). For Class A trees of all species, there was no growth reduction 3 years after the storm. For Class C trees, growth reduction ranged from 9 percent in white ash to 50 percent and 48 percent in yellow birch and sugar maple, to 70 percent in both paper birch and red maple.

For Class B trees, growth reduction ranged from 22 percent in white ash to 70 percent in paper birch with yellow birch, red maple, and sugar maple in the intermediate range of 24 to 40 percent.

Figure 2.—Mushrooms produced by root disease. The bark has been removed near the junction of a buttress root and the trunk to show white mycelial fans, an additional sign of the disease.

Growth reduction, or lack of it, depended primarily on sprouting of the upper stem to restore the crown lost to ice breakage. White ash sprouted vigorously (Fig. 4a). Many Class C ash trees lost all of their branches, but sprouts 6 feet or more in length and an inch or more in diameter were formed in the summer of 1998. Fully mature paper birch trees sprouted poorly and broken tops that failed to sprout died and decayed, while those that sprouted lived (Fig. 4b). Red maple, sugar maple, and yellow birch sprouted well, although they lagged behind ash. Sprouting of the lower stem to produce epicormic branches occurred infrequently in yellow birch and rarely in other species.

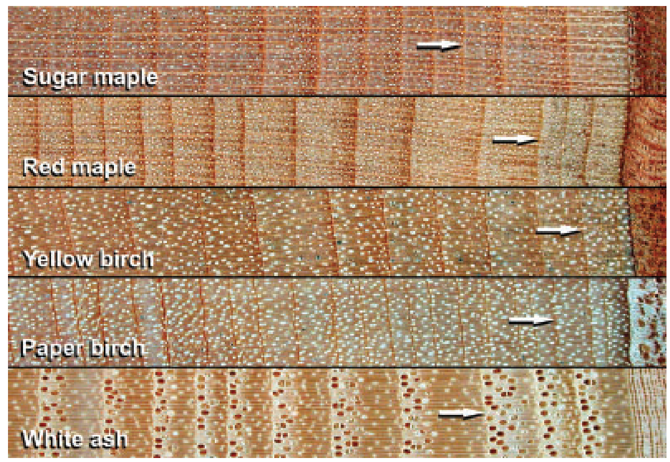

Figure 3.—Well-sanded tree-ring increment cores were used for ring-width measurement. Arrows point to the boundary between the 1997 and 1998 growth ring.

Wound closure

Wound closure occurred most frequently in white ash with no difference among crown injury classes (Table 3). Approximately half of the ash trees had closure after 1 year and nearly all were fully closed after 3 years. No ash trees showed any indication of cambial dieback associated with the borehole wound (Table 3, Fig. 5a).

Table 3.—Percentage of wound closure (and cambial dieback) associated with boreholes.

	Crown loss class		
Tree species	A	B	C
Sugar maple	43 (29)	32 (50)	17 (62)
Red maple	42 (33)	19 (69)	8 (75)
Yellow birch	45 (32)	37 (45)	7 (76)
Paper birch	—	0 (100)	0 (100)
White ash	94 (0)	100 (0)	92 (0)

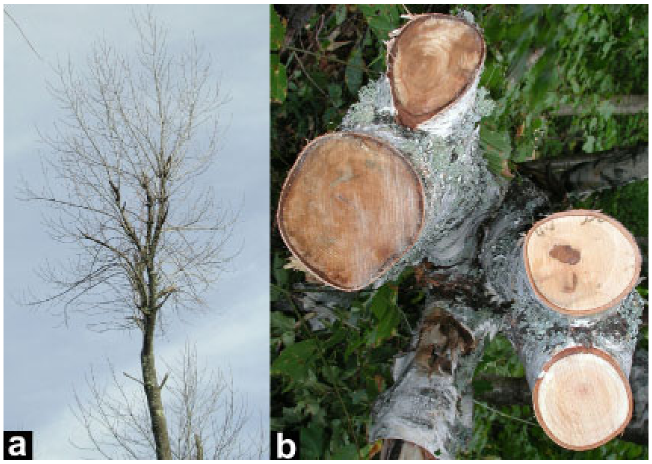

Figure 4.—Sprouting of injured trees: a, white ash with rebuilt crown 3 years after injury; b, paper birch tree with no sprouts and dead top (left) and with sprouts and live top (right).

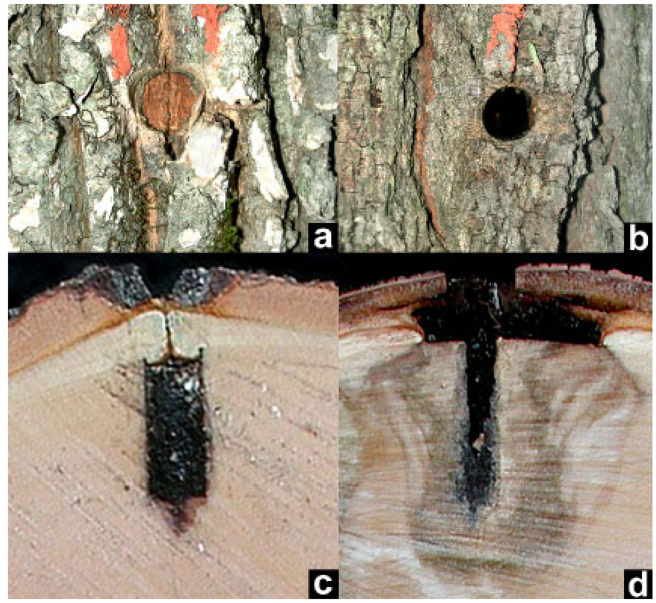

Figure 5.—Closure and dieback of boreholes: a, closed borehole on red maple; b, open borehole on red maple; c, closed borehole on yellow birch; d, open borehole and cambial dieback on yellow birch.

Wound closure did not occur in any paper birch trees (Table 3). After 3 years all holes in paper birch were fully open (Fig. 5b). All surviving paper birch trees had cambial dieback (Table 3, Fig. 5d). The death of cambium around the borehole wounds allowed for more rapid development of internal infection (discolored wood in Fig. 5d). Wound closure and cambial dieback in sugar maple, red maple, and yellow birch was intermediate to white ash and paper birch (Table 3). The frequency of closure decreased and dieback increased in Class B trees. Wound closure in sugar maple, red maple, and yellow birch was poor in Class C trees (Table 3).

Conclusions

Tree damage from the ice storm was strongly related to:

- tree health before the storm
- ability to rebuild tree crowns
- rate of wound closure

Paper birch, with suppressed growth and root disease, sprouted poorly, responded poorly to stem wounds, and exhibited high mortality 3 years after the storm. White ash that was healthy and growing well before the storm sprouted well, responded quickly to stem injuries, and suffered no mortality.

After 3 years, ash growth was reduced about 10 to 20 percent with a full recovery likely within a few more years. Sugar maple, yellow birch, and red maple were more variable in growth responses. Long-term survival of many Class B and some Class C trees is likely. However, growth of these survivors, especially Class C trees, is likely to remain suppressed and the response to injury and infection limited.

Ice storms are a natural feature of forests of the northeastern United States and will surely occur again. Trees that are healthy and responsive before the storm are more likely to survive and will recover more quickly from storm injury. Timber stand improvement to enhance tree health may be a prudent preventative treatment. Reduced residual logging damage may decrease the chance of root infection and spread of infection within the tree.

Acknowledgements

This publication is based on research conducted by the Northeastern Research Station and funded by the Northeastern Area, State and Private Forestry. We also thank the White Mountain National Forest, the State of Vermont, MeadWestvaco Corp., and the Cooperative Forestry Research Unit at the University of Maine for providing research locations. We thank Robert O. Blanchard and Jonathan Janelle (University of New Hampshire) for their assistance.