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Tree Survival 15 Years after the Ice Storm of January 1998

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Abstract

The regional ice storm of early January 1998 was a widespread disturbance for millions of acres of forest in northeastern New York, northern New England, and southern Quebec. Tree crowns were partially or totally lost as stems snapped and branches broke with the weight of the deposited ice. We tracked the effect of crown injury on a large sample of northern hardwood trees within the storm footprint. Comparisons of tree survivorship from 5 to 15 years after the storm showed that paper birch was most sensitive to storm impact followed by yellow birch. Root-rot disease present prior to the storm was associated with the high mortality of birch. Although dramatic, mortality associated with the storm during this period was consistent with mortality expected from normal stand development of northern hardwoods as illustrated by the hardwood stocking chart.

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Cover Photos

Kevin T. Smith (left, 1998) and Walter C. Shortle (right, 2003) assess tree crown injury and recovery after the 1998 ice storm in the northeastern United States and adjacent Canada. Photos by Kenneth R. Dudzik, U.S. Forest Service.

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INTRODUCTION

Ice storms and associated tree injury are part of the natural ecology of northeastern forests, occurring in some portion of the landscape every year. An unusually extensive and severe 3-day storm in early January 1998 exposed nearly 25 million acres of forest from northwestern New York and southern Quebec to the south-central Maine coast to extreme icing (Fig. 1). This storm was unusual for both its geographic extent and for 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 by wood-destroying fungi.

In anticipation of concern for the long-term effect of the storm on the forest resource, we partnered with various state, commercial, and federal land managers to establish a “tag and track” study to determine the effect of the storm on tree survival, growth, and wood quality. Study details and research findings after 4 years have been published (Shortle et al. 2003). The following are observations primarily at 5 and 15 years after the storm.

METHOD SUMMARY

In October 1998, 584 trees of six northern hardwood species with various levels of crown loss were selected and tagged from six locations (Fig. 1) within the storm footprint from eastern Vermont, across New Hampshire, and into western Maine. Large pole-sized trees (8-11 inches diameter at breast height [d.b.h.]) and small sawtimber (12-22 inches d.b.h.) were classified at each location on the basis of crown loss:

- Class A—crown loss less than one-half
- Class B—crown loss of one-half to three-quarters
- Class C—crown loss of more than three-quarters of the live crown

To determine the effect of crown loss on wound response, representative trees were drilled at breast height with a 3/8-inch bit to a depth of 2 inches. Increment cores also were collected from all trees in 2000 or 2002 to determine the effect of crown loss on growth.

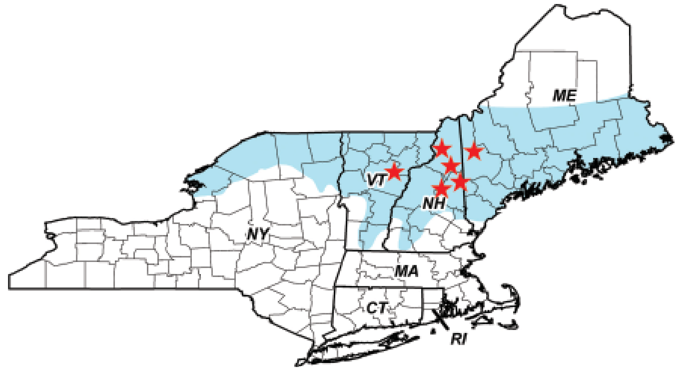

Figure 1.—Ice storm site map. The red stars show the six locations where trees were tagged.

The proportion of survivors for all 584 trees after 5 years was determined at the end of the 2002 growing season. Between 2002 and 2012, two of the six study locations were harvested for financial, rather than biological, considerations with the loss of 176 tagged trees from the study. In part due to the loss of 57 percent of the sugar maple (*Acer saccharum*) in classes B and C and 84 percent of all red maple (*Acer rubrum*), classes B and C were pooled into the combined class B+C for all comparisons.

The proportion of survivors after 15 years for all 366 remaining trees was determined in September 2012. Tree survival was summarized by tree size and species for crown loss class A and combined crown loss class B and C at 5 and 15 years after injury.

OBSERVATIONS

After 5 years for all tree species except paper birch (*Betula papyrifera*), 99 percent of class A trees and 95 percent of combined class B+C trees survived (Table 1).

Table 1.—Percent survival of northern hardwood trees 5 and 15 years after crown loss due to the January 1998 ice storm.

	Loss class			
	5-year survival		15-year survival	
Tree species	A (<half)	BC (>half)	A (<half)	BC (>half)
Sugar maple	100	99	100	94
Yellow birch	98	93	93	70
White ash	100	100	100	97
Beech	100	97	90	82
Red maple	100	100	100	100
Paper birch	89	68	57	23
Overall	99	95	95	76

Table 2.—Total number of tagged trees (number of dead trees in parentheses) 5 years after the 1998 ice storm by crown loss class for poles (8-11 inch d.b.h.) and sawtimber (12-22 inch d.b.h.).

	Loss class					
	Poles			Sawtimber		
Tree species	A	B	C	A	B	C
Sugar maple	31	19	20	63	39	27(1)
Yellow birch	21	17(2)	8	28(1)	24(1)	21(2)
White ash	5	3	7	14	17	13
Beech	9	1	0	11	19(1)	18
Red maple	16	9	10	10	10	2
Paper birch	14(1)	2(2)	7(5)	5(1)	11(1)	11(7)
Class totals	96(1)	51(4)	52(5)	131(2)	120(3)	92(10)

Mortality of paper birch within 5 years following the storm occurred in both the pole and sawtimber size classes (Table 2), with a higher percentage among smaller trees.

Dissection of dead and dying trees indicated that the main contributing factor to death of paper birch at 5 years was advanced stages of armillaria root-rot disease (Fig. 2).

The few yellow birch (*Betula alleghaniensis*) trees that died among all crown loss classes during the first 5 years also had armillaria root disease which was likely established prior to the 1998 storm. In the first 5 years, for maple, only a single large sugar maple and none of the red maple died (Table 2). No white ash (*Fraxinus americana*) and only a single large American beech (*Fagus grandifolia*) in class B died in the first 5 years after the storm.

Figure 2.—Extensive armillaria root disease visible beneath the bark of the stem flare on yellow birch.
Photo by Kenneth R. Dudzik, U.S. Forest Service.

Table 3.—Total number of tagged trees (number of dead trees in parentheses) 15 years after the 1998 ice storm by canopy loss class for poles (8-11 inch d.b.h.) and sawtimber (8-12 inch d.b.h.).

	Loss class					
	Poles			Sawtimber		
Tree species	A	B	C	A	B	C
Sugar maple	21	7	6	49	20(2)	16(1)
Yellow birch	15(2)	9(4)	7	27(1)	17(5)	21(7)
White ash	5	2	7(1)	10	13	10
Beech	9	1	0	11(2)	19(5)	18(2)
Red maple	1	1	1	4	2	0
Paper birch	2(2)	1(1)	7(7)	5(1)	11(6)	11(9)
Class totals	53(4)	21(5)	28(8)	106(4)	82(18)	76(19)

Fifteen years after the storm, 90 to 100 percent of class A trees survived in all species except paper birch (Table 1). Several paper birch that escaped heavy crown damage died, presumably from root disease (Table 3).

All the smaller paper birch in combined class B+C died and most, but not all, larger paper birch died. Some of the larger birch with major crown loss survived. These survivors appeared to have sound root system at the time of the storm. Sugar maple, red maple, and white ash in classes B and C had survival rates in the same range as class A trees, although few red maple remained in the sample due to harvesting (Table 3).

The sugar maple and beech that died after 15 years were larger trees with major crown loss (Table 3). The only ash to die was a smaller tree that lost virtually all its crown. The survivorship proportion after 15 years for yellow birch and beech was 70 percent and 82 percent, respectively (Table 1).

In the absence of the 1998 storm, some tree mortality would be expected as a consequence of stand development. The expected decrease in the number of trees per acre as trees increase in size has been empirically determined and can be represented by a stocking chart.

Based on the stocking chart (Fig. 3), an increase in mean stem diameter of 1 inch is associated with the survival of 83 percent and 88 percent of poles and sawtimber, respectively.

The overall survival rate after 15 years of “tag and track” was 84 percent, consistent with the stocking chart. On a landscape basis, the mixture of crown injury class A, B, and C trees is functioning as expected, although the trees that lost more than half their crown to the winter storm were dying five times faster than trees that lost less than half. The regional survey of 22,000 trees after the storm indicated that 80 percent of the trees would be classified as A with the remaining 20 percent evenly distributed as classes B and C.

Nearly equal numbers of the fastest-growing trees before the storm (1 to 10 rings per inch of radius [rpi]) occurred in classes A and B+C. Fewer intermediate (11 to 20 rpi) and slow-growing trees (21 to 40 rpi) occurred in class A than in class B+C trees (Fig. 4a). Survival rates were relatively constant at 89 to 100 percent for class A trees at all prestorm growth rates (Fig. 4b). Faster growing class B+C trees were comparable to survivorship of class A trees at 88 percent. Survivorship dropped to 68 to 79 percent of trees with slower prestorm stem growth rates (Fig. 4b).

After 15 years, the largest category of trees was the combined injury class B+C with open holes (Fig. 4c and Fig. 5). Class B+C trees were less effective in wound closure (Fig. 5) than class A trees (Fig. 4d), indicating the potential for increased vulnerability from subsequent injury from natural or human disturbance. Survival rates for all trees with partly or fully closed wounds was 91 to 100 percent (Fig. 4d).

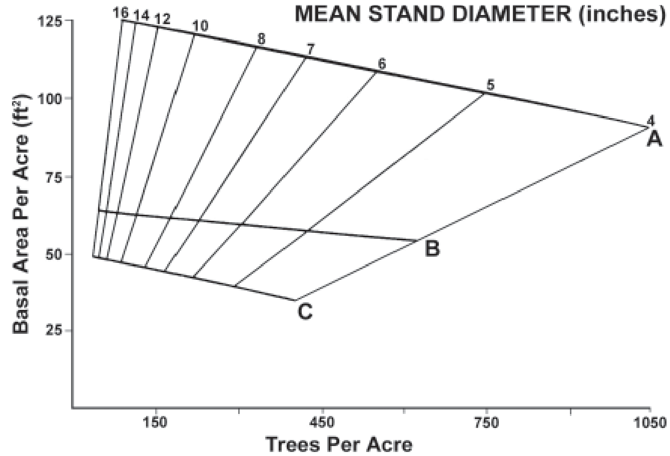

Figure 3.—Stocking chart for northern hardwood forest stands.

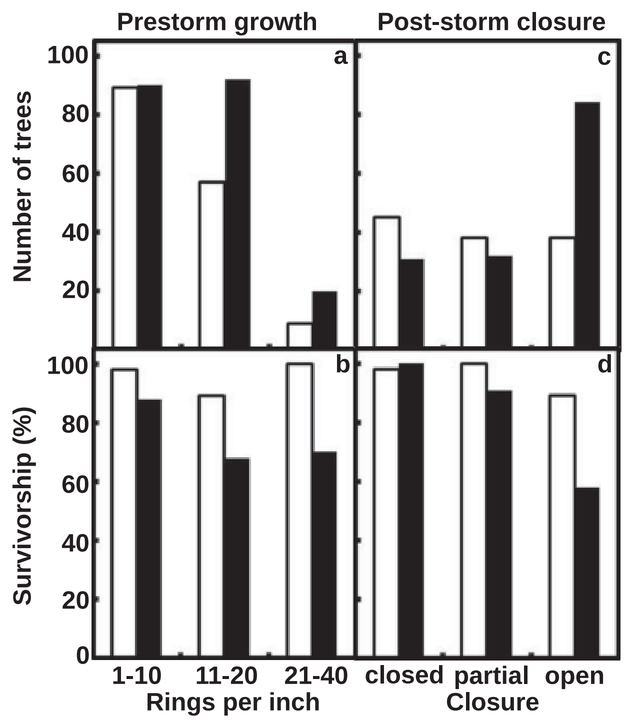

Figure 4.—Distribution of “tag and track” trees for prestorm growth (a, b) and post-storm closure (c, d) by crown injury class A (white bars) and combined injury class B+C (black bars).

Figure 5.—Open (left) and closed (right) bore holes in sugar maple. Photos by Kenneth R. Dudzik, U.S. Forest Service.

CONCLUSIONS

Across the tracked hardwood species and for the period 5 to 15 years after the 1998 storm, tree mortality increased from 1 to 5 percent for trees that lost less than one-half of their crown and from 5 to 24 percent for trees that lost more than one-half of their crown. The lowest rate of survival occurred in birch and was attributed to advanced root-rot disease which was more prevalent in paper rather than yellow birch. The disease was likely present in the root system at the time of injury. If the roots were sound and the trees were able to replace the crown with vigorous sprouting, most injured trees survived through the study period.

Storm survivorship varied by tree species, size class, prestorm growth rates, and closure of post-storm bore holes. Trees with less than one-half crown loss were least likely to die in all species studied with the exception of paper birch which is a short-lived, early successional species. Trees with more than one-half crown loss appeared less able to close the bore holes. Trees growing more slowly before the storm were more severely impacted by crown breakage and loss.

For a local stand, woodlot, sugar bush, park, or backyard, tree injury and resulting damage and loss of value could be extensive and require rapid treatment or remediation, particularly for safety considerations. The trees most resilient to storm impact are those that are healthy and growing well before the storm, whether in a rural or urban setting.

However, over the forested landscape and for a decadal or greater time scale, this case study suggests that the ice storm of 1998 was simply the specific agent to maintain normal and expectable stocking densities.

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KEY WORDS: forest disturbance, armillaria root disease, storm recovery, wound closure

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