Windfirmness of residual riparian trees following upland clearcutting and riparian thinning in Itasca County, Minnesota

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INTRODUCTION

Minnesotans highly value riparian forests. These forests provide habitat for plants and animals, clean water, places for outdoor recreation, and many other benefits. Minnesota's voluntary site-level forest management guidelines (MFRC 1999) help landowners, resource managers, and loggers concerned with sustaining those benefits make informed forest management decisions.

Retaining live trees in riparian areas during harvesting, as suggested by the guidelines, is one method of preserving forest values while meeting economic objectives. The guidelines incorporated the best information available into its recommendations for the tree species, sizes, and locations of residuals on harvest sites. However, information about the windfirmness of trees left as residuals following timber harvest in Minnesota is very limited.

This study provides forest managers with objective information about the windfirmness of residual trees. We compared the fates of trees on plots in riparian areas along the Pokegama Creek near Grand Rapids, MN, that had been experimentally thinned following harvest in adjacent uplands, on plots that had not been thinned, and on plots where no harvesting had occurred in riparian or upland areas. The study addressed the following questions:

- Are some tree species more susceptible to windthrow than others?
- Is susceptibility to windthrow related to tree size?
- Is susceptibility to windthrow related to distance from the clearcut edge?

METHODS

In 1997, 12 experimental plots were established along Pokegama Creek on UPM Blandin Company land in southern Itasca County, Minnesota, in the Northern Minnesota Drift and Lake Plains Ecosystem (Figure 1). Plots contained equal areas on each side of the creek and were 11.3 - 12.1 ac in size and 450 - 600 ft wide. The riparian portions of the plots were 2.1 – 2.75 ac in size and included the area within about 100 ft of the stream centerline.

The experimental design included 3 replicates of each of four experimental treatments. Nine upland plots were clearcut, using either a cut-to-length logging system or a feller/buncher grapple skidder system. In 6 adjacent riparian areas, trees were thinned, using the same system as in the upland with a target residual basal area of 25 ft^2/ac. Trees on riparian areas adjacent to the remaining 3 cut uplands were not thinned. On 3 plots there was no harvesting or thinning on either uplands or riparian areas. Thus, the experimental design included 3 replicates of each of four experimental treatments: upland clearcut, riparian area thinned using cut-to-length system; upland clearcut, riparian area thinned using feller/buncher system; upland clearcut, riparian area uncut; and no harvesting in upland or riparian area. Experimental plots were established in late summer and early fall 1997. Field data collection focused exclusively on the riparian portions of the experimental plots.

<u>Data and statistical analyses</u>: Prior to thinning, the trees in riparian portions of plots were characterized using the point-quarter technique. For each tree selected using this method, species, diameter at breast height (dbh), and position relative to clearcut edge (within 16 ft, 16-49 ft away, > 49 ft away) were recorded. These measurements provided an estimate of the relative abundance of each tree species and an estimate of the size class distribution on riparian portions of plots for all tree species combined and for each species individually.

Following thinning in the riparian portions of experimental plots, the species, dbh, and position relative to clearcut edge of each residual tree were recorded. This complete enumeration provided information on species composition and size class distribution on the 6 experimental plots with riparian thinning. Point-quarter and complete enumeration data were used to characterize initial conditions on plots and to estimate the basal area removed during thinning.

Once each year for 3 years following treatment harvests (in 1998, 1999, and 2000), the species, dbh, and distance from stream of each tree on experimental plots that had been windthrown since the last measurement period were recorded. No distinction was made between trees that were windthrown directly and those that were damaged by an adjacent tree that was windthrown. These data were used in calculations of the susceptibility to windthrow of residual riparian trees.

Species composition and size class distributions of trees on riparian portions of experimental plots following thinning (i.e., at the beginning of the experiment) varied widely. Based on chance alone, one would expect that a greater number of trees of species that were abundant than of species that were rare would be windthrown during the course of the experiment. Similarly, one would expect there to be more damage to trees of the most abundant size class than to trees of rare size classes. To avoid biasing the results because of initial differences in abundance, I estimated 'susceptibility to windthrow' and used this value as the response variable in all analyses. In general, 'susceptibility to windthrow' was a ratio of the number of trees that were windthrown during the experiment to the number of trees that could have been windthrown (i.e., the number present at the beginning of the experiment). More specifically, susceptibility to windthrow was a ratio of relative abundance (of individual trees of a species, of trees of certain size classes, or of trees at certain distances from the stream) immediately after treatment harvests to relative abundance (of the same measure) in the pool of windthrown trees after three years. For example, susceptibility of Red maple to windthrow was calculated as the percent of all windthrown trees after 3 years that were Red maples divided by the percent of individual trees immediately after thinning that were Red maples. Thus, a species with an index value less than 1.0 was windthrown less frequently than would be expected based solely on its initial abundance (and availability to be windthrown). A species with an index value greater than 1.0 was windthrown more frequently than would be expected based solely on its initial relative abundance. Where data were available, susceptibility to windthrow was calculated for each species, size class, and distance category on each experimental plot.

Initial analyses of the data suggested that differences in windfirmness of residual trees for any species, size class, or distance category that may have resulted from differences in the methods of harvest were not statistically detectable. This was likely due to small sample size and high within-harvest method variability in susceptibility to windthrow. Consequently, data from the thinned plots, regardless of harvesting system used, were pooled for statistical analyses. Analysis of variance of the effects of species, dbh class, distance from clearcut edge, and treatment was performed using the Statistical Analysis System (SAS). Measures of susceptibility to windthrow were transformed using a square root transformation prior to analysis.

RESULTS and DISCUSSION

Initial density and species composition of the trees in the riparian areas of the experimental plots varied widely due to treatment thinnings and the natural patterns of tree distribution in the area (Figure 2). Thinning reduced total basal area by 16-63% compared to pre-thinning levels. Following treatments, basal areas on thinned plots averaged 76.2 ft^2/ac compared to 128.0 ft^2/ac on unthinned stands (Figure 2a). Tree species that were most abundant in the general area of the experimental plots were not evenly distributed on the experimental plots (Figure 2b). Trembling aspen, the most abundant species, constituted as much as 34% and as little as <1% of the basal area on experimental plots. Although cedar was the second most abundant species, it was concentrated on 2 plots and uncommon on others. Initial density and composition differences may have influenced the results obtained in this experiment even though calculations of susceptibility to windthrow were intended to minimize their affects.

Are some species more susceptible to windthrow than others?

The number of observations (i.e., calculated susceptibilities to windthrow) used in the analysis was determined by the distribution of the species over the experimental plots, with a maximum number of observations (n) = 12 for each species. The number of observations per species ranged from 12 for Paper birch, Basswood, Black ash, and Sugar maple, which were abundant and widely distributed on the experimental plots, to 4 for American elm and 3 for White spruce and White pine, which were less common (Table 1).

Susceptibility to windthrow varied widely among species on the experimental plots (Figure 3). Trembling aspen, Balsam fir, and Balm of Gilead were most susceptible to windthrow, contributing to the pool of windthrown trees at about 2 times the rate expected solely from their abundance on the plots. Paper birch, Basswood, Red maple, Cedar, Big-toothed aspen, Black Ash, and Sugar Maple were moderately windfirm and were windthrown about in proportion to their abundance on the plots. Red oak, Yellow birch, White spruce, White pine, and American elm were least susceptible to windthrow. These species, however, were not as abundant on the experimental plots as other species and fewer observations were used in the analyses.

These results are generally in agreement with recommendations for residual trees contained in the guidelines with minor exceptions. The guidelines recommend some species more highly for use as leave trees based not only on windfirmness but also longevity and potential for providing cavities. Trembling aspen, highly susceptible to windthrow in this study, is characterized as ‘good’ as a leave tree in the guidelines. Of the species we observed to be moderately windfirm, paper birch is rated ‘fair’ and basswood, black ash, and sugar maple are rated ‘excellent’ in the guidelines.

Is susceptibility to windthrow related to tree size?

For this analysis, an observation was recorded (i.e., susceptibility to windthrow was calculated) for each size class and species combination present on a plot. The maximum number of observations possible for each species was 108 (9 size classes times 12 plots). The actual number of observations per species ranged from 4 for White spruce and White pine to 44 for Black ash. There were 389 total observations, averaging 24 observations per species. Because Sugar maple, Paper birch, and Black ash were abundant and occurred in numerous size classes on the study site they were disproportionately important in the analysis.

Although differences in susceptibility to windthrow by size class were not statistically different ($P > 0.10$), larger trees appeared to be more prone to windthrow (Figure 4) than smaller trees. Trees with dbh greater than 12 inches were windthrown in greater numbers than expected based on their abundance on the plots. Similarly, trees with smaller dbh were windthrown less frequently than would be expected based solely on their abundance on the plots. This overall trend was exhibited by many of the abundant species (Figure 5). Extreme susceptibility values, however, likely reflect small sample sizes rather than high susceptibility to windthrow.

Based on casual observation alone, most field foresters likely would agree that larger trees are more susceptible to windthrow than are smaller trees. Larger trees, however, generally are more valuable to wildlife and the guidelines recommend leaving a range of tree sizes that includes larger trees. Additional steps may be needed to protect larger trees from being windthrown, given their greater susceptibility to wind damage, if management objectives include retaining large standing trees.

<u>Is susceptibility to windthrow related to distance from the clearcut edge?</u>
Data on distance from the clearcut edge were available from only 6 of the 12 experimental plots. For this analysis, plots were divided into three shelter classes based on distance from the clearcut edge: sheltered (82-98 ft from edge and 0-16 ft from stream); moderately sheltered (49-82 ft from edge and 16-49 ft from stream); and least sheltered (0-49 ft from edge and >49 ft from stream). Data on all species in a subdivided plot were combined to calculate a single index of susceptibility to windthrow for that shelter class and plot (n = 18).

Although differences in susceptibility to windthrow by shelter class were not statistically different ($P > 0.10$), trees nearer the clearcut edge appeared to be more prone to windthrow than trees that were more sheltered (Figure 6). This is consistent with most field observations and common sense. It is likely that small sample size or the distance categories for characterizing exposure were inadequate for detecting statistical significance.

The guidelines suggest that the leave tree clumps, strips, or islands left following clearcutting be positioned adjacent to riparian areas. Following this suggestion likely would make residual trees in the riparian area less susceptible to windthrow.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Minnesota Forest Resources Council. 1999. Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers. Minnesota Forest Resources Council, St. Paul, Minnesota.

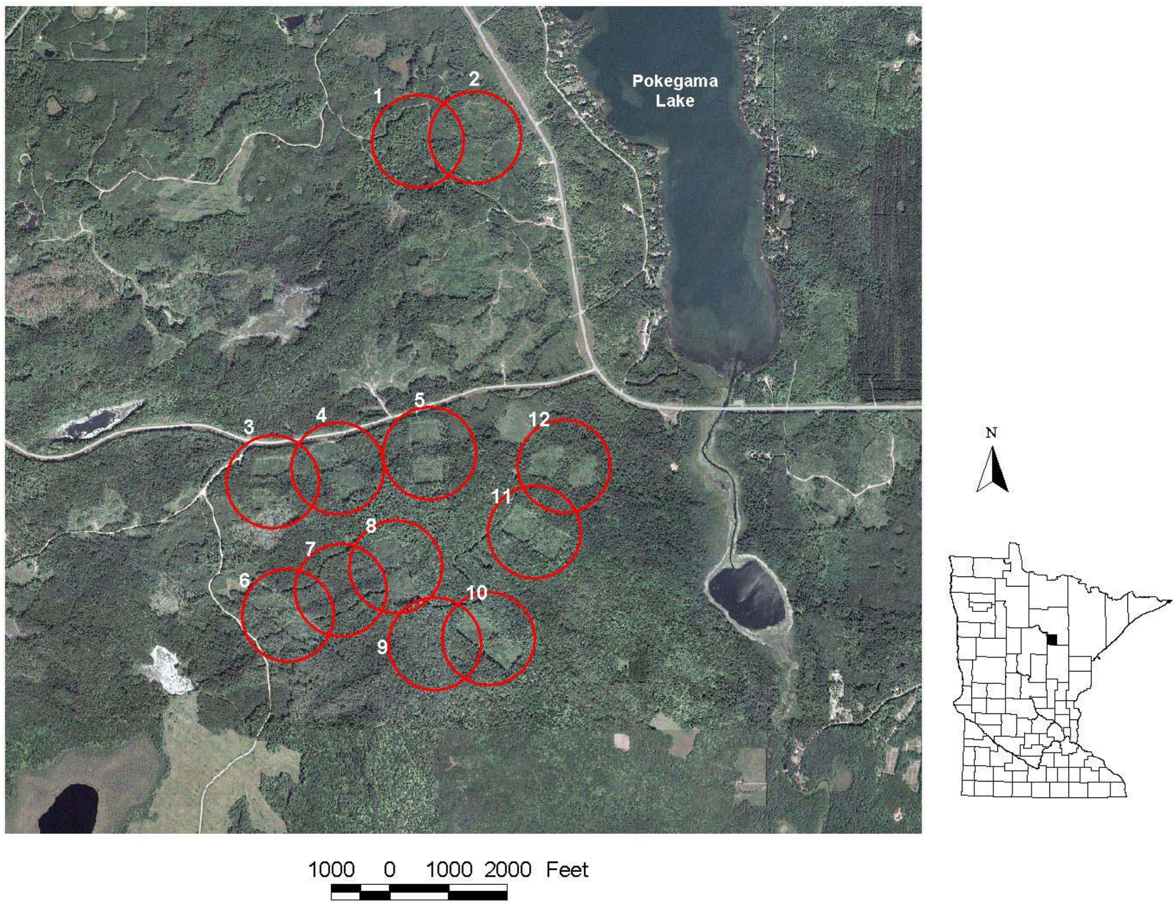

Figure 1. Location of experimental plots used in this study. The upland portions of plots harvested in 1997 are still identifiable in this aerial photo taken in 2003. On plots 2, 4, 6, 8, 10, and 11 the uplands were clearcut and the riparian areas thinned. On plots 3, 5, and 12, the uplands were clearcut and the riparian areas were not thinned. On plots 1, 7, and 9 no harvesting or thinning occurred. The small map shows the approximate location of the study area in southern Itasca County.

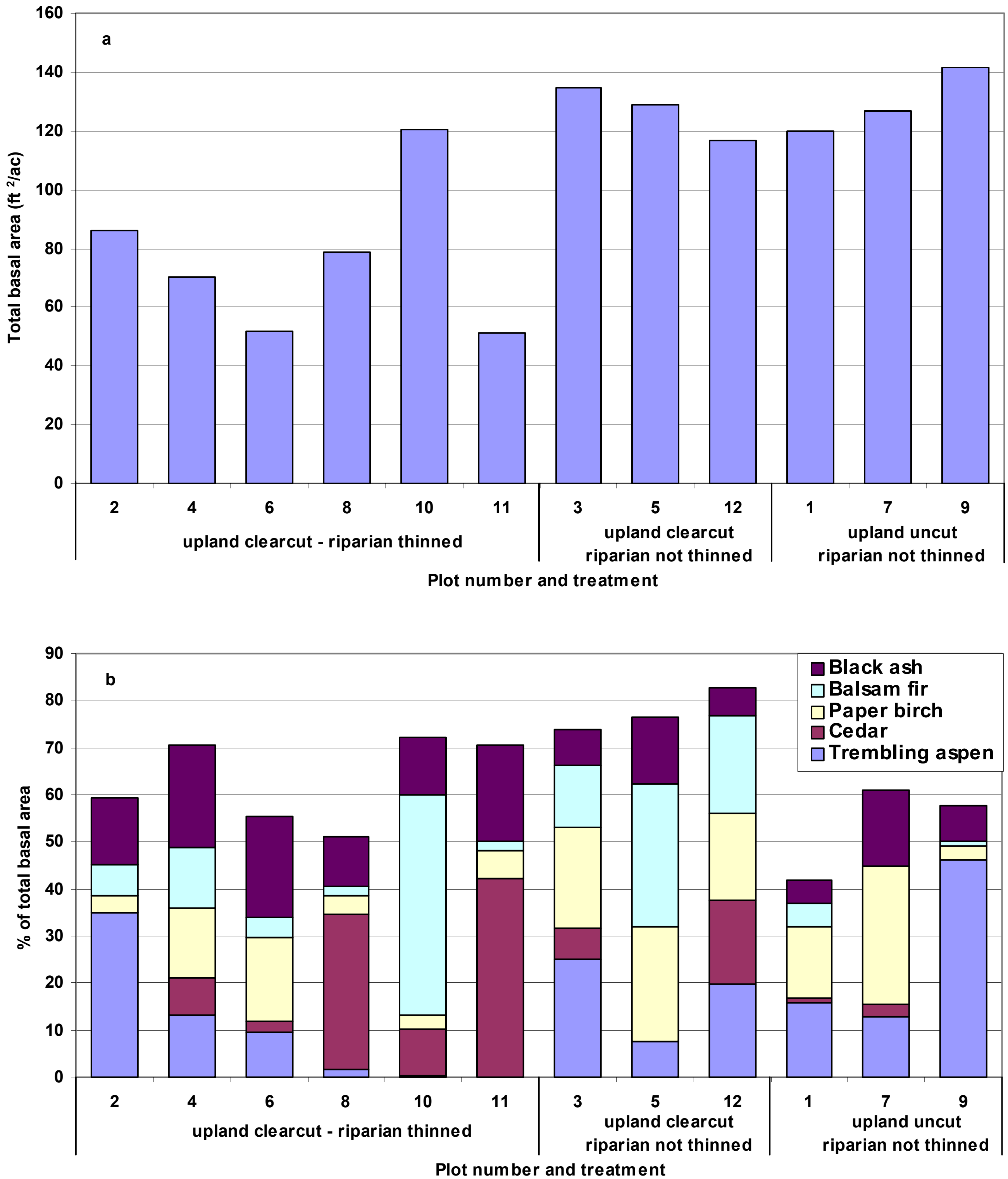

Figure 2. a) Basal area of all trees in the riparian areas of experimental plots at the beginning of the experiment (immediately after thinning on plots 2, 4, 6, 8, 10, and 11). b) Species composition on experimental plots for the 5 most abundant species. Data are presented as percent of total basal area to minimize differences due to large differences in the number of trees present on thinned plots compared to unthinned plots.

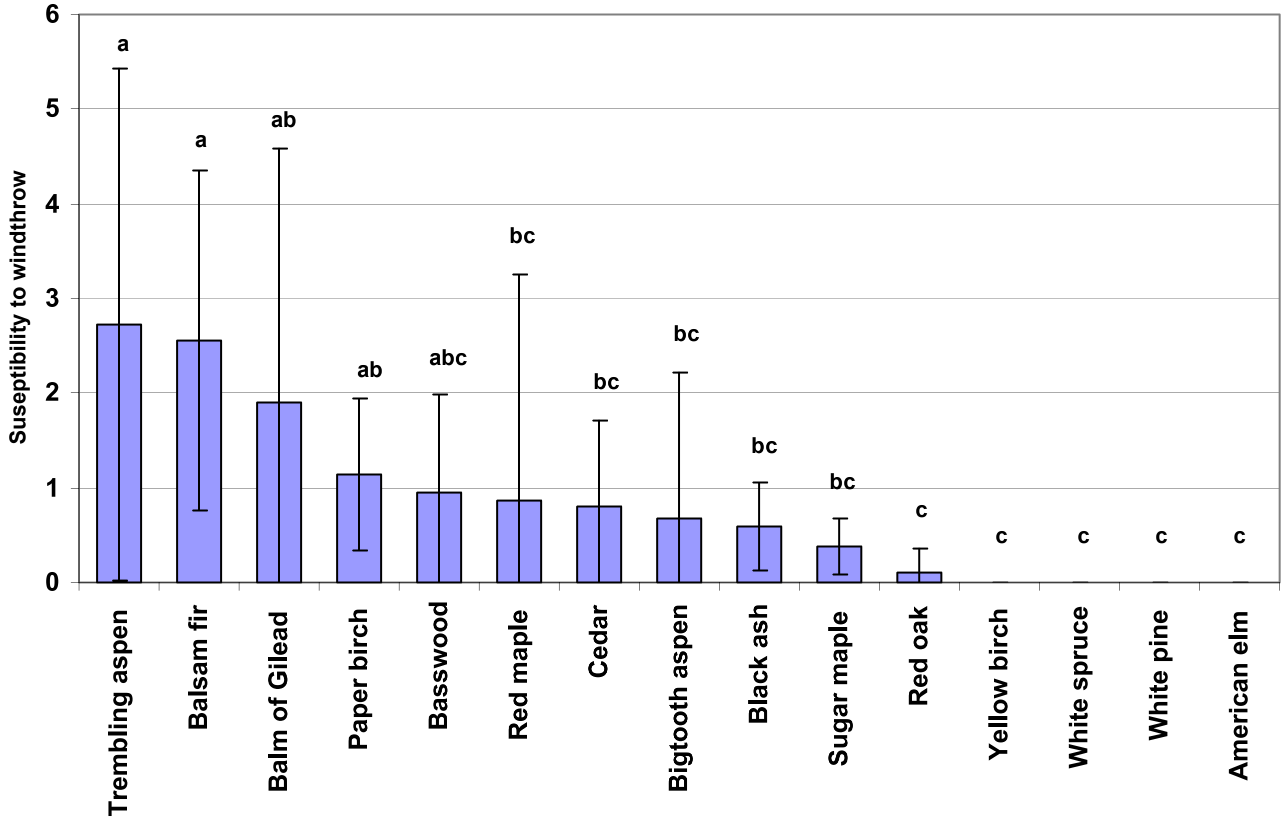

Figure 3. Mean susceptibility to windthrow of different species following upland clearcutting. A value greater than 1 indicates that the species was windthrown in greater proportion than would be expected by initial abundance alone. Error bars are 1 standard deviation of the species mean. Means with dissimilar letters are significantly different ($P < 0.05$).

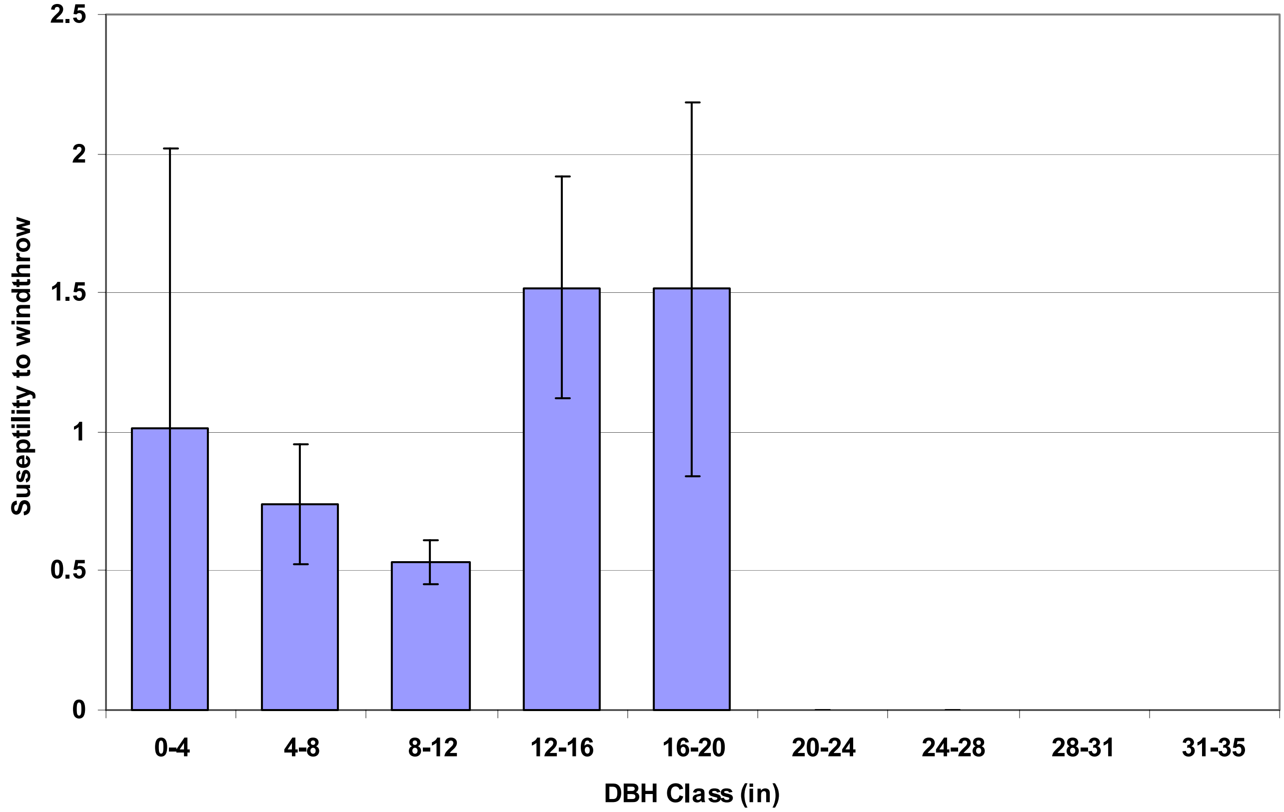

Figure 4. Mean susceptibility to windthrow of different size classes following upland clearcutting and riparian thinning. For this analysis, data from all species were combined. A value greater than 1 indicates that the size class was windthrown in greater proportion than would be expected by its abundance alone. Means are not significantly different (P>0.10). Error bars are 1 standard error of the mean.

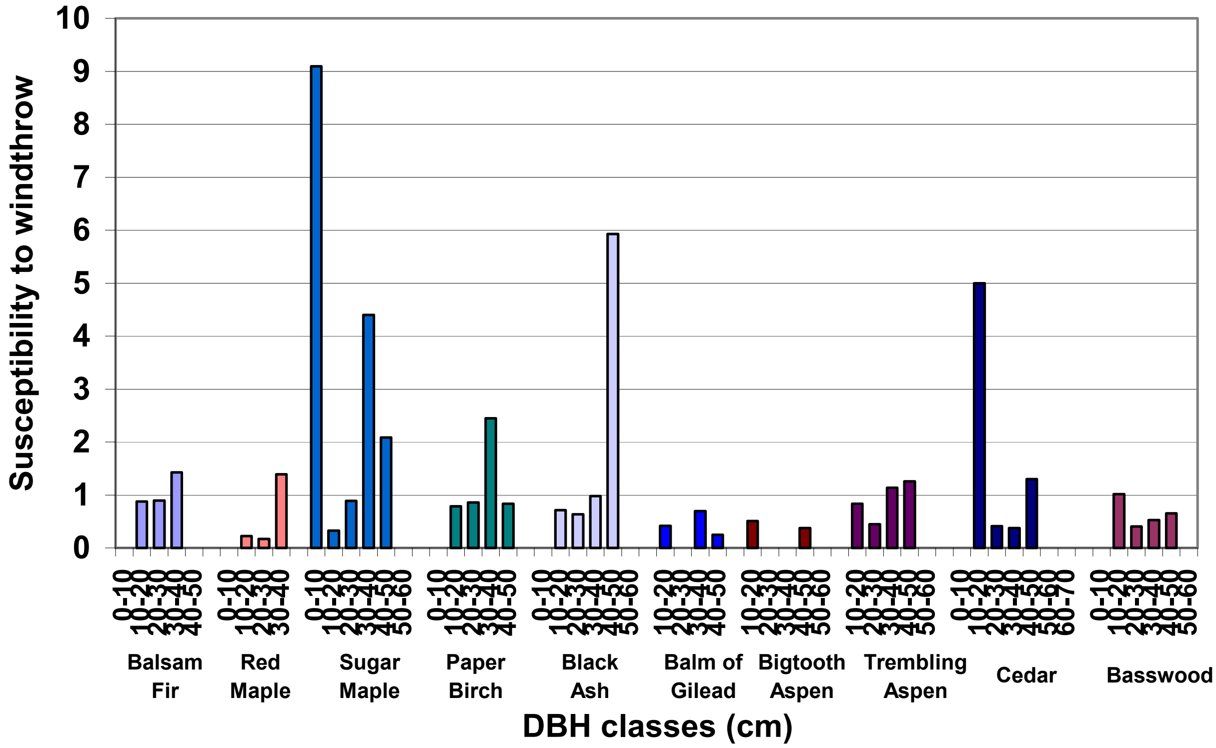

Figure 5. Mean susceptibility to windthrow of different size classes of the most abundant species following upland clearcutting and riparian thinning on the Pokegama Creek experimental plots. Values for size classes without visible bars are 0 (i.e., individual trees of the size class and species were present on the experimental plots but none were windthrown). An index value less than 1.0 indicates less damage from windthrow than would be expected based solely on its initial abundance and an index value greater than 1.0 indicates greater damage.

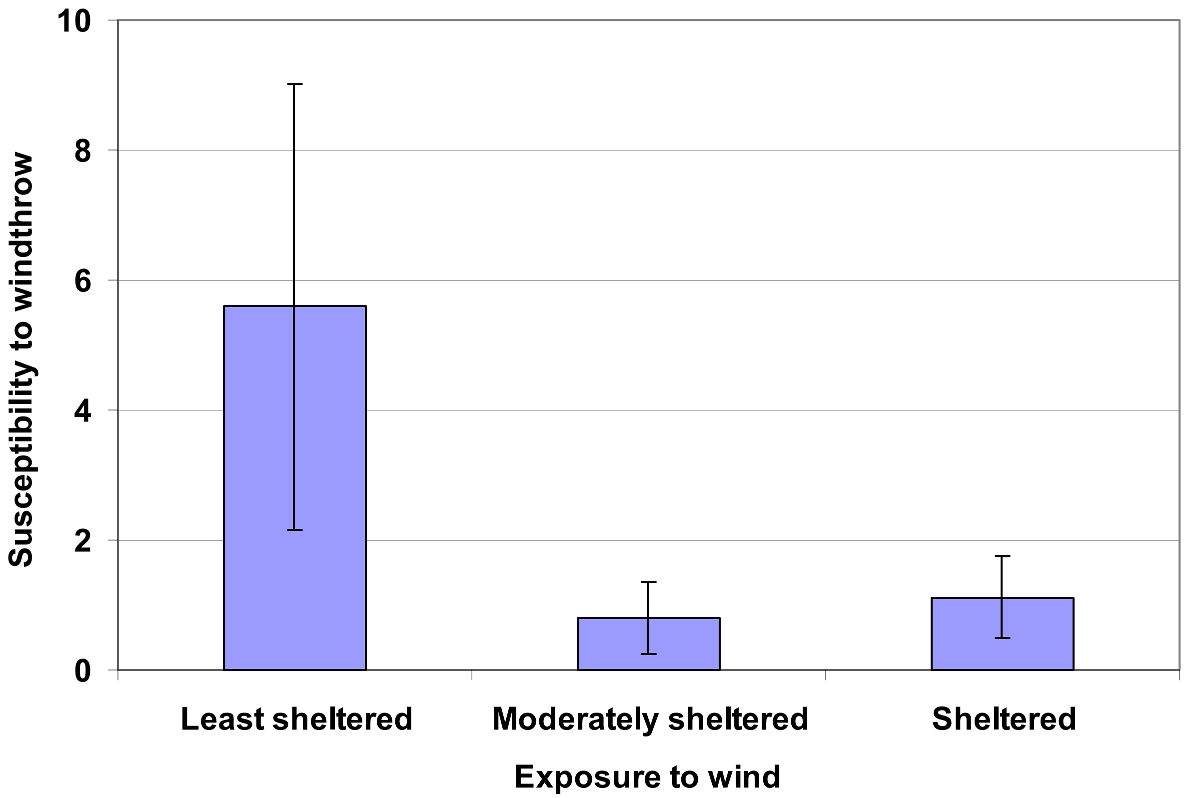

Figure 6. Mean susceptibility to windthrow of trees nearest the clearcut edge (Least sheltered), near the stream (Moderately sheltered) and adjacent to the stream (Sheltered) following upland clearcutting and riparian thinning. Means are not significantly different (P>0.10). Error bars are 95% confidence intervals about the means.

Table 1. The number of observations (N) used in the analysis of species differences in susceptibility to windthrow (Figure 3).

Species	N
Balsam fir	11
Red maple	12
Sugar maple	12
Yellow birch	8
Paper birch	12
Black ash	12
White spruce	3
White pine	3
Balm of Gilead	7
Bigtooth aspen	5
Trembling aspen	11
Red oak	7
Cedar	9
Basswood	12
American elm	4