THE EFFECT OF WIND GUSTS ON BRANCH FAILURES IN THE CITY OF ROCHESTER, NEW YORK, U.S.

Christopher J. Luley, Andrew Pleninger, and Susan Sisinni

The effect of pruning and daily wind gusts on branch failures was investigated in the City of Rochester, New York, U.S. This paper expands on the results of a recent study of 8 years of historical electronic data that evaluated the effect of pruning on branch failures of street trees. The majority of branch failures occur in wind events greater than 50 mph and during the period when leaves are present on trees. A regression equation predicted the number of branch failures due to wind gust and precipitation during the wind events with an $R^2 = 0.66$. However, other yet undetermined factors apparently can increase the number of branch failures at wind gusts both greater and less than 50 mph. High wind gusts (50 to 75 mph) in the leafless period seldom resulted in more than ten branch failures in a citywide population of 59,000 street trees. This presentation suggests that critical evaluation of other factors in addition to wind gust in the leafy period is needed to better predict the potential for branch failure in high winds.

This study expands on a recently completed project that evaluated the effect of rotational pruning on service requests, branch failures, and priority maintenance in the City of Rochester, New York, U.S. (Luley et al. 2002). That earlier work found that pruned management areas experienced numbers of branch failures similar to management areas that were not pruned. Further, comparison between pruned and unpruned management areas during high wind events (wind gust between 40 and 65 mph) showed some high wind events resulted in substantially greater number of branch failures than other wind events with similar or higher wind speeds. This finding suggested that factors other than wind gust speed alone might be important in causing tree branch failures.

The current study was initiated to determine if a specific wind factor, or combination of wind and other environmental factors, was responsible for the majority of branch failures in the City of Rochester.

MATERIALS AND METHODS

Details of the urban forest in Rochester, New York, pruning cycles and specifications, and the database used for this study can be found in previous papers (Sisinni et al. 1995; Luley et al. 2002). Briefly, electronic data used in this study were

extracted from a street tree inventory that was completed in 1991 and was updated again starting in 1995. Data on requests for maintenance and maintenance work completed were available in two forms: service requests and work histories as described previously (Luley et al. 2002). These data were updated daily by City of Rochester forestry staff during the study period of 1992 through 1999.

The analysis presented in this paper is based on daily branch failure reports ("service requests"), daily maximum wind gust, and precipitation amounts during the wind gust event. The daily maximum wind gust (averaged over a 5-second period) and the precipitation amounts during the wind gust were taken from hourly weather data from the Rochester International Airport (Monroe County, CoopID 307167, National Climatic Data Center). The final data set consisted of daily reported branch failures, maximum daily wind gust, and the amount of precipitation 1 hour before and during the hour of the gust. Minor adjustments were made to the daily branch failure data set to account for branch failures that occurred late in the evening and were reported the following day and for extreme wind events for which branch failure reports were made over several days. Otherwise, those data were analyzed as reported.

RESULTS AND DISCUSSION

Monthly Branch Failure and Wind Gust

The total number of branch failures by month (Figure 1) shows a distinct increase failures in the period when foliage is present on trees in Rochester. Branch failures increase starting in May and drop off starting in October. The peak in branch failures in September (Figure 1) is somewhat artificial because 243 of these failures are due to a single wind event of 89 mph in September 1998. In our previous paper (Luley et al. 2002), we used the period May 15 to November 15 as the leafy period. In retrospect, the leafless period should start sooner, probably in the beginning of October, when leaves begin to fall in large numbers from most trees and when high winds are likely to dislodge leaves as they are naturally abscising.

Monthly wind data for gusts greater than 40 mph are presented in Figure 2. The increase in branch failures in the leafy period clearly cannot be attributed to more frequent wind gusts when leaves are present. In fact, Figure 2 shows that the frequency of high wind gusts is greater in the leafless period from October to mid-May. As discussed previously (Mattheck and Breloer 1994; Chaney 2001; Luley et al. 2002), the "sail effect" apparently is significant for branch breakage. Given this relationship, we analyzed the branch failure data separately for the leafy and leafless periods.

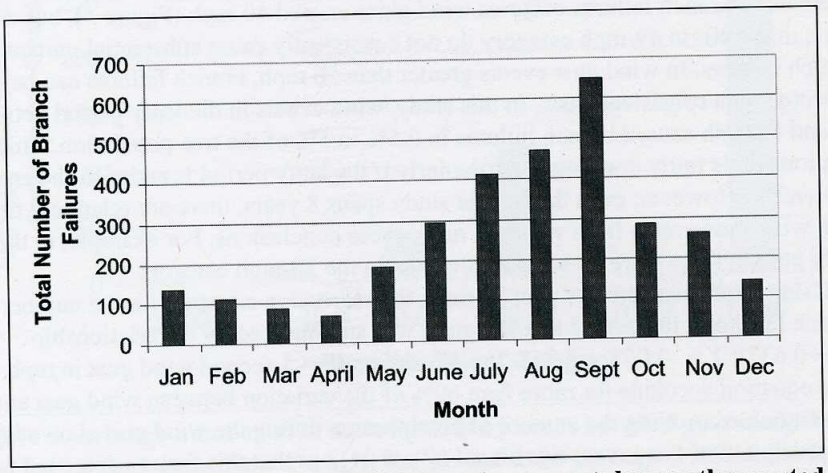

Figure 1. Total branch-failure-related service requests by month reported for street trees in the City of Rochester, New York. Note that a single wind event in September 1998 resulted in 243 branch failures in that month.

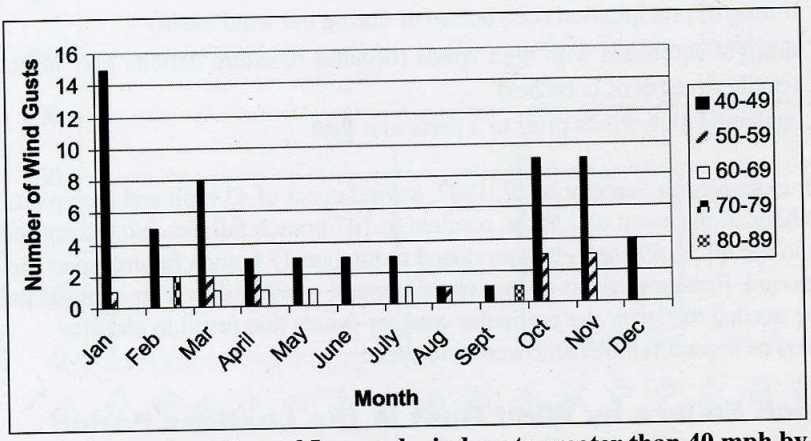

Figure 2. Total number of 5-second wind gusts greater than 40 mph by month in the period 1992 through 1999 in the City of Rochester, New York.

Branch Failure by Wind Gust Speed in the Leafy Period

Daily branch failure and wind gust data showed that relatively few significant branch failures occur in wind speeds less than 40 mph (Figure 3). Increasing numbers of branch failures occur as wind gusts exceed 40 mph (Figure 4), but wind gusts in the 40- to 49-mph category do not consistently cause substantial numbers of branch failures. In wind gust events greater than 50 mph, branch failures can be expected on a consistent basis. In this study, wind events in the leafy period between 50 and 85 mph caused branch failures in 0.5% to 5% of the tree population. This relationship is fairly consistent, particularly if the leafy period is ended at the end of September. However, even though the study spans 8 years, there are relatively few high wind gust events from which to make these conclusions. For example, in the leafy period, there were no wind gust events in the 70-mph category.

Using wind gusts greater than 30 mph, the regression equation for the number of branch failures with respect to wind gusts was summarized by the relationship ($R^2 = 0.637$): $Y = -11.37 + 3.868^{E-4} \times W^3$, where W = 5-second wind gust in mph. This equation accounts for more than 60% of the variation between wind gust and branch failure. Adding the amount of precipitation during the wind gust showed that the precipitation factor was significant ($P = 0.01$) but that this factor accounted for only a slight increase in the R^2 to 0.66. These regression results, as well as the presence of branch failures in some high wind events and not others during the leafy period (Figure 4), suggest that other factors in addition to wind gust alone also contribute to the amount of branch failure that occurs in certain high wind gust events.

A few factors that might be involved in increasing branch failures during some wind events and not others include

- timing of precipitation (i.e., before or during the wind event)
- drought combined with high winds (because moisture deficits may affect the tensile strength of branches)
- sustained high winds prior to a particular gust.

For example, on September 29, 1997, a wind event of 43 mph and precipitation in the hour of the event of 1.92 in. resulted in 147 branch failures. No other wind event in the 40- to 49-mph class produced more than 15 branch failures over the 8-year period. Further analysis of branch failure and weather data over a longer period will be needed to clarify the particular weather events that result in elevated numbers of branch failures at lower wind speeds.

Branch Failure by Wind Gust in the Leafless Period

There appeared to be little consistent relationship between wind gust and branch failure in the leafless period (Figure 5). In the winter months, ice, sleet, and snow loads, in combination with wind, are probably more important in causing branch failures than high wind speeds alone. The greatest number of daily branch failures in the leafless period was 12 during a 35-mph wind event on February 24, 1997.

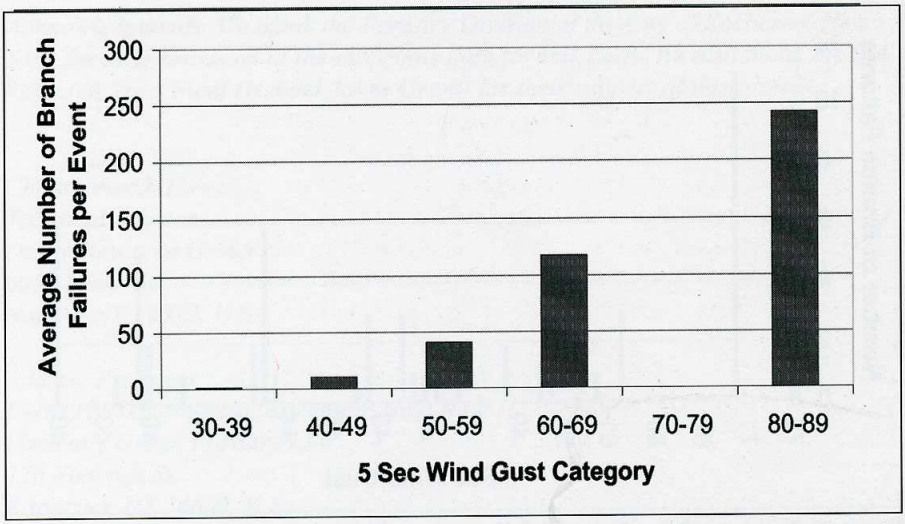

Figure 3. Average number of branch failures by event by wind gust category in the City of Rochester, New York, in the period 1992 through 1999 in the leafy period.

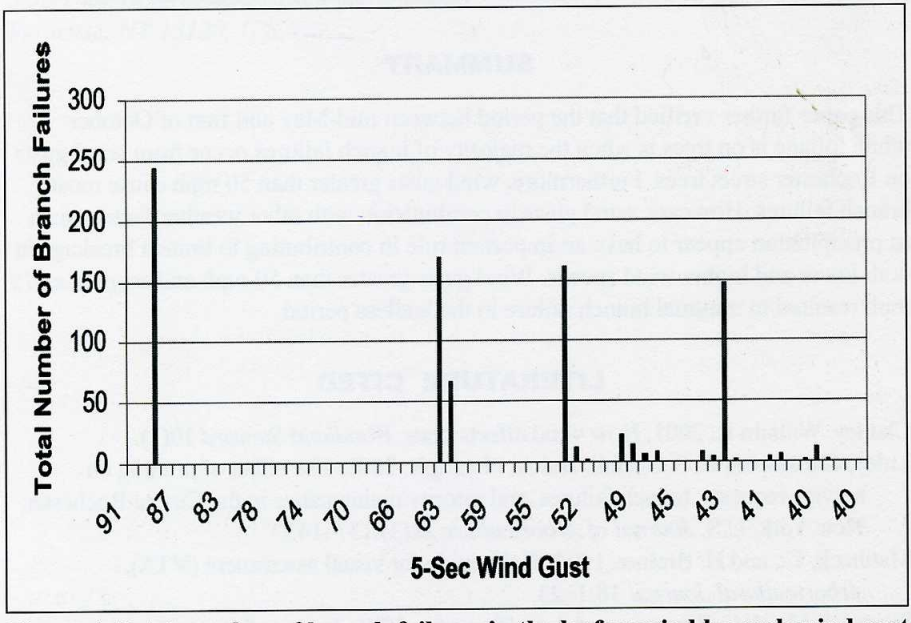

Figure 4. Total number of branch failures in the leafy period by each wind gust event greater than 40 mph in the city of Rochester, New York, in the period 1992 through 1999.

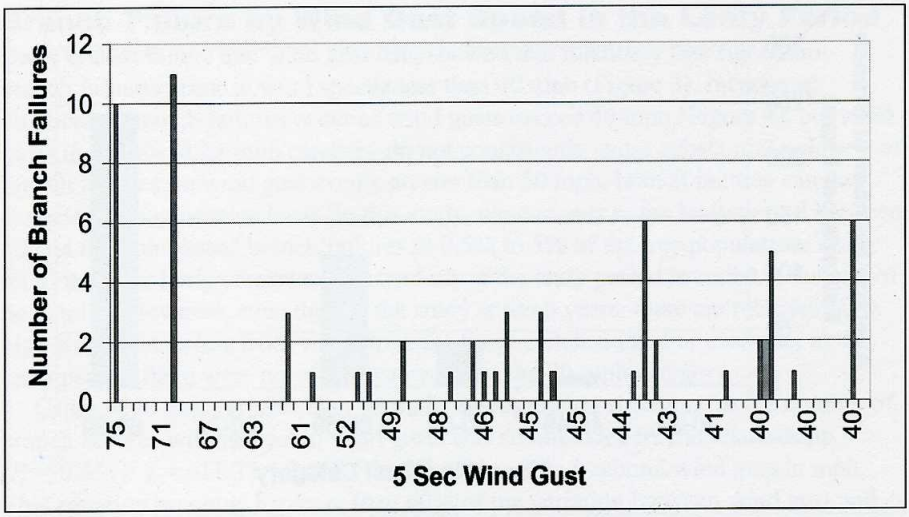

Figure 5. Total number of branch failures by wind gust event in the leafless period in the City of Rochester, New York, in the period 1992 through 1999.

Ten wind gusts between 50 and 74 mph did not cause more than 11 branch failures over the study period and averaged 2.7 failures per wind event. However, the devastating potential of ice and wind in winter months cannot be ignored (Sisinni et al. 1995).

SUMMARY

This paper further verified that the period between mid-May and first of October while foliage is on trees is when the majority of branch failures occur from wind gusts on Rochester street trees. Furthermore, wind gusts greater than 50 mph cause most branch failures. However, wind gusts in combination with other weather factors such as precipitation appear to have an important role in contributing to branch breakage at both lower and higher wind speeds. Wind gusts greater than 50 mph and as great as 75 mph resulted in minimal branch failure in the leafless period.

LITERATURE CITED

Chaney, William R. 2001. How wind affects trees. *Woodland Steward* 10(1).

Luley, Christopher J., S. Sisinni, and A. Pleninger. 2002. The effect of pruning on service requests, branch failures, and priority maintenance in the City of Rochester, New York, U.S. *Journal of Arboriculture* 28(3):137–143.

Mattheck, C., and H. Breloer. 1994. Field guide for visual assessment (VTA). *Arboricultural Journal* 18:1–23.

Sisinni, S.M., W.C. Zipperer, and A.G. Pleninger. 1995. Impacts from a major ice storm: Street tree damage in Rochester, NY. *Journal of Arboriculture* 21:156–167.

Acknowledgments. *We thank the Forestry Division of the City of Rochester, New York, for their provision of the electronic data for this study. We also thank the ISA Research Trust Fund (Hyland Johns Grant) for their support of this project.*

Christopher J. Luley
Technical Advisor
Davey Resource Group
6050 Hicks Rd.
Naples, NY 14512, U.S.

Andrew Pleninger
Formerly City Forester, Rochester, New York
Currently Urban Forestry LLC
176 Elmcroft St.
Rochester, NY 14609, U.S.

Susan Sisinni
Forester
USDA Forest Service
1100 Irving Ave.
SUNY Environmental Science and Forestry
Syracuse, NY 13120, U.S.