THE EFFECT OF PRUNING ON SERVICE REQUESTS, BRANCH FAILURES, AND PRIORITY MAINTENANCE IN THE CITY OF ROCHESTER, NEW YORK, U.S.

by Christopher J. Luley[1], Susan Sisinni[2], and Andrew Pleninger[3]

Abstract. The effect of pruning on service requests, branch failures, and priority maintenance was evaluated in the City of Rochester, New York, U.S., using 8 years of historical data on street trees. Pruning, which was completed on a management unit basis, was evaluated by comparing pruned and unpruned management units. Analysis of service request data showed that pruned management units had lower forestry-related requests and fewer pruning-related requests from the public but not lower requests for branch-failure-related maintenance annually or during high wind events. Analysis of work history or work completed showed that pruned management units had lower priority maintenance after pruning but not lower branch failure rates. Branch failure rates averaged 7.6 and 6.5 failures per 1,000 trees annually when based on requests and work completed, respectively. On the average, branch failure rates during the leaf-on period were three times greater than when foliage was not present. These results will help other communities compare the relative effectiveness of their pruning program and provide a branch failure probability for managed street trees.

Key Words. Pruning; service requests; branch failure; street trees; tree hazards; wind damage.

Many communities rely on periodic tree pruning to enhance the condition and safety of their street trees. However, there have been few, if any, studies to show that pruning actually provides these desired benefits. Miller and Sylvester (1981) showed that there was an advantage economically and to tree condition to pruning trees on a 5-year rotation versus shorter or longer rotations. In that study, pruning on shorter or longer rotations resulted in increased pruning costs or decreased tree valuation, respectively, compared to the 5-year rotation. Based on this information, a goal of many communities is to achieve a 5-year rotational pruning program.

A severe ice storm struck the City of Rochester, New York, U.S., in 1991. Characteristics of the ice storm and its effect on the city's street tree resource were described previously (Sisinni et al. 1995). After recovery efforts from the ice storm were completed, the city initiated a rotational pruning program in 1996. The intent was to prune all its trees within a 5-year period. Prior to 1996, although a substantial number of trees had been pruned, there was no formal effort to prune the entire tree population on a rotational basis.

This study was initiated near the end of the 5-year rotational pruning program to determine if the pruning was providing the desired impact on the city's street trees. The primary objective of the study was to compare pruned and unpruned management units in the city to assess the impact of pruning on service requests from the public, branch failures, and priority maintenance work. A second objective was to estimate branch failure rates in the City of Rochester.

MATERIALS AND METHODS

The effects of pruning were studied for the period from 1992 through 1999 on the city's street tree population. Prior to 1996, pruning was completed using NAA Class II and III pruning guidelines (NAA 1988). After 1995, pruning was completed from specifications developed from ANSI A300-1995 maintenance pruning standards (ANSI 1995).

Specifically, each tree in a management area that was pruned was crown cleaned down to branches 1-in. diameter, including broken and hanging limbs, dead wood, split branches, and decaying branches with less than 65% sound wood. Structural pruning was included in the pruning specification to remove branches with less than 45-degree angle of attachments and to maintain apical dominance where appropriate. Crown thinning was completed to no more than 25% of the canopy and 2-in. diameter branches. Each tree received at least some crown thinning as part of the city contracts. Crown raising was 15 ft over streets and 8 ft over sidewalks. Crown restoration was for storm-damaged branches down to 1-in. diameter.

For forestry management purposes, the City of Rochester was divided into 31 management sections.

The management sections ranged in size from containing anywhere from 530 to 3,082 street trees. Trees ranged in size from recently planted (2.5-in. caliper) to over 40-in. diameter at breast height (dbh). As described below, all street trees were included in the service request analysis, and only large trees (greater than 6-in. dbh) were included in the work history analysis.

Annual pruning work described above was completed on a management unit basis using city forestry crews prior to 1996 and outside contract crews from 1996 to 1999. Contracts were bid annually on a management unit basis by contractors. Contractual pruning was inspected by city forestry technicians for compliance with the specifications described above.

A management unit was not considered as pruned in the data analysis until the entire unit had been completely pruned. In a limited number of cases, pruning of a management unit required more than 1 year. Pruned management units were returned to the unpruned pool of management units after five or more growing seasons. This included management units that were pruned in 1992, 1993, and 1994.

Electronic data used in this study were obtained from the City of Rochester. These data were based on a street tree inventory that was completed in 1991 and was updated again starting in 1995. The city diligently recorded calls from the public and from maintenance work completed using the database. Data on requests for maintenance and maintenance work completed were available in two forms—service requests and work histories, respectively.

Service Request Data Analysis

Service request data included requests for tree work directly from citizens or other parties. These requests were recorded in the database using a standard list of request types that best matched the work being called for. Service request data are referenced to an address and cannot be referenced to an individual tree record electronically. Therefore, service request analysis was completed on all 59,215 trees present in the database between 1992 and 1999.

Service request data were analyzed for the effects of pruning on all forestry-related service requests (all types of requests that had to do with tree maintenance and not just pruning) and pruning-related service requests (such as trimming requests, low branches, apparent branch failures, branches affecting traffic, and other similar requests). Service request data were also analyzed for requests that were related only to branch failures.

Branch-failure-related service requests were also analyzed for a period of 1 week after five specific high-wind events. The high-wind events were randomly selected from a pool of high-wind events between 64.3 and 96.5 km/h (39 and 60 mph) (maximum wind gusts averaged over 5 seconds) that occurred in the leaf-on period. The wind data were obtained from weather information collected from the Rochester International Airport, located approximately 7 miles from downtown Rochester, New York.

A final service request analysis compared branch and tree failures in the period when leaves were on trees (leaf-on) and the period when leaves were off trees (leaf-off). The leaf-on period was May 15 to November 15, and the leaf-off period was January 1 to May 14 and November 16 to December 31.

Work History Data Analyses

Work history data include work that was actually completed in the field on an individual tree. The type of work history was recorded in the database using a standard list of codes that best represented the type of work that was done.

Work history data were linked to individual trees and therefore could be sorted based on tree diameter or other variables. This allowed trees in the 15.2- to 78.7-cm (6- to 31-in.) diameter class, or the majority of trees that were pruned during contractual pruning of management areas, to be separated out and analyzed apart from small-diameter trees.

Work history data from pruned and unpruned management areas were compared for work completed as a result of branch failures. In addition, pruned and unpruned management areas were compared for priority maintenance work completed prior to and after pruning. The priority maintenance work was completed as a result of an annual citywide survey by the city's forestry technical staff. Priority maintenance work was defined as pruning work on individual trees specifically for safety purpose to eliminate or reduce hazardous branches.

RESULTS

Number of Trees Pruned

The total number of trees in pruned and unpruned management areas by year that were used in the service request analysis is presented in Figure 1. The work history analysis showed a similar distribution of pruned and unpruned tree annually but included only 36,064 trees in the 15.2- to 78.7-cm (6- to 31-in.) dbh diameter range.

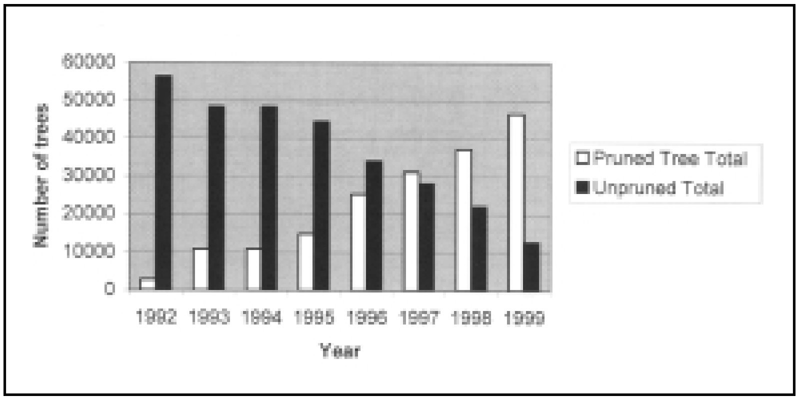

Figure 1. Cumulative number of pruned and unpruned trees in the City of Rochester, New York, in the period between 1992 and 1999. Trees that were in management areas that had been pruned for longer than 5 years were returned to the unpruned pool of trees.

Effect of Pruning on Service Requests

When all types of forestry-related service requests were included in the analysis, pruned management areas had significantly ($p = 0.05$) fewer requests than unpruned management units. On the average over the 8-year study period, there were 7.8 fewer requests per 1,000 trees in the pruned management areas (Figure 2).

Pruning-related service requests also decreased significantly in the pruned management areas compared to the unpruned management areas. On the average over the 8-year period, pruned management areas produced 6.6 fewer pruning-related requests per 1,000 trees than unpruned management areas (Figure 3). However, branch-failure-related service requests were not significantly lowered in the pruned management areas (average of 7.1 branch-failure-related service requests per 1,000 trees) when compared to the unpruned management areas (7.5 requests per 1,000 trees). When pruned and unpruned management areas were combined, the total requests for branch-failure-related service averaged 7.6 requests per 1,000 trees. In the 8-year period, the requests for branch-failure-related maintenance ranged between 4.3 and 14.0 requests per 1,000 trees (Figure 4).

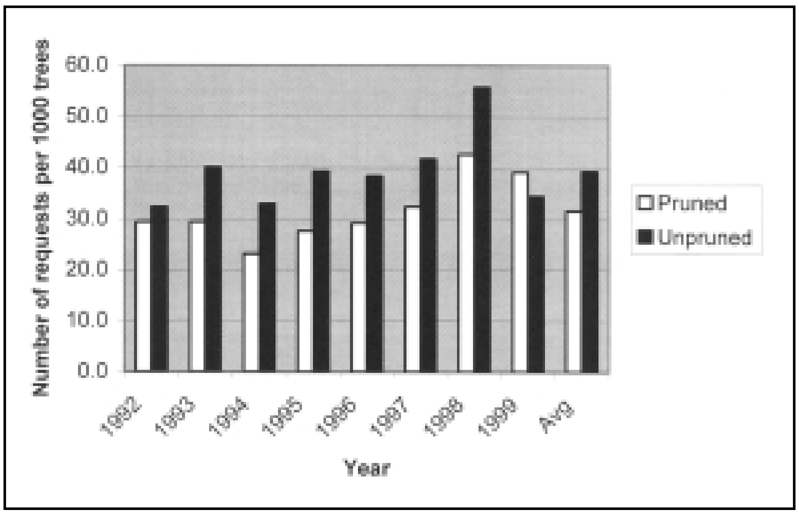

Figure 2. Number of forestry-related service requests in pruned and unpruned management areas in the City of Rochester, New York, in the period between 1992 and 1999. LSD on the average of pruned (31.6 requests per 1,000 trees) and unpruned (39.4 requests per 1,000 trees) management areas = 7.4; P = 0.05.

Branch-failure-related service requests were compared in pruned and unpruned management areas in the week after five high-velocity wind events in the city. These comparisons showed little difference between pruned and unpruned management areas, with one exception. In August 1999, a wind event of 85.3 km/h (53 mph) produced more branch-failure-related requests in the pruned management areas (Figure 5).

Analysis of branch failure in the leaf-on and leaf-off periods showed that there were nearly three times more branch failures in the leaf-on period (Figure 6). Analysis of branch-failure-related requests and work histories showed the same trend.

Work History Analysis

Work history data analysis of branch failures showed a very similar trend to branch-failure-related service requests in that there was no significant difference between the pruned and unpruned management areas. Overall, the total branch failure rate based on work histories was 6.5 branches per 1,000 trees.

The effect of pruning on priority maintenance needs was evaluated by comparing priority maintenance work in the years prior to and the years after each management unit was pruned. Figure 7 shows that in all years, annual priority maintenance work decreased significantly in the pruned management units compared to the amount of priority work in the same management units in the years prior to pruning.

DISCUSSION

This study provides an analysis of nearly 60,000 street trees during an 8-year period from 1992 through 1999. Rotational pruning was initiated in the City of Rochester in 1996 in an attempt to prune one-fifth of the city's street trees annually. However, substantial numbers of trees were pruned in the period from 1992 through 1995, and data from these management units were also used in this study (Figure 1).

These results clearly show that pruning reduced the number of service requests for general tree and pruning-related maintenance (Figures 2 and 3). This suggests that pruning is providing the citizens of Rochester with a certain degree of satisfaction with their general forestry maintenance program and other maintenance directly related to pruning. This presupposes that citizen satisfaction with pruning can be measured by reduced numbers of calls for general and pruning-related maintenance.

This study showed that pruning did not significantly reduce requests for branch-failure-related maintenance in the City of Rochester on an annual basis. Work history analysis confirmed that branch failure clean-up work was not significantly different in the pruned and unpruned management areas. Given the large number of trees and 8-year time period that was analyzed, this is an important finding of this study.

During the period from 1997 through 1999, there was an increased number of high-wind events compared to the period from 1992 through 1996. Weather data documented that there were 66 high-wind events in excess of 64.3 km/h (40 mph) in the period from 1997 through 1999 compared to 16 events in the period from 1992 through 1996. The number of branch failures increased substantially in this period as well, apparently due to the impact of these wind events (Figure 4). However, branch failures were not reduced during all the selected high-wind events in the pruned management areas (Figure 5). Except for the August 4, 1999, event of 85.3 km/h (53 mph), most of the wind events selected had relatively few branch failures, making an assessment of the impact of pruning on branch failure in high-winds difficult. Further, other factors may be influencing branch breakage in these

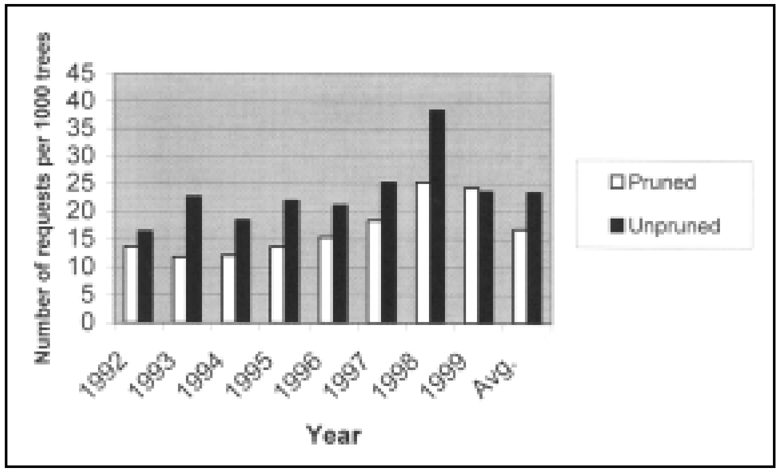

Figure 3. Number of pruning-related service requests in pruned and unpruned management areas in the City of Rochester, New York, in the period between 1992 and 1999. LSD on the average of pruned (16.8 requests per 1,000 trees) and unpruned (23.4 requests per 1,000 trees) management areas = 6.4; P = 0.05.

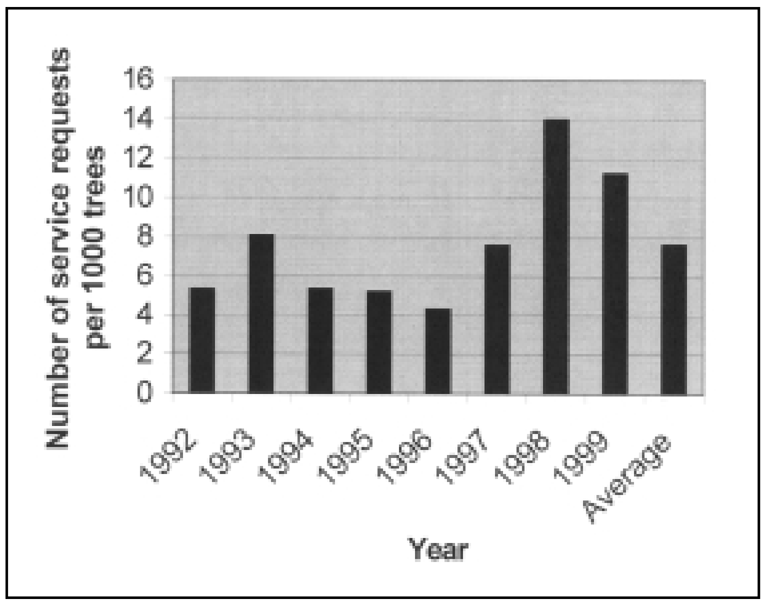

Figure 4. Total branch-failure-related service requests for all trees in the City of Rochester, New York, in the period between 1992 and 1999. There was no significant difference between pruned and unpruned management areas; therefore, the data were combined.

events, including precipitation and the localized nature of some windstorms.

The failure of pruning to reduce branch failure rates annually and in some of the high-wind events indicates that the type of pruning conducted on these trees (i.e., cleaning, thinning, restoration, and raising) may not provide significant protection from branch breakage, particularly as wind speeds increase. It is possible that there may be a wind speed threshold above which pruning has little effect on branch failures. Certainly, more study is warranted on this topic, particularly to determine if pruning throughout the lifetime of a tree would reduce branch failures.

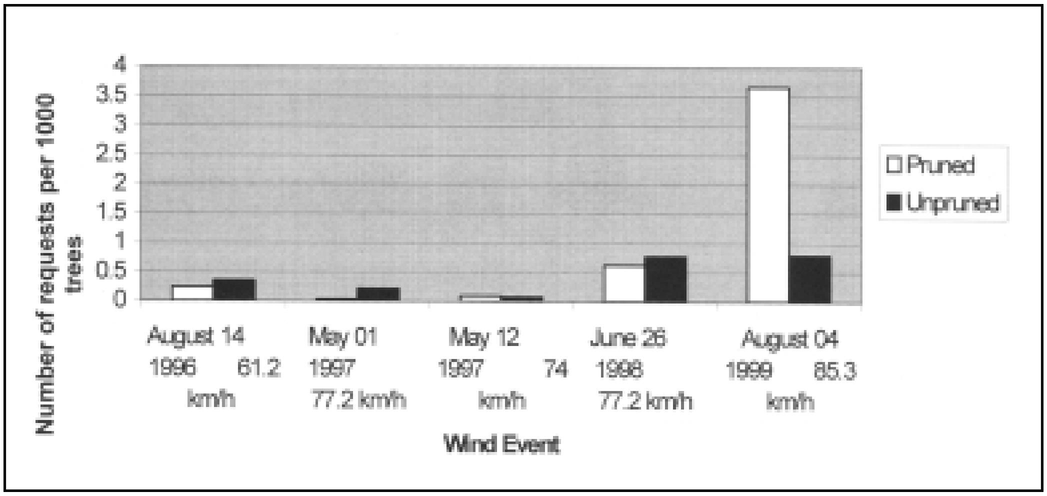

Figure 5. Branch-failure-related service requests one week after high-wind events in pruned and unpruned management areas in the City of Rochester, New York.

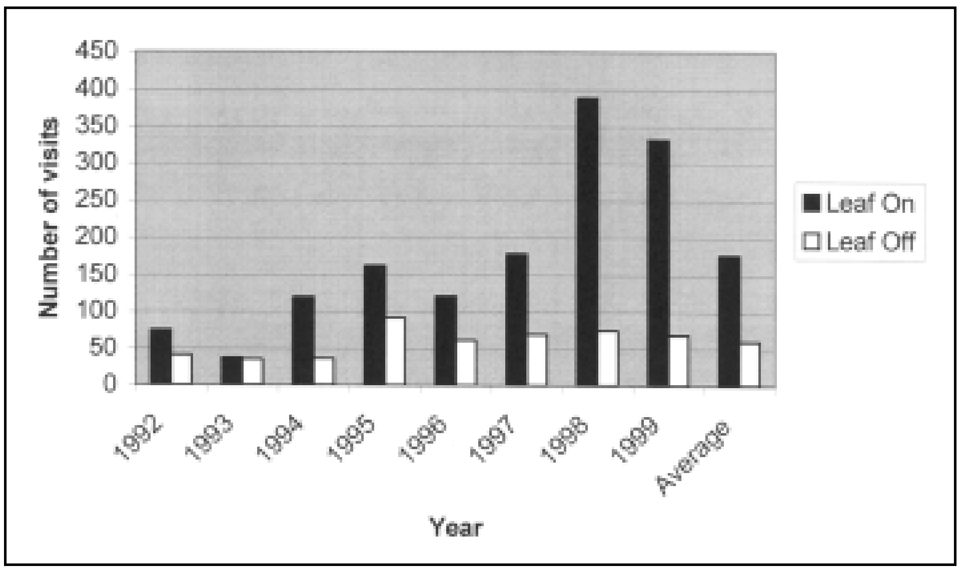

Figure 6. Branch failure work completed in the leaf-on and leaf-off period in the City of Rochester, New York, from 1992 through 1999. Leaf-on period ran from May 16 to November 15. LSD on the average number of visits in the leaf-on period (176.7 visits) and leaf-off branch failure work completed (60.0 visits) = 94.5; P = 0.05.

In general, pruning could increase or decrease branch failures depending on the amount and type of pruning. Pruning could reduce branch failures by removing dead or defective branches that are likely to break (Figure 7). Pruning could also reduce branch failures by reducing the overall weight of large limbs or possibly the "sail" effect on individual limbs. Pruning, or specifically crown thinning (ANSI 1995), could also increase branch failure by opening the crown up and subjecting remaining branches and stems to new stress from wind (Larson 1965). Poor pruning (e.g., topping) may also contribute to branch failure (Antonaroli 2000).

More specific details of this relationship between wind speeds and branch failure cannot be derived from the data in this study. However, reducing crown size, either through pruning or branch breakage in wind events, could be of benefit to the whole tree. Branch shedding may be a mechanism for reducing the potential for whole tree failures (Niklas and Spatz 2000). The practice of crown reducing has been shown to reduce whole-tree failures in evergreen forest tree species (Barton 1995; Davies-Colley and Turner 1999). Yet there appear to be minimal data quantifying the effect of pruning on tree failures in urban environments.

The study offers insight into annual branch failures rates for the city's street trees. The branch failure rate, whether based on service requests (7.6 branches per

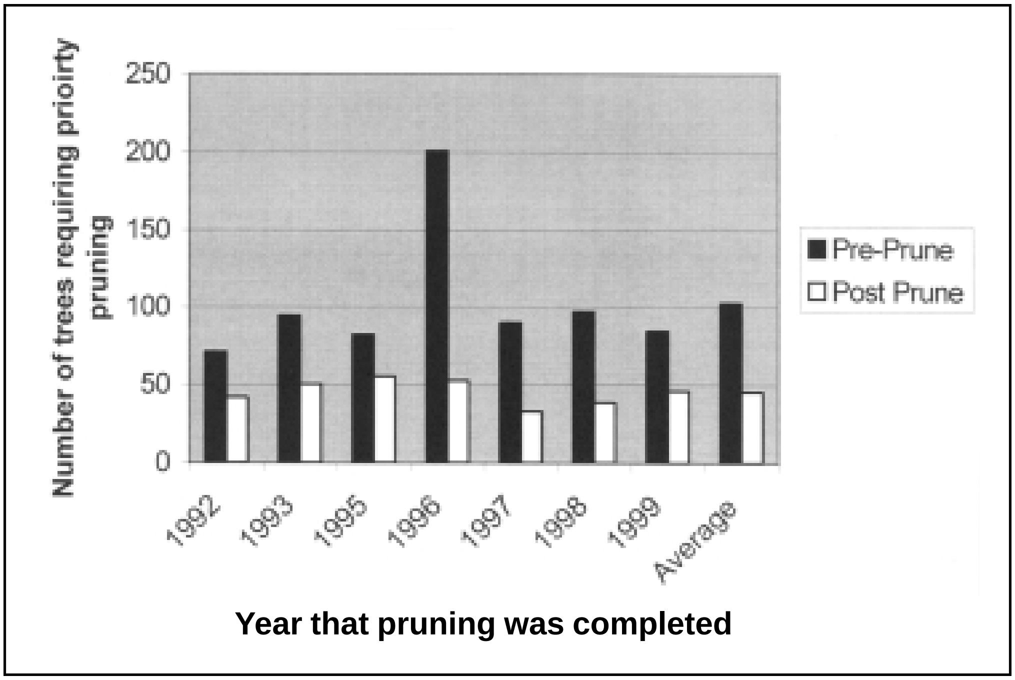

Figure 7. Priority maintenance work in pruned and unpruned management areas in the City of Rochester, New York, in the period from 1992 through 1999. Priority maintenance work is safety pruning that was identified based on annual survey work in the city. Yearly numbers are the average of priority visits in the years prior to and post-pruning. LSD between average annual priority pruning prior to (102.8 priority pruning) and post-pruning (45.3 priority pruning) = 36.8; P = 0.05.

1,000 trees) or work histories (6.6 branches per 1,000), provides a baseline for other cities for comparison. Branch failure rates also provide one part of the tree risk equation where the potential for a tree-related accident is equal to the risk or probability of failure times the probability of a target being struck (Lonsdale 1999).

Helliwell (1990) estimated that branch failure rates fall between 1 in 10 and 1 in 10,000, depending on tree size and condition. However, he presented no data to support these estimations. In this study, branch failure rates are from trees and branches of all sizes that were reported to or cleaned up by the city. Certainly, larger branches pose a potentially greater threat to individuals or property. We have no method to assess the effect of pruning in this study on the size of branches that were included in these failure estimates. However, the branches were apparently of large enough size that city forestry staff were specifically involved in or requested in their clean-up.

Another important result of this study was that priority or safety-related maintenance was reduced in the years post-pruning in comparison to the years prior to pruning. Reducing such maintenance in the years after pruning may provide an economic benefit to a community. A complete economic analysis that compared savings due to the reduction in priority maintenance to the cost of rotational pruning was beyond the scope of this study.

Not surprisingly, branch and tree failure rates were substantially higher when foliage was present on trees. Branch failure rates were three times higher in the leaf-on period. The added sail-effect due to leaves is known (Mattheck and Breloer 1994; Peltola et al. 1999; Chaney 2001) but has seldom been quantified.

This study provides a number of benchmarks that allow other communities to compare the effects of their urban forestry program on service requests and branch failures. Ultimately, urban foresters and administrators will need to base arguments supporting expenditures for tree pruning programs based on impact of tree pruning on citizen satisfaction and safety.

LITERATURE CITED

American National Standards Institute. 1995. American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices (Pruning) (A300, Part 1). American National Standards Institute, New York, NY.8 p.

Antonaroli, R. 2000. Wind damage to urban trees: The case of Formigine (Modena district). (CAB abstract) Sherwood-Foreste 6:11–14.

Barton, I. 1995. Preliminary results form a sailing pruning trial of *Cupressus* species. New Zealand Tree Grower (CAB abstract) 16:28–29

Chaney, William R. 2001. How wind effects trees. Woodland Steward 10:1–8.

Davies-Colley, P., and J. Turner. 1999. Crown lightening young radiata pine to reduce the risk of topple. New Zeal. Tree Grower (CAB abstract) 20:34–35.

Helliwell, D. R. 1990. Acceptable levels of risk associated with trees. Arboric. J. 14:159–162.

Larson, P.R. 1965. Stem form of young *Larix* as influenced by wind and pruning. For. Sci. 11:412–424.

Lonsdale, D. 1999. Principles of tree hazard assessment and management. Research for Amenity Trees No. 7. The Stationary Office, London, UK.

Mattheck, C., and H. Breloer. 1994. Field guide for visual assessment (VTA). Arboric. J. 18:1-23.

Miller, R.W., and W.A. Sylvester. 1981. An economic evaluation of the pruning cycle. J. Arboric. 7:109–112.

National Arborist Association (NAA). 1988. Pruning standards for shade trees. National Arborist Association, Manchester, New Hampshire. 7 pp.

Niklas, K.J., and H.C. Spatz. 2000. Wind-induced stresses in cheery trees: Evidence against the hypothesis of constant stress level. Trees 14:230–237.

Peltola, H., S. Kellomaki, H. Vaisanen, and V.-P. Ikonen. 1999. A mechanistic model for assessing the risk of wind and snow damage to single trees and stands of Scots pine, Norway spruce and birch. Can. J. For. Res. 29: 647–661.

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

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[1*]*Technical Advisor*
Davey Resource Group
6050 Hicks Rd.
Naples, NY 14512, U.S.

[2]*Forester*
USDA Forest Service
1100 Irving Ave.
SUNY Environmental Science and Forestry
Syracuse, NY 13120, U.S.

[3]*Formerly City Forester, Rochester, NY*
Currently Urban Forestry LLC
176 Elmcroft St.
Rochester, NY 14609, U.S.

**Corresponding author*

Zusammenfassung. Auf der Basis 8 jähriger Erhebungen von Daten über Straßenbäume in der Stadt Rochester, New York, wurden die Effekte von Rückschnitten auf Nachfrage, Astversagen und notwendiger Pflege bewertet. Der Rückschnitt, der auf der Basis einer Managementeinheit fertiggestellt wurde, wurde durch den Vergleich von geschnittenen und ungeschnittenen Einheiten bewertet. Die Analyse der Serviceanfrage zeigte, dass geschnittene Einheiten weniger Nachfragen aus der Bevölkerung bzgl. des Rückschnitts und des Managements haben, aber keine niedrigen Anfragen bzgl. der jährlichen Pflege aufgrund Astversagens oder während Sturmereignissen. Die Analyse des Arbeitsablaufs oder der ausgeführten Arbeiten zeigte, dass gepflegte Einheiten weniger dringenden Handlungsbedarf nach dem Rückschnitt, aber eine größere Anzahl von Astbrüchen hatten. Das Astversagen lag zw. 7,6 und 6,5 Ereignissen pro 1000 Bäumen jährlich, basierend auf den Anfragen und ausgeführten Arbeiten. Im Durchschnitt lagen die Astbrüche im belaubten Zustand 3mal höher als im unbelaubten Zustand. Diese Ergebnisse werden anderen Kommunen ermöglichen, die relative Effektivität ihrer Pflegeprogramme zu vergleichen und eine Wahrscheinlichkeit für mögliche Astbrüche von gepflegten Strassenbäumen zu ermitteln.

Resumen. Se evaluó el efecto de la poda sobre las demandas de servicios, falla de ramas y prioridades de mantenimiento en la Ciudad de Rochester, NY usando 8 años de datos históricos en árboles urbanos. La poda, que fue realizada con base en el manejo, fue evaluada comparando unidades podadas y no podadas. El análisis de los datos de demandas de servicio mostraron que las unidades podadas tuvieron menores demandas de servicios del publico, pero no las menores por fallas de ramas relacionadas con el mantenimiento anual o durante los eventos de vientos fuertes. El análisis histórico del trabajo o el trabajo completado mostró que las unidades de manejo podadas tuvieron más baja prioridad de mantenimiento después de la poda pero no los menores para las tasas de falla de las ramas. Las tasas de falla de las ramas promediaron 7.6 y 6.5 fallas por 1000 árboles anualmente cuando se basaron en demandas y trabajos completados, respectivamente. En promedio, las tasas de falla de las ramas durante el período con hojas fueron 3 veces mayor que cuando el follaje no estuvo presente. Estos resultados ayudarán a otras comunidades a comparar la efectividad relativa de sus programas de poda y proporcionan una probabilidad de falla de ramas para árboles urbanos manejados.