JOURNAL OF
ARBORICULTURE

December 1990
Vol. 16, No. 12

STREET TREE PRUNING AND REMOVAL NEEDS

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Abstract. Street tree pruning and removal needs were examined for 11 species from inventory data collected in 11 cities in the North Central and Northeastern United States. The needs ranged from predominantly no pruning and routine pruning of small trees to safety pruning and removal of large trees. Species were ranked in terms of overall pruning and removal urgency, with London planetree and honeylocust having the least urgent pruning and removal needs and American elm and boxelder the most urgent needs.

L'élagage et les besoins en abattages des arbres de rues étaient étudiés pour 11 espèces à partir de données d'inventaire amassées auprès de 11 villes du centre Nord et du Nord-Est des Etats-Unis. Les besoins s'étalaient de la non-prédominance de l'élagage et de l'élagage de routine de petits arbres à l'élagage de sécurité et l'abattage de grands arbres. Les espèces étaient classées en fonction d'élagage complet et d'abattage urgent, avec le platane anglais et le févier inerme ayant les besions les moins urgents en élagages et en abattages et avec l'orme d'Amérique et l'érable à giguère ayant les besoins les plus urgents.

Pruning and tree removal are two of the most important street tree maintenance activities, and are two of the most costly. On average, 30% of a city's total tree care budget is allocated to trimming activities and 28% to tree removal and disposal (8). Because tree species vary in pruning requirements and removal rates, great savings could be realized by planting species that require minimal maintenance.

There is little published information on how pruning needs vary by tree species. The purpose of this paper is to present data on pruning needs from various cities to examine how species pruning and removal needs differ.

For this study, 11 computerized, 100% inventories of city street trees were analyzed (Table 1). Eleven of the most commonly occurring tree species, approximately 65% of the total inventory population, were analyzed (Table 2).

Methods

Inventory field data were collected by Davey Environmental Services in 1983 (Bay City; MI; Edina, MN; Bexley, Mount Vernon, and Perrysburg, OH; and Mount Horeb and River Falls, WI) and 1984 (Plymouth, MN; Newark, NJ; Great Neck, NY; and Bratenahl, OH). For each city and species, the number of trees within each 6-inch diameter class (0-6; 7-12; 13-18; 19-24; 25-32; and 33+) were counted for each of four pruning/removal categories.

1) Removals. Most trees designated as removals have one or more defects that constitute a safety hazard and that cannot be remedied cost-effectively or practically. These defects include extensive trunk decay and/or a severely decayed or weakened V-crotch. In most of the trees listed as removals, a significant percentage of the crown is dead.

2) Safety prune. Trees in the safety prune category require pruning to remove deadwood and/or broken branches. Included are trees with dead, dying, diseased, or weakened branches more than 2 inches in diameter that pose an immediate or potential threat of bodily injury or property damage.

3) Routine prune. Trees in the routine prune category have defects that can become hazardous if not corrected. Included are trees with: a) minor dead, dying, or diseased wood between 1 and 2 inches in diameter that pose little or no immediate threat of bodily injury or property damage; b) correctable structural problems;

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and/or c) growth patterns that would eventually result in tree limbs obstructing traffic or interfering with utility wires or buildings.

4) No prune. Trees that do not require pruning or removal.

After each species was categorized, the pruning needs of individual species and the total population were summarized by diameter class (Table 3).

To rank species by overall priority of pruning needs, pruning urgency values (PUV) were devised. PUV's potentially range from zero to 100. A PUV of zero represents an ideal population that needs no pruning or removals; a PUV of 100 represents a population in which all trees must be removed. The values are a relative index for comparing species based on the overall pruning and removal needs of a species population. The higher the PUV, the more urgent the pruning needs of the population.

PUV's are calculated by a double-weighting procedure. First, each pruning percentage is weighted by its respective diameter class weighting. This weighting was derived from the total analyzed population diameter distribution (0-6 inches = 0.180; 7-12 inches = 0.183; 13-18 inches = 0.261; 19-24 inches = 0.185; 25-32 inches = 0.120; and 33+ inches = 0.071). Weighting by overall diameter classes alleviates distortions caused by inequitable species diameter distributions.

Second, each weighted pruning percentage is weighted again by its respective pruning class weighting. The most urgent pruning category, removals, is weighted by 1.0; safety prunes by 0.75; routine pruning by 0.25; and no pruning by 0. Double-weighted pruning percentages (24 per matrix) are then summed to yield the PUV.

No statistics were used in this study because the inventories were complete censuses of the street tree populations. Any differences in PUV's indicate actual differences of the population based on the given weighting system. Future species comparisons must use the same weighting procedure to be comparable.

Results

Each species exhibited a similar overall pattern in pruning and removal needs, though individual needs differed (Table 3). Pruning and removal needs increased in severity with size (age); the larger sizes generally required increasingly more safety pruning and removals.

In terms of overall pruning and removal needs, London planetree and honeylocust exhibited the least urgent maintenance needs while boxelder

Table 1. 1980 city (9) and street tree population data.

City	*1980 city population*	*No. of street trees analyzed (11 species)*	*% of analyzed population*
Newark, NJ	329,248	24,800	41
Bay City, MI	41,593	11,948	20
Edina, MN	46,073	5,186	9
Bexley, OH	13,405	4,352	7
Plymouth, MN	31,615	3,646	6
Mount Vernon, OH	14,380	3,064	5
Perrysburg, OH	10,215	2,990	5
River Falls, WI	9,019	2,313	4
Great Neck Estates, NY	9,168	697	1
Bratenahl, OH	<5,000	674	1
Mount Horeb, WI	<5,000	582	1
	Total =	60,252	100

Table 2. Tree species analyzed, species population (N), species as percent of analyzed population and species as percent of total street tree population (10).

Species	*(N)*	*% of analyzed population (11 species)*	*% of total street tree population (all species)*
Norway maple *(Acer platanoides)*	11,719	19.4	12.6
Silver maple *(Acer saccharinum)*	10,424	17.3	11.2
London planetree *(Platanus x acerifolia)*	7,406	12.3	8.0
Pin oak *(Quercus palustris)*	7,239	12.0	7.8
Sugar maple *(Acer saccharum)*	6,428	10.7	6.9
American elm *(Ulmus americana)*	5,586	9.3	6.0
Red maple *(Acer rubrum)*	4,736	7.9	5.1
Red oak *(Quercus rubra)*	2,121	3.5	2.3
Boxelder *(Acer negundo)*	2,031	3.4	2.2
Honeylocust *(Gleditsia triacanthos)*	1,700	2.8	1.8
White oak *(Quercus alba)*	862	1.4	0.9
Total =	60,252	100.0	64.8

and American elm had the most urgent needs (Table 4).

Discussion

Factors influencing Removals. Removals would be expected to increase with diameter (age) due to the gradual attrition associated with aging. Richards (13) termed this type of mortality as "senescence-related losses"—those associated with aging, often precipitated by adverse environmental conditions such as drought. The onset of senescence-related losses varies with species, tree environment, and the type of early tree care.

Two other general types of mortality also affect street trees (13): 1) establishment-related losses—those unique to young trees before they are established enough to resist or survive minor accidents, vandalism, etc.; and 2) relatively age-independent losses that might occur at any time due to serious insect or disease attacks, major accidents, gas leaks, street construction, or wind and ice damage. Both establishment-related losses and age-independent losses, like senescence-related losses, are influenced by species, tree environment and maintenance practices.

In a survey of urban tree managers in the United States, Beatty and Heckman (1) found an inverse relationship between city size and the rate of tree survival. Survival rates also were higher in regions with milder climates, with western cities reporting

Table 3. Pruning and tree removal percentages by diameter class (DBH in inches).

	Total Analyzed Population					Norway Maple					Red Oak				
DBH	REM	SP	RP	NP	N	REM	SP	RP	NP	N	REM	SP	RP	NP	N
0-6	7	2	47	44	10,814	5	2	29	64	2,185	5	3	65	26	284
7-12	7	11	77	4	11,009	10	10	72	9	3,758	4	11	86	1	353
13-18	7	26	65	1	15,734	14	27	59	1	3,924	6	28	66	0a	526
19-24	8	38	53	1	11,156	13	38	49	0a	1,371	5	42	53	0a	421
25-32	9	52	38	1	7,258	10	50	40	0a	401	6	50	44	0	277
33+	12	59	27	1	4,281	14	46	40	0	80	3	65	31	2	260
	Silver Maple					London Planetree[b, c]					Honeylocust[d]				
0-6	3	3	44	49	1,364	6	4	25	66	557	6	1	37	56	1,063
7-12	3	9	84	3	1,081	5	7	87	1	1,046	2	9	86	3	283
13-18	6	23	69	1	1,562	6	13	82	0a	2,435	0a	29	67	4	275
19-24	14	40	45	0a	2,256	3	13	84	0a	1,799	1	51	47	1	79
25-32	16	55	28	0a	2,421	3	18	78	0a	1,042					
33+	19	59	22	0a	1,740	3	23	74	1	527					
	Pin Oak[b, c]					Sugar Maple					White Oak[b]				
0-6	6	3	39	52	497	2	4	64	29	1,582	3	0	57	39	97
7-12	5	10	84	1	1,255	2	19	72	6	1,246	1	9	89	1	99
13-18	3	33	65	0a	1,970	3	37	55	5	1,869	2	28	69	1	320
19-24	3	49	47	0	1,601	6	48	36	10	1,061	3	38	59	0	163
25-32	3	67	30	0a	1,197	5	51	34	10	551	1	69	29	1	90
33+	4	81	16	0	719	8	63	23	6	119	5	75	17	2	93
	American Elm[e]					Red Maple					Boxelder[b]				
0-6	20	3	65	13	1,187	3	3	48	46	993	18	0a	52	30	1,005
7-12	14	18	66	2	495	6	7	85	2	1,165	10	17	72	1	228
13-18	6	34	58	1	1,491	6	22	71	2	1,064	16	38	46	1	298
19-24	2	40	58	1	1,443	10	40	47	1	745	24	42	35	0	217
25-32	2	55	41	2	656	13	57	29	0a	456	22	48	31	0	167
33+	3	71	23	2	314	14	64	21	1	313	45	40	16	0	116

a. Between 0 and 0.5%.
b. Does not include data from all 11 cities.
c. More than 90% of species population from Newark, NJ.
d. N $<$ 6 for 25-32 and 33+ diameter classes.
e. Ninety-two percent of population from Minnesota and Wisconsin.
DBH = Diameter at breast height; REM = removal; SP = safety prune; RP = routine prune; NP = no pruning; N = sample size.

the greatest success in the survival of newly planted trees. According to Beatty and Heckman, the five most common problems associated with urban tree growth are: 1) insufficient water; 2) nutrient deficiency; 3) vandalism; 4) soil compaction; and 5) mechanical injury.

Gilbertson and Bradshaw (5) found similar results in a study of city trees in northern England. They found that the mortality of newly planted trees generally was higher in larger metropolitan areas than in smaller towns. This difference was attributed to the likely differences in average site quality, vandalism, and planting and maintenance practices. They also determined that the most frequent cause of mortality in newly planted trees is water and nutrient stress (56%), followed by vandalism (18%), tree guard girdling (12%), soil compaction (9%), and improper staking and tying techniques (5%).

In a study of newly planted street trees in Oakland and Berkeley, California, Nowak et al. (11) found that areas of lower socio-economic status had the most mortality, with percent mortality most strongly correlated with percent unemployment (r = 0.78). Also, street trees adjacent to apartments and public greenspaces had significantly high mortality while trees next to single family houses and rapid transit stations exhibited significantly low mortality. Therefore, cities can be expected to differ in mortality rates due to differences in social and physical environments and maintenance practices.

Pruning. The number of safety prunes would be expected to increase with tree size, as the number of routine prunes would be expected to decrease, because of the branch diameter limitations defined by these categories. Safety prunes included potentially hazardous limbs with a 2-inch minimum diameter while routine pruning included "nonhazardous" limbs less than 2 inches in diameter.

Table 4. Pruning urgency values (PUV) for 11 species (PUV = 41.9 for total analyzed population).

Species	*PUV*
London planetree	31.3
Honeylocust	34.5a
White oak	39.6
Red oak	41.6
Red maple	41.7
Sugar maple	41.8
Silver maple	42.3
Pin oak	42.5
Norway maple	42.6
American elm	46.4
Boxelder	52.7

a. Computation adjusted for using only the first 4 diameter classes (0-24").

Relatively little pruning was needed in the 0- to 6-inch diameter class. Most of the pruning required in this class was designated as routine, most likely to prevent future problems. Most trees greater than 6 inches in diameter are found to need pruning, generally to avoid future problems when small and to reduce hazards when large.

Biases in the Data. Factors that influence the amount and type of pruning needed are tree size (age), species, environment, past maintenance, and size at maturity. That the cities studied contributed different amounts of information to the sample and have different tree environments and maintenance practices, complicates the interpretation of just how tree size and species influence pruning and removal needs. Therefore, caution must be used in interpreting the results.

The sample of city inventories was not chosen at random to represent the street tree population of the region, but was donated by Davey Environmental Services. All analyzed cities requested that Davey Environmental Services inventory their street trees, indicating a desire to manage this resource. This sample of cities is, therefore, biased.

The sampled cities range from plant hardiness zone 4 in Minnesota and Wisconsin to zone 7 on Long Island, NY (7). This gradation in winter cold temperatures influences the amount of winter tree damage and subsequent pruning needs.

The proportion of different land uses within an urban area does not appear to vary significantly among cities (14). Larger cities, though, would be expected to have a poorer street tree environment due to such factors as increased soil compaction and mechanical injury, decreased water infiltration and gaseous diffusion, and increased air and soil pollution.

However, Giedratis and Kielbaso (4) and Kielbaso et al. (8) found no direct relationship between city size and annual maintenance expenditure per tree, though their surveys did ascertain a relationship based on geographic location. Cities in the North Central United States averaged

$1.65 more in mean annual per-capita expenditures for tree care than cities in the Northeast. This difference is likely due in part to the increased costs of sanitation programs for Dutch elm disease and the high proportion of elms in street tree populations (4).

Size at maturity also influences the degree and type of pruning need. Larger trees have greater need for safety prunes due to the increased proportion of limbs more than 2 inches in diameter. All trees in this sample are medium to large trees with a minimum height at maturity of 50 feet. The exception is boxelder which has an average mature height of 35 to 50 feet (6, 7).

Species Analysis. In the following commentary, judgments are made about each species in the context of the biases in the data and what other authors have concluded.

London planetree has been regarded as one of the most successful large species for planting in heavily polluted city environments (7), but it does not grow well in extremely low temperatures (12). Approximately 95% of both the London planetree and pin oak samples came from Newark, NJ. London planetree ranked lowest in pruning and removal needs (PUV = 31.3) while pin oak ranked fourth highest (42.5). This difference indicates that the London planetree's low PUV is not likely due to maintenance practices specific to Newark. By far the largest city sampled, Newark also is likely to have, on average, the worst street tree environment. Considering these factors, London planetree seems a good candidate for minimal pruning and removal. In colder environments (e.g., hardiness zone 4), this species may have higher pruning and removal needs due to increased winter injuries.

Honeylocust is considered adaptable to a variety of soils, drought, and pollution (7). It ranked second lowest in pruning and removal needs but most of the trees in the sample population were less than 24 inches in diameter, so the PUV was adjusted to compensate for the reduced diameter distribution. Removal rates were low in all diameter classes but safety prunes increased greatly with increased diameter (Table 3). Thus, the PUV for honeylocust is lower than the likely PUV for an older population with a full range of diameters.

White oak, red oak and *red maple* had the third, fourth, and fifth lowest PUV, respectively. Although the PUV for white oak was relatively low, this species is highly sensitive to disturbance and difficult to transplant (3, 7). Red oaks and red maples had near average PUV's. Red maple is weak wooded and is easily damaged by ice and heavy, wet snowfalls (7). Red maple usually requires little maintenance except for pruning after storm damage (3).

Although *sugar maple* is considered strong-wooded and a low-maintenance tree (3, 6) its PUV was slightly higher than that of red maple because of its relatively high safety prune needs in the 7- to 12 and 13- to 18-inch diameter classes. Problems with sugar maple can result from planting too close to roads where soil is dry, poorly drained, or compacted, and where de-icing salts are used (3). Sugar maple also suffers badly from insufficient moisture (15), so its pruning needs would be expected to increase more than the other analyzed species after a drought.

Silver maple had a moderately high PUV due to relatively high removal needs in diameter classes beyond 18 inches. Silver maple's fast growth results in weak wood, making it unusually susceptible to storm damage. This problem often is aggravated in street trees following severe pruning done to minimize potential storm damage. Unusually weak wood follows severe pruning, making the tree more susceptible to storm injury than if no pruning were done (3). Silver maple may require less pruning when grown in regions relatively free from severe wind and ice storms, for example, Syracuse, NY (13).

Pin oak ranked fourth highest in PUV due mainly to high safety prune rates for trees larger than 6 inches in diameter. Ninety-four percent of the pin oak sample came from Newark, NJ, and the high PUV rating may be partially due to the poorer average growing environment there. Pin oak is noted for drooping branches that interfere with traffic (12), which may increase the need for routine pruning of this species.

Norway maple, the most frequently occurring and planted street tree in the United States (4) generally is considered a satisfactory street tree, requiring little or no maintenance except for the removal or pruning of diseased or storm-damaged trees (3, 12). However, in this study Norway maple ranked third highest in pruning and removal needs. In fact, relatively high removal needs were indicated for all diameter classes above 6 inches.

Pirone (12) noted that many municipalities are planting Norway maple seedlings less frequently due to the constant pruning required to remove low-hanging branches and to keep them well shaped.

Ninety-two percent of the *American elm* sample came from three cities in the North Central United States. Sanitation programs to control Dutch elm disease allow a large elm population to exist in this region. Even with the high expenditures for such programs, indicating a probable high level of previous care for the elm population, this species ranked second highest in pruning and removal urgency. One explanation is that the American elm has weak limb crotches that split easily (12) and the tree itself is susceptible to storm breakage (3).

High levels of safety prunes were needed for trees more than 6 inches in diameter and abnormally high removal needs were indicated for trees less than 12 inches. One possible reason for the early removal needs is that many of the small diameter elms are volunteers that were removed to reduce the elm population and control Dutch elm disease (D. French, pers. comm., Univ. of Minn., 1987). The low removal needs for trees more than 18 inches in diameter may reflect good sanitation programs that are protecting these older trees.

Boxelder had the highest PUV and commonly is regarded as an unsatisfactory street tree due to its short lifespan, frequent injury from wind and sleet, susceptibility to several sucking, defoliating, and boring insects, and heart rot (2). Boxelder attains a smaller height at maturity than the other analyzed species. This difference would tend to shift pruning needs toward more routine prunes due to the higher proportion of smaller limbs in the species. Because boxelder demonstrated both a relatively high need for safety prunes in diameter classes above 12 inches and an unusually high need for removals in all diameter classes, this species generally is a poor choice for use as a street tree.

Conclusions

Although actual pruning and removal costs were not measured, relative pruning and removal costs can be inferred from the PUV's. Species with higher PUV's generally have higher pruning and removal costs associated with them. These costs include the direct costs associated with tree pruning and removal, the increased probability of injury to citizens associated with trees in the removal and safety prune categories, direct loss of tree value associated with tree removal, nonmonetary costs of tree mortality, and the costs associated with replanting.

Pruning and removal needs are an important consideration in species selection, but other species-specific costs and benefits also must be weighed before deciding which species to plant. The data indicate that London planetree, honeylocust, and white oak have minimal pruning and removal needs and thus should be excellent candidates as street trees for reducing this aspect of maintenance costs. However, honeylocust performance is tentative pending analyses over a full range of diameters.

Pruning and removal values for red oak, red maple and sugar maple were lower than average making these species good candidates as "minimal maintenance" street trees. Values for silver maple, pin oak and Norway maple were slightly above average. More local benefits should be expected from these species if a manager wants to plant them and maximize the benefits per cost of the street tree population.

American elm and boxelder had high pruning and removal needs and should not be planted unless the benefits yielded by these species are relatively high. Such is the case with the American elm. Cities with large elm populations value these trees highly and pay more to maintain this species through good sanitation programs. No such benefits are expected from boxelder so this species should not be planted or used only minimally.

These species recommendations are made based only on pruning and removal needs taken from a limited data set. This information should be tempered by regional experiences and performances to allow for better street tree planning and management.

Acknowledgments. I thank Ken Joehlin of ACRT Inc., Kent, Ohio, (formerly Davey Environmental Services) for his generosity in supplying the data; Drs. Rowan Rowntree and Norman Richards for their assistance throughout this study; and Drs. Joe McBride, Phil Barker, and Martin Jones for their review and comments on earlier drafts of this paper.

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ABSTRACT

GERSTENBERGER, PETER. 1989. **Tree support systems.** Grounds Maintenance 24(9): 42, 44. 46, 82, 86-87.

In an ideal world, we would plant only strong-wooded trees, and we would properly prune and shape them when they are small. Then trees might not break up in storms. The reality is that many trees are naturally weak-wooded. In addition, many trees develop without help from a knowledgeable caretaker. As these trees mature, their branches weaken. Winds, storms and even the weight of their own foliage can easily damage them. Near houses, automobiles and people, these trees are hazards and liabilities for the owners. If a tree starts to break up, the owner must decide whether to remove it or prune out large parts of its canopy. Both options may be undesirable. Fortunately, there are other alternatives. For trees that are in reasonably good shape, guy wires, cables and rigid bracing are options that support and strengthen the trees. We use these mechanical systems to repair damaged trees and to help prevent or reduce future property damage and tree disfigurement.