ANALYSIS OF STREET TREE SPECIES ADAPTABILITY TO URBAN CONDITIONS

by

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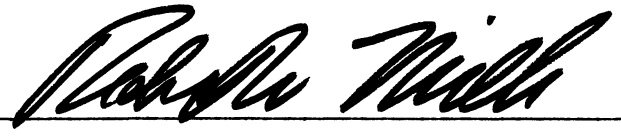

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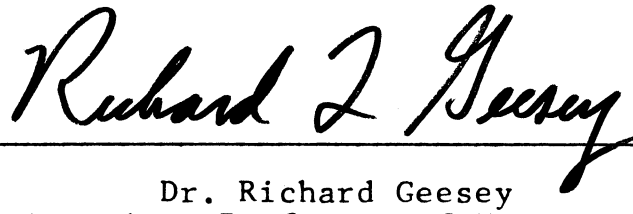

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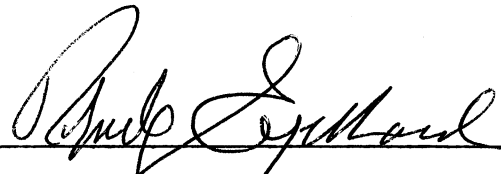

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ABSTRACT

Street tree inventory results from the Wisconsin cities of Milwaukee, Waukesha, Stevens Point, Wisconsin Rapids and Bloomer show a total of 55 species from 32 genera and 18 families. American elm (*Ulmus americana* L.) makes up from 2.9 percent of the total street tree population in Waukesha to 46.8 percent of the Wisconsin Rapids street tree population. The most common tree species encountered in Milwaukee and Waukesha are Norway maple (*Acer platanoides* L.), green ash (*Fraxinus pennsylvanica* Marsh.) and honeylocust (*Gleditsia tricanthos inermis* Pursh.). Red maple (*Acer rubrum* L.), silver maple (*Acer saccharinum* L.) and Norway maple are the species most common in Stevens Point, Wisconsin Rapids and Bloomer. Species analysis shows Norway maple. green ash, littleleaf linden (*Tilia cordata* Mill.) and honeylocust to be the best adapted species for planting on city streets in Wisconsin. Those tree species not recommended for street planting include boxelder (*Acer negundo* L.), silver maple, elms (*Ulmus* spp.) and catalpa (*Catalpa speciosa* Warder ex Engelm).

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1. INTRODUCTION

Urban areas provide an unnatural environment for trees. This environment includes problems such as air and water pollution, soil infertility and compaction, and vandalism. Insects and disease problems are frequently more severe in cities due to environmentally induced stress. Success of urban trees depends heavily on each individual species' ability to adapt to environmental stress.

Trees planted between the sidewalk and curb (street trees) seem to suffer the most stress because of their close proximity to city streets and boulevards. Street trees are subject to the previously mentioned problems and are also susceptible to many others. Foster and Blaine (1978) estimate the average survival rate for street trees in residential Boston to be 10 years although trees planted in parks and yards of Boston live to near normal longevity. Their list of major problems include construction damage, water stress, auto impact, improper care and salt damage, as well as vandalism and air pollution.

Until the mid 1900s, the tree species deemed best suited for metropolitan areas in the United States was the American elm (Ulmus americana L.). American elm was chosen because of its beautiful vase shape and its ability to thrive under harsh urban conditions. People responsible for street tree planting, especially in the midwest, relied heavily upon the American elm. It seemed to be the perfect urban tree.

In 1933, a vascular fungal disease was identified in Ohio that would become known as the Dutch elm disease (Ceratocystis ulmi). Soon after, Dutch elm disease (DED) reached epidemic proportions. Its ability to spread both by root graphs and insect vectors, and large rural elm populations made DED virtually unstoppable. By 1956, DED reached Wisconsin and since then most of the cities within the state have reported massive elm losses. In the years following the introduction of DED to the U. S., many "save the elm" programs have been attempted. Some proved more effective than others, but presently none of the methods have proven to be the entire answer.

To combat the loss of the American elm, most Wisconsin municipalities have started aggressive replanting programs using many different species. These costly programs were not started without good reason. Both Payne (1973) and Morales (1980) suggest a positive correlation between the amount of tree cover and residential property values. Recent studies have shown that most people want and need trees for their urban environment (Kalmbach and Kielbaso, 1979, and Getz, Karow and Kielbaso, 1982). Holmes (1977) lists 17 reasons why people love shade trees. Trees are an essential part of most city-dwellers' lives.

Weidhass (1976) lists "planning for selection and planting of trees and shrubs..." as the number one goal for any shade tree program. We should be selecting species to be planted on streets based on objective species evaluation, rather than planting whichever trees are available.

Analysis of existing street tree inventory data can help urban forest managers compare species and cultivar performance. It can also help determine population species and size make-up, as well as overall condition. The purpose of this study is to evaluate tree species currently being planted on the streets of selected Wisconsin cities.

The objectives of this study are to:

1. Determine the pattern of elm replacement in selected Wisconsin cities by species and frequency.
2. Determine those species best adapted to city street environments based on their relative overall condition.

II. LITERATURE REVIEW

Species Performance Evaluation

Many researchers and urban forest managers have suggested the planting of species and cultivars based upon general appearance, maintenance needs and availability. Very few have utilized an objective evaluation method for their species selections.

In Philadelphia, 414 trees of 23 different species were evaluated 14 years after planting (Rhoads, Meyer and Sanfelippo, 1981). The trees were individually evaluated, on city streets, with measurements of trunk diameter, crown diameter and height (to determine relative growth rates). Condition of the foliage was rated on a one to four scale (1=excellent, 4=poor) and insect, disease or abiotic problems noted. Results show the most successful species evaluated in terms of growth rate and freedom from insect and disease problems were: Kwanzan oriental cherry (Prunus serrulata cv. Kwanzan), black locust (Robina pseudoacacia), chinese elm (Ulmus parvifolia), japanese pagoda tree (Sophora japonica), ginkgo (Ginkgo biloba) and English oak (Quercus robur). Other species evaluated less highly include: honeylocust (Gleditsia tricanthos), red oak (Quercus rubra), hawthorn (Crataegus phaenopyrun), American elm (Ulmus americana cv. Augustine), littleleaf linden (Tilia cordata) and Norway maple (Acer platanoides).

Gerhold and Bartoe (1976) describe specific methodology for testing the performance of new cultivars in urban areas.

The plan involves a network of cooperating arborists and nurserymen supplying information on tree cultivars they are testing to a coordinator, who maintains records, analyzes, and makes recommendations to those involved. Trees are measured and evaluated when they are planted and then the process is repeated every four years. Measurements include height, crown spread and diameter. Evaluations include the "healthiness" of foliage, branches and trunk on a simple scale. Tree problems are also noted. The authors feel costs involved with the program would be offset by lower mortality and reduced costs of tree trimming and spraying.

A project initiated in 1955 at the Ohio Agricultural Research and Development Center (OARDC) set forth to identify tree species and cultivars well adapted to conditions associated with urban street and highway use (Kozel, Toth and Mannell, 1975, Kozel, 1974, Chapin and Kozel, 1975 and Sydnor, 1979). Trees have been planted in the shade tree evaluation plot at Wooster, Ohio, each year since 1965. In 1974 the species and cultivar list totalled 128, with 842 individuals planted in the plot. Twice each year an evaluation committee made up of individuals from utility companies, the Ohio State University, the nursery industry, and the Ohio Chapter of the International Society of Arboriculture rate each tree in the Shade Tree Evaluation Plot. The rating is based on observations with a zero to four scale used (0=excellent, 4=dead). Criterion used for this rating includes foliage density, foliage color, branch and crotch development,

disease and insect susceptibility, overall growth rate, and tree condition. Through the years, some tree species have been considered outstanding, while others are not acceptable for street planting. A list of these categories of species and cultivars appears in Appendix 1.

The Metropolitan Tree Improvement Alliance (METRIA) has begun two projects dealing with the suitability and urban hardiness of trees planted in urban areas (Karnosky, Gerhold and Collins, 1982). The projects involve Species Trials and Cultivar Testing. The Species Trials Project attempts to develop comprehensive knowledge about those species tested. This is done to determine species or families that are better adapted to climatic conditions at a given site, than the present cultivars. Also the METRIA originators feel that most cultivars selected to date have been chosen for ornamental value, and not for urban hardiness. As a result, there is a need to screen diverse populations and to select trees that are tolerant of the many urban stresses. The Cultivar Testing Project involves performance tests of available cultivars. The METRIA projects are organized, and results will be summarized on a regional level.

Species Selection

As previously mentioned, planning for selection and for planting of trees and shrubs, has been considered by some the number one goal for shade tree programs (Weidhass, 1976). It has also been suggested that correct species selection can vary the annual maintenance costs from 20 to 50 percent of the

planted price (Chapman, 1981).

Steps to consider when selecting trees for any given area, have been documented by King (1979). He suggests that the right type of tree should be selected so that at maturity the tree will be an asset and not a liability to its owner. His species selection recommendations are as follows:

a. Select trees so that at maturity the tree fits the area without interfering with buildings, travel on sidewalks or streets, curbs, street lighting and utility wires and cables. If the area is large, plant a tree which will be large at maturity; if the area is confined, plant smaller growing trees or columnar type trees.

b. Select trees that are hardy for your planting zone.

c. Vary the species, genus and family of trees to be used so that if a disease occurs, only a limited number of trees will be affected.

Syndor (1982) also outlined his recommendations for species selection, maintaining that specific selection requirements will reduce the subjectivity of species chosen. Syndor's major considerations involve design, architectural, site and maintenance factors.

Gerhold and Sacksteder (1982) advocate the use of species performance testing results as a guide for urban tree selection. However, with specific performance data difficult to obtain for many years, they recommend a threefold strategy for urban tree managers.

1. Exploit current knowledge more fully.

2. Participate in tree testing to obtain more extensive objective data.

3. Consider special analyses of existing plantings to fill the gap until test results became available.

Frequency and Distribution of Species

Diversity of species in rural areas been described as "natures insurance policy" (Flemer, 1981). A steady state environment of complexity, diversity, and interdependence found in truly natural ecosystems, results from many centuries of trial and error (Hall, 1981). However, in urban environments, man must try to provide the necessary diversity to avoid creating an ecologically unstable environment.

In the New York cities of Poughkeepsie, Rochester and Syracuse, Norway maple dominates the list of species existing on the city streets (Valentine, Westfall and Manion, 1978). In Poughkeepsie, 71 percent of those trees greater than 5 inches in diameter are Norway maples. In the population of trees 5 inches in diameter or less, 23 percent are Norway maples. Inventory data from Rochester shows 56 percent of the street trees greater than 5 inches in diameter and 22 percent of the population 5 inches or less are Norway maples. Similarly, in Syracuse Norway maple makes up 42 percent of the population of street trees greater than 5 inches in diameter and 24 percent of the trees 5 inches or less.

Pickering and Perkins (1982) report planting frequencies in 21 southern Ontario cities. Based on street tree planting records from 1971 to 1980, almost 90 percent of the trees planted were comprised of six species and their cultivars. Pickering and Perkins warn that: "Urban forest managers must be careful not to sacrifice short term gains for long term management difficulties through reduced species diversity."

To control species diversity, Barker (1975) calls for a tree population density plan to be included in the municipal or county tree ordinance. His plan would require a current street tree inventory and would limit planting of species by predetermined maximum population densities. A master list of trees would be constructed, with species grouped in maximum density categories. The four planting categories used in the plan's prototype were:

1. Liberal use - not to exceed 5% of the total street trees within the city.
2. Limited use - not to exceed 2%.
3. Candidate use - not to exceed 0.3%.
4. Deferred use - the street tree population is currently adequate.

At the end of a designated time period, the master list would be reviewed and species shifted as necessary.

Species For Wisconsin Streets

In the publication "Street Trees for Wisconsin" (Hasselkus, 1980); selection suggestions as well as recommended trees are outlined. In Appendix 2 those trees recommended for planting on city streets in Wisconsin, as well as those trees to be avoided, are listed.

III. METHODS

Study Areas

Study areas involved in this project are the Wisconsin cities of Milwaukee, Waukesha, Stevens Point, Wisconsin Rapids and Bloomer (Figure 1).

Milwaukee

Milwaukee is located on Lake Michigan in the southeastern section of the state in hardiness zone five (Figure 1). Average annual precipitation for Milwaukee is approximately 30 inches, with a growing season of 160 frost-free days. Soils of the Milwaukee area, although filled and amended like most cities, are fine silty material underlaid by calcereous clay to silty clay. The soils of the area are moderately well drained, with pH in the range from 5.8 to 7.0 in surface horizons, with up to pH 8.5 at greater depths (Hole, 1976).

The northeast and northwest quadrants of Milwaukee were inventoried in 1979 and 1980. The inventory, undertaken by the Wisconsin Department of Natural Resources as part of the Dutch Elm Disease Demonstration Project, was completed with field evaluation crews made up of students of urban forestry and horticulture from the University of Wisconsin-Stevens Point and the University of Wisconsin-Madison.

Waukesha

Waukesha is located west of Milwaukee in the southern section of Wisconsin, in hardiness zone five (Figure 1).

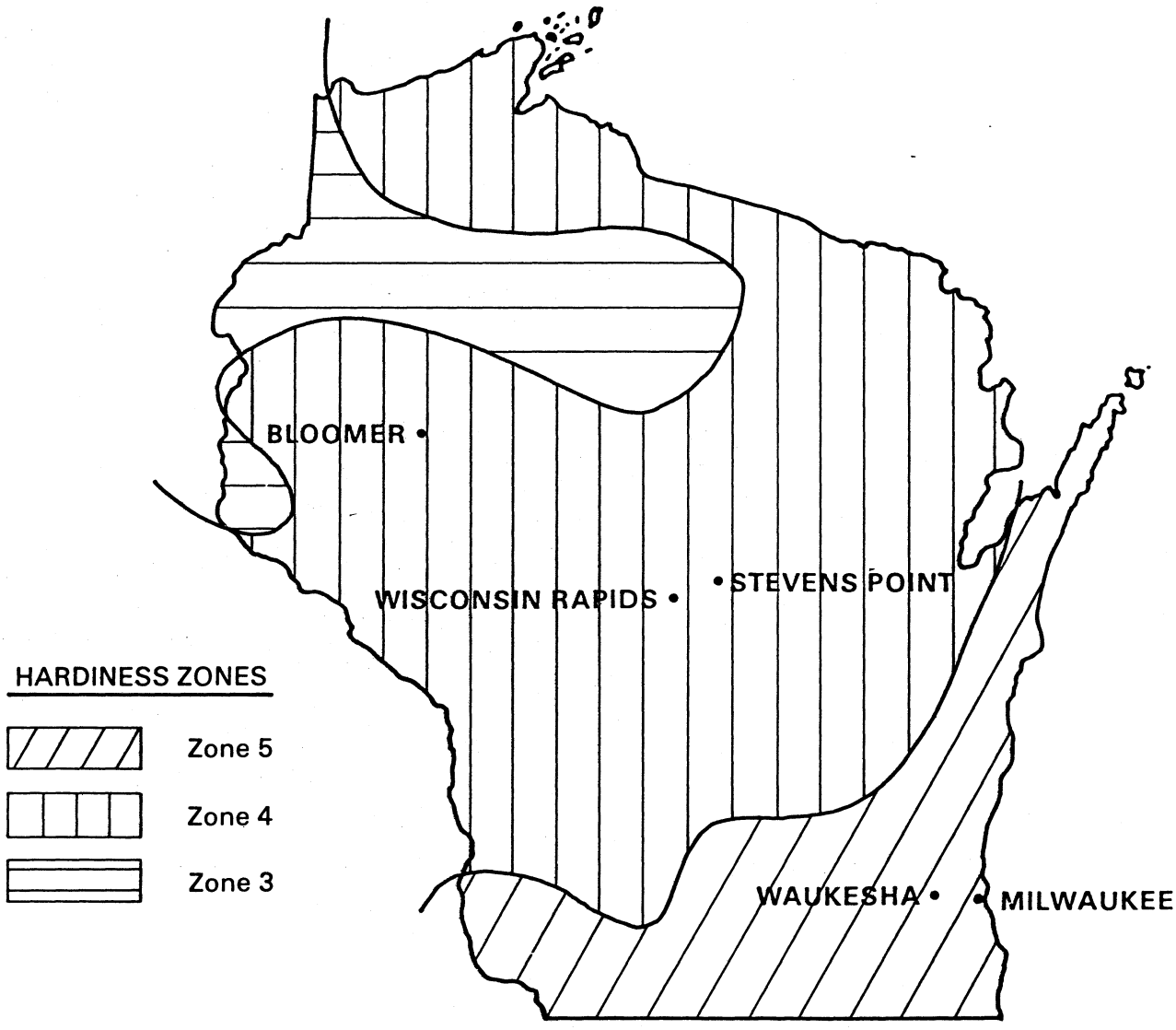

Figure 1. Location of hardiness zones and selected cities in Wisconsin.

Mean annual precipitation for the Waukesha is 30 inches. The length of the growing season is 160 days. Soils of the Waukesha area are well drained fine silty material over calcereous gravel or sandy skeletal. The pH of Waukesha soils is in a range from 6.0 to 7.3 at the surface, with up to pH 8.5 at greater depths (Hole, 1976).

City forestry crews inventoried the city street trees in Waukesha in 1980. The inventory was updated in 1981.

Stevens Point

Stevens Point is located in central Wisconsin in hardiness zone four (Figure 1). The growing season is approximately 140 days, with a mean annual precipitation of 31 inches. The soils of this area are excessively well drained sandy to course loamy soils, with very low organic matter. Soil reaction for the soils in the Stevens Point area range from pH 5.2 to 6.2 (Hole, 1976).

The city-owned trees in Stevens Point were inventoried in 1981 by a graduate research assistant at the University of Wisconsin-Stevens Point. The inventory was a part of a cooperative project between the Wisconsin Department of Natural Resources, the city of Stevens Point and the University of Wisconsin-Stevens Point, dealing with an urban forest planning model for smaller cities.

Wisconsin Rapids

Wisconsin Rapids is located in hardiness zone four, near Stevens Point in central Wisconsin (Figure 1). Wisconsin Rapids, like Stevens Point, receives about 31

inches of precipitation annually. The soils of the Wisconsin Rapids area are similar to the excessively well drained sands of nearby Stevens Point (Hole, 1976).

The street tree inventory of Wisconsin Rapids was completed in 1979 as part of the Dutch Elm Disease Demonstration Project through the Wisconsin Department of Natural Resources. Field evaluation was done by Wisconsin-Stevens Point urban forestry students.

Bloomer

Street trees of Bloomer were inventoried in 1979 along with Milwaukee and Wisconsin Rapids, as part of the Dutch Elm Disease Demonstration Project.

Bloomer receives 30 inches of precipitation per year and has a growing season of 140 days of frost-free weather. Soils of this small northwestern Wisconsin city are well drained, primarily fine loamy over sandy to coarse loamy textures. Soil reaction for the area soil types range from pH 4.7 to 6.6 (Hole, 1976).

UW/SP URBAN FOREST

Street tree inventory data for this study was collected and summarized with the use of the computerized urban forest inventory system: UW/SP URBAN FOREST (Miller, Sylvester and Marano, 1979). This system computes tree value, following the Council of Tree and Landscape Appraisers approved formula method (International Society of Arboriculture, 1979).

Data Collection

Inventory field crews record specific data for each street tree and make recommendations for species to be planted in

vacant spaces. Information on existing trees were recorded, including location, species, diameter, condition class, vigor rating, percent deadwood, tree damage (by type), pruning and removal recommendations, survival estimation, and site discriptive data.

Condition Class

Condition class is a rating for overall condition of a tree, using a number of physical attributes. This percentage rating is applied directly to the Council of Tree and Landscape Appraisers formula method for determining tree value (International Society of Arboriculture, 1979). A tree which is dead or nearly dead will receive a zero percent rating for condition class, while a perfect specimen rates 100 percent (Table 1).

Species Comparisons

The five Wisconsin cities in this study were selected on the basis of existing complete inventory data. The street tree inventory data for each city, is a 100 percent survey of the city-owned trees. They do not represent a statistical sample of street tree populations in the Midwest or even Wisconsin; however, comparison of general trends within each city will give insight as to which tree species are well adapted to urban conditions and those which are not.

To analyze inventory data for determination of species adaptability, the condition class percentage data were used. Other variables were tested including vigor, percent deadwood, damage and survivability.

Table 1. Formula for tree value estimation.

TREE VALUE = BASE VALUE X SPECIES CLASS X CONDITION CLASS X LOCATION CLASS

Where:

TREE VALUE = Estimate of total tree value.

BASE VALUE = Established at $21.00 per square inch of cross sectional area at 4.5 feet above the ground.

SPECIES CLASS = A rating of the desireability of a tree species, from 0 to 100%.

CONDITION CLASS = A rating of a tree's overall condition, based on vigor, damage, form, etc. from 0 to 100%.

LOCATION CLASS = A rating of the desireability of the location of a tree, from 0 to 100%.

For example, a tree may be rated very high in terms of vigor, yet may have a low condition class due to poor form, improper maintenance or damage. Condition class was decided upon because it is a combined measure of overall condition, including all the aforementioned variables.

Comparison of species between cities on an equal basis was not possible because of substantial variation in city mean condition class and ranges in species condition class percentages. The variation, it appears, is a result of population ages, levels of maintenance and evaluation by different field crews. Species comparisons between cities was based on each city's mean overall condition. Species condition class percentages were expressed in a percentage of the overall city mean condition class. Therefore, if a species condition class percentage was less than the city mean, it would rate a species condition "rating" of less than 100 percent.

Comparisons were conducted for each species with at least 10 individuals in one of the cities. A progressive approach to analysis was used, beginning at the family level and continuing through genus, species and cultivar (when data is available). Overall conclusions were drawn based on comparisons.

Nomenclature

Common names were identified with the use of Otis (1931) and Harlow, Harrer and White (1979). Scientific nomenclature for common names used in the remainder of this report, are listed in Table 2.

Table 2. Scientific name equivalence for common names referred to in text.

COMMON NAME	SCIENTIFIC NAME
Ailanthus	*Ailanthus altissima* (Mill.)Swingle
American elm	*Ulmus americana* L.
Amur corktree	*Phellodendron amurense* Rupr.
Basswood	*Tilia americana* L.
Black locust	*Robinia pseudoacacia* L.
Black oak	*Quercus velutina* Lam.
Boxelder	*Acer negundo* L.
Bur oak	*Quercus macrocarpa* Michx.
Busiman elm	*Ulmus carpinafolia* 'Christine Buisman' Gleditsch
Butternut	*Juglans cinera* L.
Callery pear	*Pyrus calleryana* Decaisne
Catalpa	*Catalpa speciosa* Warder ex Engelm
Cedar	*Thuja* spp. or *Juniperus* spp.
Chestnut	*Castanea dentata* (Marsh.) Borkh
Cottonwood	*Populus deltoides* Bartr. ex Marsh.
Crabapple	*Malus* spp.
Crimean Linden	*Tilia x euchora*
English oak	*Quercus robur* L.
European ash	*Fraxinus excelsior* L.
Ginkgo	*Ginkgo biloba* L.
Green ash	*Fraxinus pennsylvanica* Marsh.
Hackaberry	*Celtis occidentalis* L.
Hawthorn	*Crataegus phaenopyrum* (L.f.)Medic.
Hedge compestre maple	*Acer compestre* L.
Hickory	*Carya* spp.
Honeylocust	*Gleditsia tricanthos* inermis Pursh.
Hornbeam	*Carpinus caroliniana* Walt.
Horsechestnut	*Aesculus hippocastanum* L.
Ironwood	*Ostrya virginiana* (Mill.) K. Koch

COMMON NAME	SCIENTIFIC NAME
Kentucky coffeetree	*Gymnocladus dioicus* (L.) K. Koch
Littleleaf linden	*Tilia cordata* Mill.
Mountain ash	*Sorbus aucuparia* L.
Mulberry	*Morus* spp.
Norway maple	*Acer platanoides* L.
Norway spruce	*Picea abies* (L.) Karst.
Ohio buckeye	*Aesculus glabra* Willd.
Paper birch	*Betula papyrifera* Marsh.
Pin oak	*Quercus ellipsoidalis* E. J. Hill
Popular	*Populus* spp.
Red elm	*Ulmus rubra* Muhl.
Red maple	*Acer rubrum* L.
Red oak	*Quercus rubra* L.
Red pine	*Pinus resinosa* Ait.
Shubert cherry	*Prunus virginiana* 'Shubert' L.
Siberian elm	*Ulmus pumila* L.
Silver maple	*Acer saccharinum* L.
Sugar maple	*Acer saccharum* Marsh.
Sycamore	*Platanus occidentalis* L.
Walnut	*Juglans nigra* L.
White ash	*Fraxinus americana* L.
White cedar	*Thuja occidentalis* L.
White oak	*Quercus alba* L.
White pine	*Pinus strobus* L.
White spruce	*Picea glauca* (Moench) Voss
Willow	*Salix* spp.

IV. RESULTS AND DISCUSSION

Pattern of Elm Replacement

Current overall conditions of the five inventoried cities are tabulated in Table 3. The street tree populations of the five inventoried cities include 55 species of 33 genera and 19 families. The size and relative proportion of the ever-decreasing population of American elm is described in Table 4 for each of the cities.

Milwaukee

The inventory of street trees in Milwaukee's northeast and northwest quadrants shows a mean diameter of 7.5 inches. The population size distribution in Milwaukee at the present is skewed toward the small diameter classes. Nearly 50 percent of the total population is in the four inch diameter class or smaller (Figure 2). This situation is due to elm losses and the strong planting program implemented by the city.

Milwaukee has a mean condition class of 74.4 percent, the result of an excellent tree maintenance program. Figure 3 shows the average condition class by diameter for the city peaks between six and eight inches in diameter, dips, then levels off in the higher diameter classes.

The list of 43 species and cultivars, along with their frequency, relative average condition class and average size are shown in Table 5. Norway maple and cultivars of Norway maple make up the largest percentage of the total street tree population (48.5%), with an average diameter of 6.6 inches. Following are 10,944 (13.6%) green ash, 7.692 (9.5%) honeylocust and 7.545 (9.4%) sugar maple. These four species,

Table 3. Comparision of street tree population size, average diameter and average condition class for the 5 inventoried cities in Wisconsin.

CITY	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Milwaukee	80,598	7.5	74.4
Waukesha	14,530	5.8	65.7
Stevens Point	3,487	9.5	64.1
Wisconsin Rapids	1,918	13.4	54.5
Bloomer	1,770	10.0	49.8

Table 4. Comparision of American elm population size, relative proportion average diameter and average condition class for the 5 inventoried cities in Wisconsin.

CITY	TOTAL NUMBER OF ELMS	PORTION OF CITY BY NUMBER (PERCENT)	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Milwaukee	5998	7.4	19.6	70.0
Waukesha	424	2.9	18.9	58.6
Stevens Point	388	11.1	18.7	59.8
Wisconsin Rapids	897	46.8	16.3	52.0
Bloomer	406	22.9	18.2	42.1

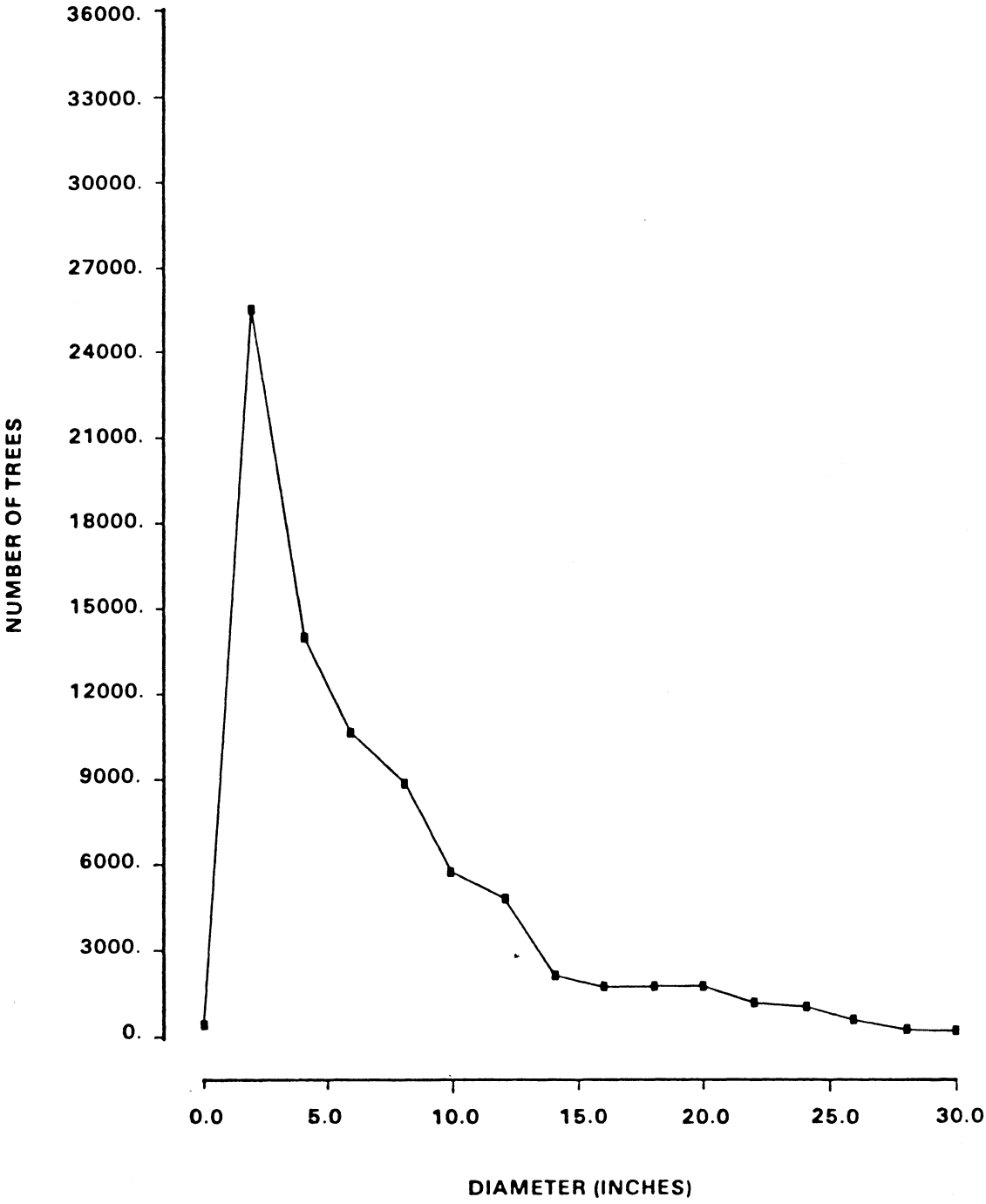

Figure 2. Population - size distribution for Milwaukee.

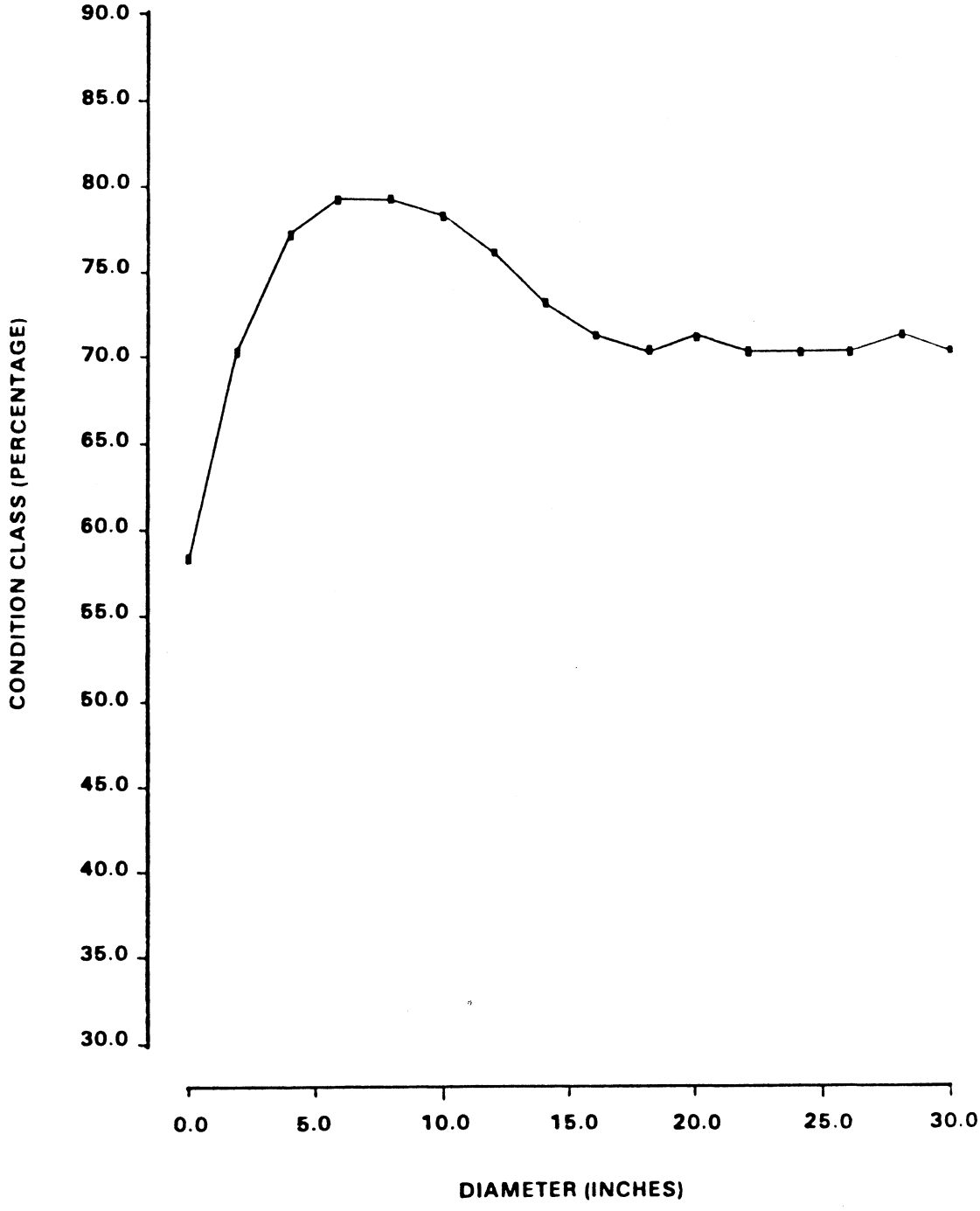

Figure 3. Condition class - size distribution for Milwaukee.

Table 5. Frequency, average diameter and average condition class of species and cultivars in Milwaukee Districts 1 and 2.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Norway maple	25390	7.2	75.8
Green ash	10944	5.8	74.7
Norway maple cv. schwedleri	7943	6.3	77.0
Honeylocust	7692	4.7	75.7
Sugar maple	7545	6.6	74.6
American elm	5998	19.6	70.0
Norway maple cv. columnare	3642	4.1	75.6
Littleleaf linden	2811	3.7	73.0
Norway maple cv. faasen	2330	4.7	73.7
Basswood	1308	12.5	74.1
White ash	1291	6.9	67.6
Silver maple	1157	21.0	68.6
Hackberry	789	3.3	62.2
Ginkgo	332	2.8	74.9
Catalpa	297	21.1	62.1
Siberian elm	245	16.5	64.4
Sycamore	115	5.3	65.4
Horsechestnut	109	20.3	74.5
Red oak	95	2.8	63.8
Boxelder	70	18.1	65.1
Poplar	69	1.8	42.3
White ash cv. modesto	68	10.6	61.2
Mountain ash	54	6.8	75.6
Callery pear	45	2.4	60.0
Crabapple	45	6.6	67.6
Bur oak	43	4.9	70.7
English oak	41	3.0	64.4
Red maple	36	8.1	65.5
Littleleaf linden cv. stewart	21	4.5	78.1

Table 5. Continued.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
White oak	19	11.6	65.3
European ash cv. hessi	16	5.2	73.7
Ohio buckeye	15	14.2	78.7
Ironwood	12	7.4	76.7
Hickory	11	14.8	70.9
Ailanthus	10	3.6	72.0
Pin oak	8	4.1	65.0
Hedge compestre maple	6	6.3	73.3
Hornbeam	6	10.5	56.7
Hawthorn cv. washington	5	8.4	84.0
Cottonwood	4	23.7	80.0
Willow spp.	3	4.5	60.0
Kentucky coffeetree	2	24.5	80.0
Amur corktree	1	19.0	80.0
Black oak	1	8.0	100.0
TOTALS	80598	7.5	74.4

with cultivars, make up 81 percent of the total tree population.

Diversity in both species and age are important for ecologically stable systems. Disregarding the zero to one inch diameter class due to the city's current two inch minimum planting diameter, the diameter distribution resembles an inverse "J" shape; typical of an uneven-aged forest stand distribution. This condition, although not in a traditional forest situation, is much more stable ecologically than, for instance, a population with an even-aged profile that contains a majority of trees in the middle to large diameter classes. The unevenaged distribution tends to create a buffering effect for major disasters because of the wide range of sizes (and directly, ages) of trees. As stated earlier, Norway maple makes up 48.5 percent of the entire population of street trees in Milwaukee. Although Milwaukee plants are least three different cultivars of Norway maple, and these varieties have noticeably different color and growth habit; they remain genetically similar. Cultured varieties have proven effective for predicting eventual physical traits, but do not expand the overall species diversity. Milwaukee has definite problems with species diversity in their street tree population which may result in problems in the future.

Waukesha

Waukesha has 14,530 street trees of 55 species and cultivars. The American elm population in Waukesha has been reduced to 424 street trees, just 2.9 percent of the total population. As a result, Waukesha has a street tree population that is

very young. The average diameter for the city is 5.8 inches. Over 50 percent of all trees are two inches in diameter or less, while less than ten percent are 14 inches in diameter or greater (Figure 4). The diameter distribution is similar to that of Milwaukee, with even more unbalance toward the small diameter classes.

The average condition class for the city of Waukesha is 65.1 percent. Figure 5 shows the mean condition class percentage by diameter for the city. Trees in the two through ten inch diameter classes make up the highest level of condition class percentages (6.5 to 57.2%). From the high average condition class ratings in the small diameter classes, the averages then steadily drop off in the larger diameters. In 1980, Waukesha completed the third year of a five year, systematic street tree pruning rotation. The high condition class percentages in the lower diameter classes may be credited to this program.

The list of species and cultivars found in Waukesha, along with the population parameters which describe them are shown in Table 6. Although 40 different species are present, Norway maple (with six cultivars) is the species with the greatest number of individuals, making up 41.1 percent of the city street tree population. Following Norway maple are green ash (15.1%), littleleaf linden (12.5%) and honeylocust (6.8%). These four species make up over 75 percent of the total street tree population in Waukesha.

Stevens Point

Stevens Point has a total of 3,487, city-owned, street

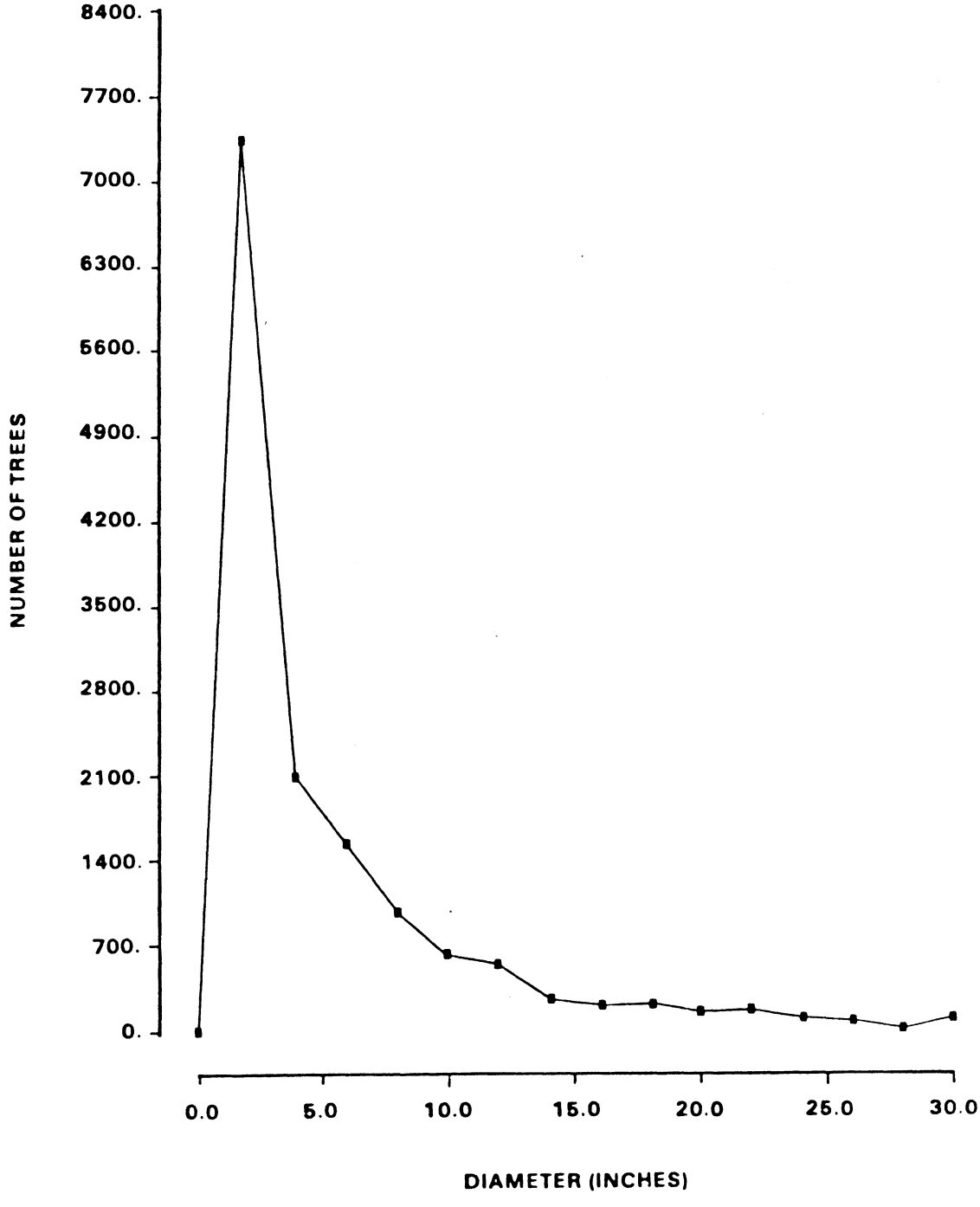

Figure 4. Population - size distribution for Waukesha.

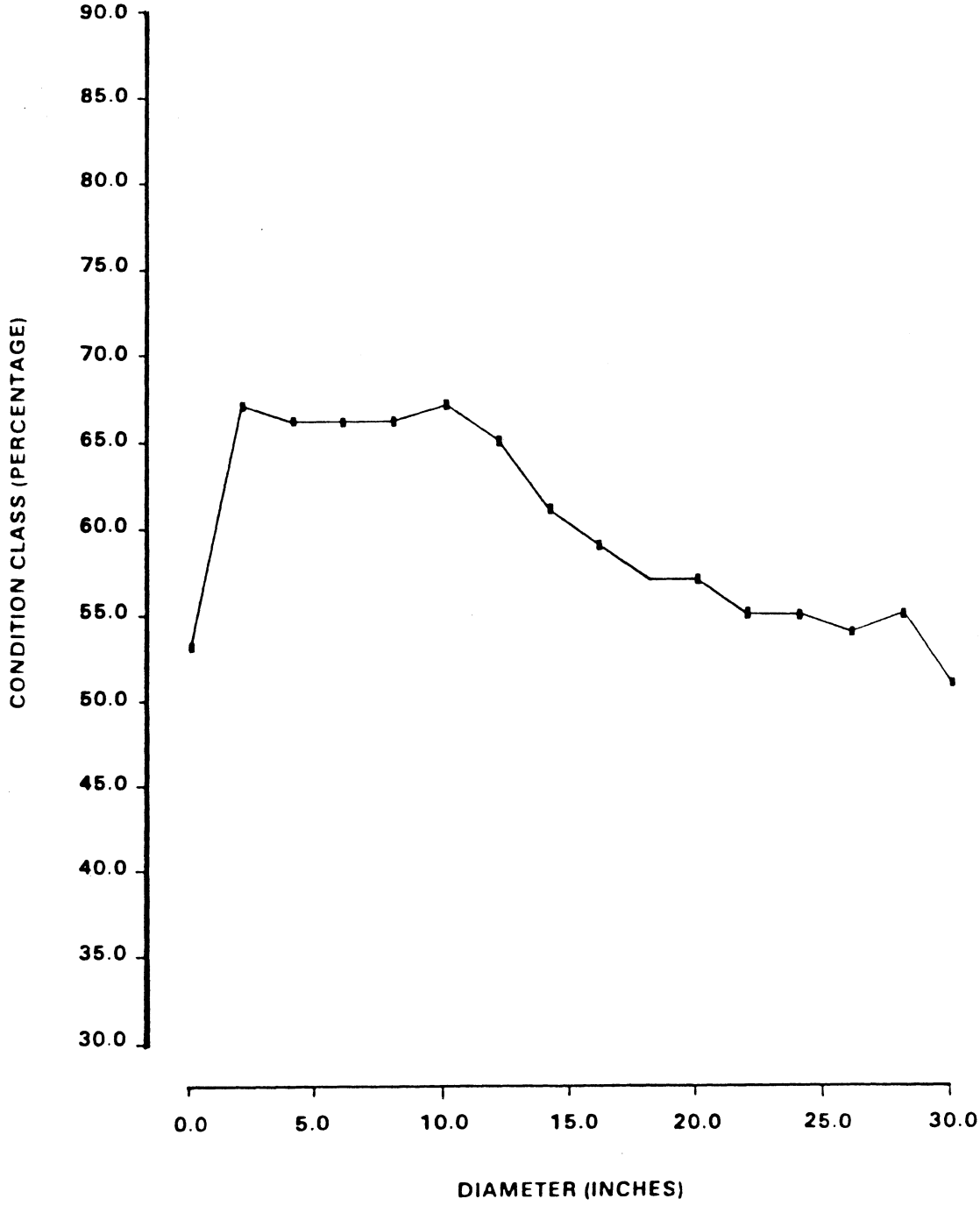

Figure 5. Condition class - size distribution for Waukesha.

Table 6. Frequency, average diameter and average condition class of species and cultivars in Waukesha.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Norway maple cv. schwedleri	2056	3.8	66.6
Green ash cv. marshall's seedless	2019	5.4	67.4
Norway maple cv. columnare	1882	2.6	70.1
Littleleaf linden cv. greenspire	1722	4.0	66.7
Norway maple cv. emerald queen	1068	2.3	69.2
Honeylocust cv. maxwell	652	8.5	65.2
Hackberry	625	6.7	64.4
Norway maple	450	12.8	65.2
Sugar maple	445	13.6	60.6
American elm	424	18.9	58.6
Red maple	369	4.8	59.6
Silver maple	317	18.9	53.2
Norway maple cv. cleveland	261	2.8	68.8
Crabapple	259	5.8	63.8
Honeylocust cv. sunburst	216	4.6	59.3
White ash cv. autumn purple	210	3.0	52.8
Green ash cv. summit	182	2.0	75.8
Norway maple cv. crimson king	144	2.4	66.1
Norway maple cv. jadeglen	114	2.1	73.0
European ash	102	7.8	50.2
Littleleaf linden cv. chancellor	100	2.0	68.8
Honeylocust cv. shademaster	95	2.0	71.8
Littleleaf linden cv. rancho	85	3.4	66.6

Table 6. Continued.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Redmond linden	76	4.0	68.9
White ash	72	17.5	51.9
Callery pear	69	2.0	61.4
Siberian elm	61	17.4	57.7
Boxelder	44	22.3	51.8
Amur corktree	39	3.7	62.6
Cherry	35	7.5	45.1
Basswood	32	18.6	58.8
Walnut	31	13.4	54.2
Honeylocust cv. skyline	30	2.8	78.7
European ash cv. hessi	27	2.0	68.1
Hawthorn	22	4.8	39.1
English oak	22	3.1	67.3
White oak	19	26.9	48.4
Sycamore	18	8.4	64.4
Catalpa	18	14.1	58.9
Red elm	15	17.9	56.0
Bur oak	13	28.5	58.5
Busiman elm	12	15.8	43.3
Pin oak	11	10.3	58.2
Red oak	10	26.4	52.0
Mountain ash	10	4.5	68.0
Hickory	8	13.3	60.0
Butternut	6	13.3	63.3
Chestnut	6	16.8	56.7
Ironwood	6	10.1	46.7
Poplar	6	15.3	63.3
Black locust	5	9.0	60.0
Ailanthus	4	10.0	55.0
Ginkgo	3	2.3	66.7
Birch	2	8.5	40.0

Table 6. Continued

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Mulberry	1	2.0	60.0
TOTALS	14530	5.8	65.7

trees of 25 different species and cultivars. The inventory shows the population of American elms on Stevens Point streets has been reduced to 388 (11.1% of the population). The average diameter for the entire street tree population is 9.5 inches. The two inch diameter class dominates the frequency-size graph with 1,061 trees, which represents over 30 percent of the total population (Figure 6).

The average condition class for the city of Stevens Point is 64.1 percent. The condition class percentage by diameter profile peaks at the two inch diameter class, with greater than 74 percent (Figure 7). The condition class percentages fall from the peak at two inches to level off from six inches and above, in the 55 to 60 percent range.

The list of 25 species and cultivars found in Stevens Point appears in Table 7. The most frequent species encountered is red maple (24.3%), followed by Norway maple (12.8%) and silver maple (11.3%).

Wisconsin Rapids

Wisconsin Rapids has 25 species and cultivars numbering 1,918 total street trees. The 897 remaining elms constitute the majority (46.8%) of city tree species. The number of elms remaining does not indicate a lack of Dutch elm disease mortality, but rather a lack of planting program to replace those lost.

The average diameter for the street tree population in Wisconsin Rapids is 13.4 inches. The frequency-size graph approaches the normal bell-shaped curve typical of pure even-aged stands in traditional forestry (Figure 8). Wisconsin

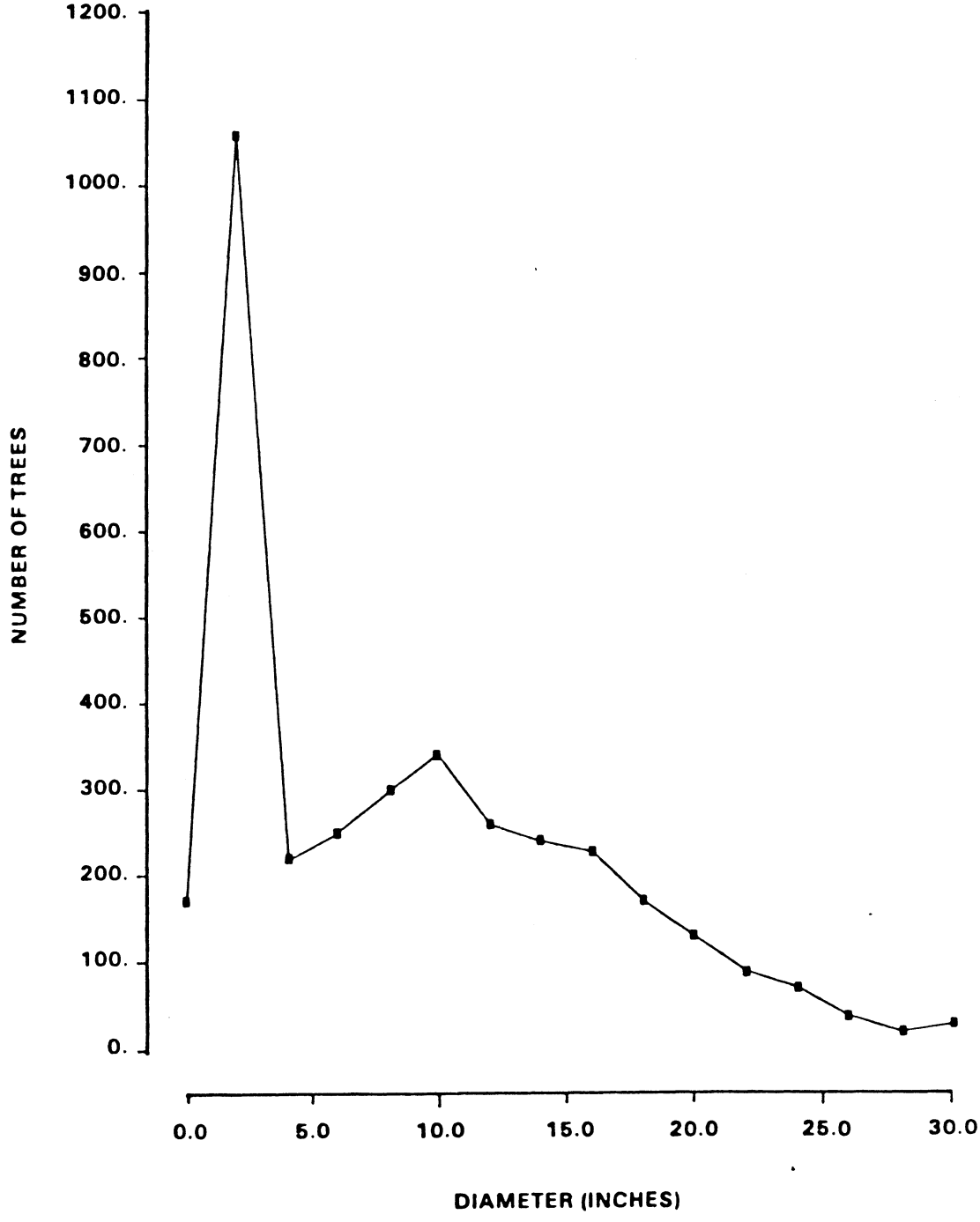

Figure 6. Population - size distribution of Stevens Point.

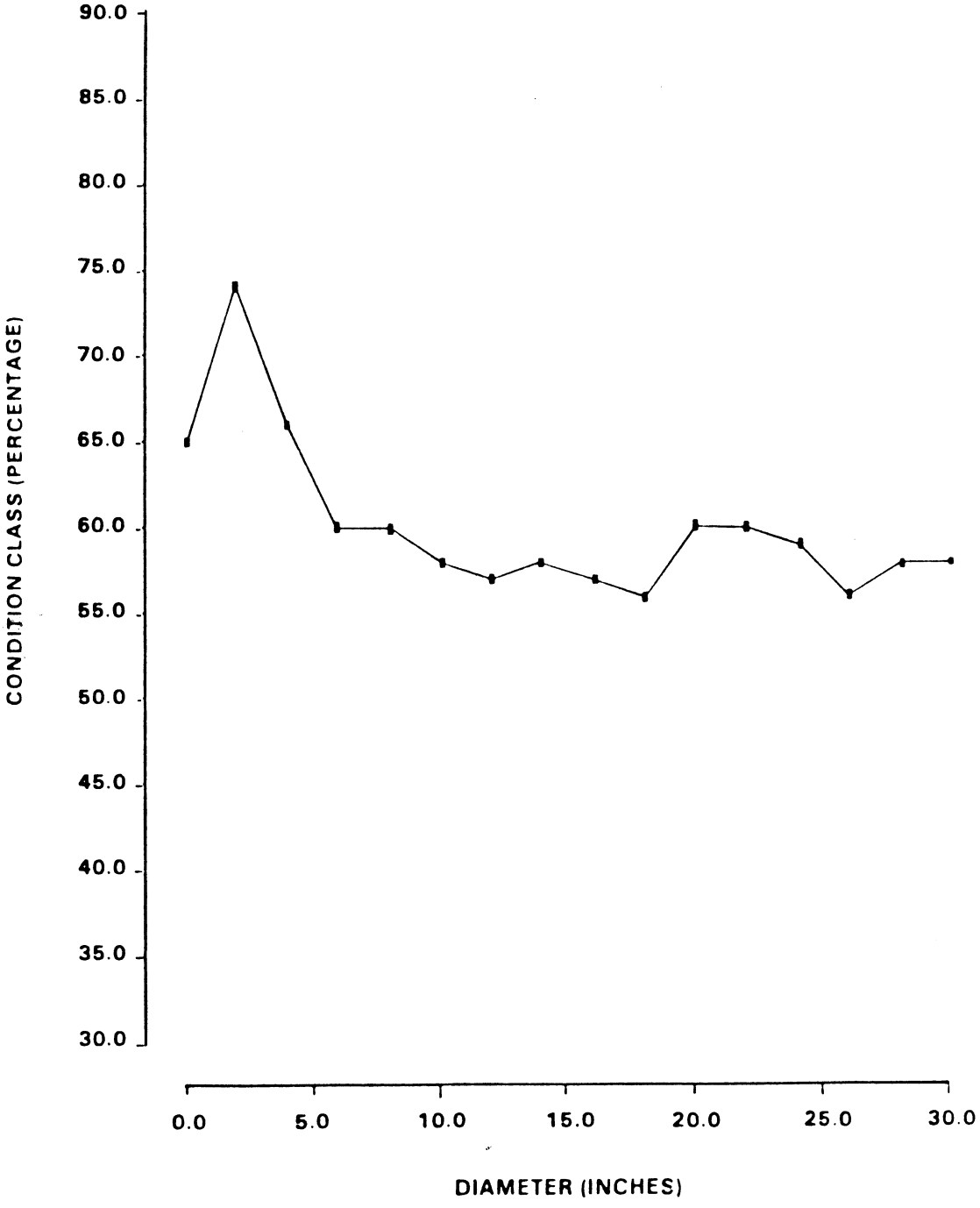

Figure 7. Condition class - size distribution for Stevens Point.

Table 7. Frequency, average diameter and average condition class of species and cultivars in Stevens Point.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
Red maple	849	10.4	59.9
Norway maple	446	4.3	71.3
Silver maple	395	14.7	56.4
American elm	388	18.7	59.8
Green ash cv.marshall's seedless	241	2.4	82.2
Sugar maple	163	9.3	55.3
Littleaf linden	100	2.6	80.0
Pine spp.	98	6.6	69.8
Shubert cherry	91	1.7	71.9
Siberian elm	87	13.0	55.4
Basswood	81	15.2	62.2
Green ash	78	6.5	66.4
Honeylocust	73	3.8	68.2
White ash	45	5.4	73.3
Oak spp.	43	16.6	62.3
Boxelder	40	12.0	50.5
Hackberry	39	3.3	70.8
Spruce spp.	32	4.0	81.9
Catalpa	30	12.9	58.0
Crabapple	28	1.4	75.0
Paper birch	13	6.3	58.5
Poplar spp.	11	13.4	65.5
Kentucky coffeetree	9	2.0	66.7
White cedar	8	7.0	55.0
Ginkgo	5	2.0	84.0
All others	94	4.6	54.0
TOTALS	3487	9.5	64.1

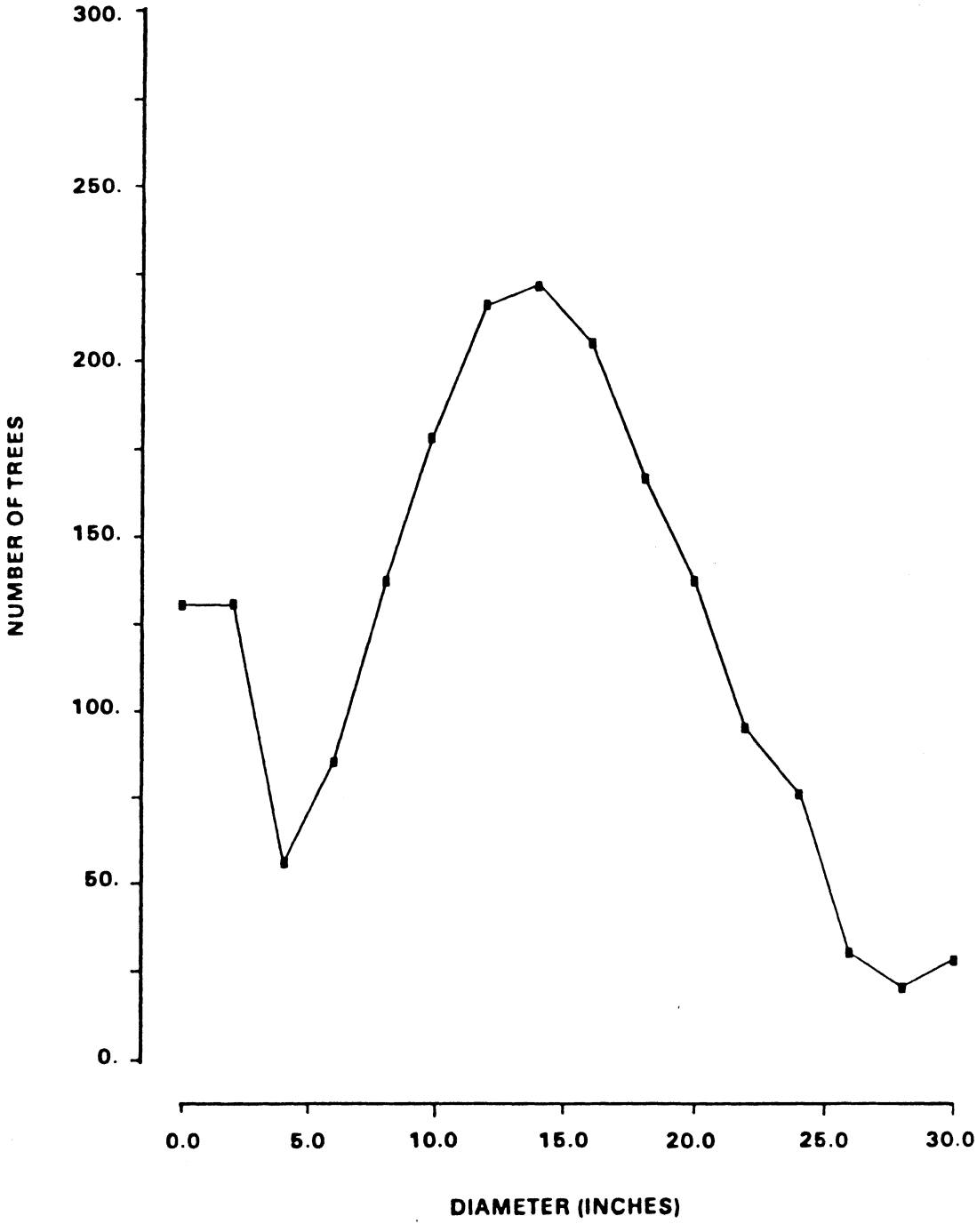

Figure 8. Population - size distribution for Wisconsin Rapids.

Rapids has since started a formal replanting program. However, in a city with a similar overall tree population size and condition without a formal planting program, the street tree population would continue to decrease and the remnants would continue to age toward biological maturity. Figure 9 shows the overall average condition class percentages for the city, by diameter. The highest condition percentages are for the large and small diameter trees, with the worst trees, in terms of condition class, in the range from eight to 20 inches.

Table 8 contains the list of species and cultivars present in Wisconsin Rapids. As previously stated, American elm is the most frequent (46.8%), followed by red maple (15.7%) and silver maple (14.2%).

Bloomer

The inventory of Bloomer shows 1,770 street trees of 24 species and cultivars. The average diameter for the city street trees in Bloomer is 10.0 inches. Bloomer has 489 trees in the zero to one inch diameter class representing 27.6% of the total population (Figure 10). Figure 11 shows the condition class percentage, for all species, by diameter for the city. The graph indicates that the average condition class percentage, by diameter, peaks at the six inch diameter class. The average overall condition class for the city is 49.8 percent, lowest of the five inventoried cities.

Table 9 is a list of species and cultivars in Bloomer,

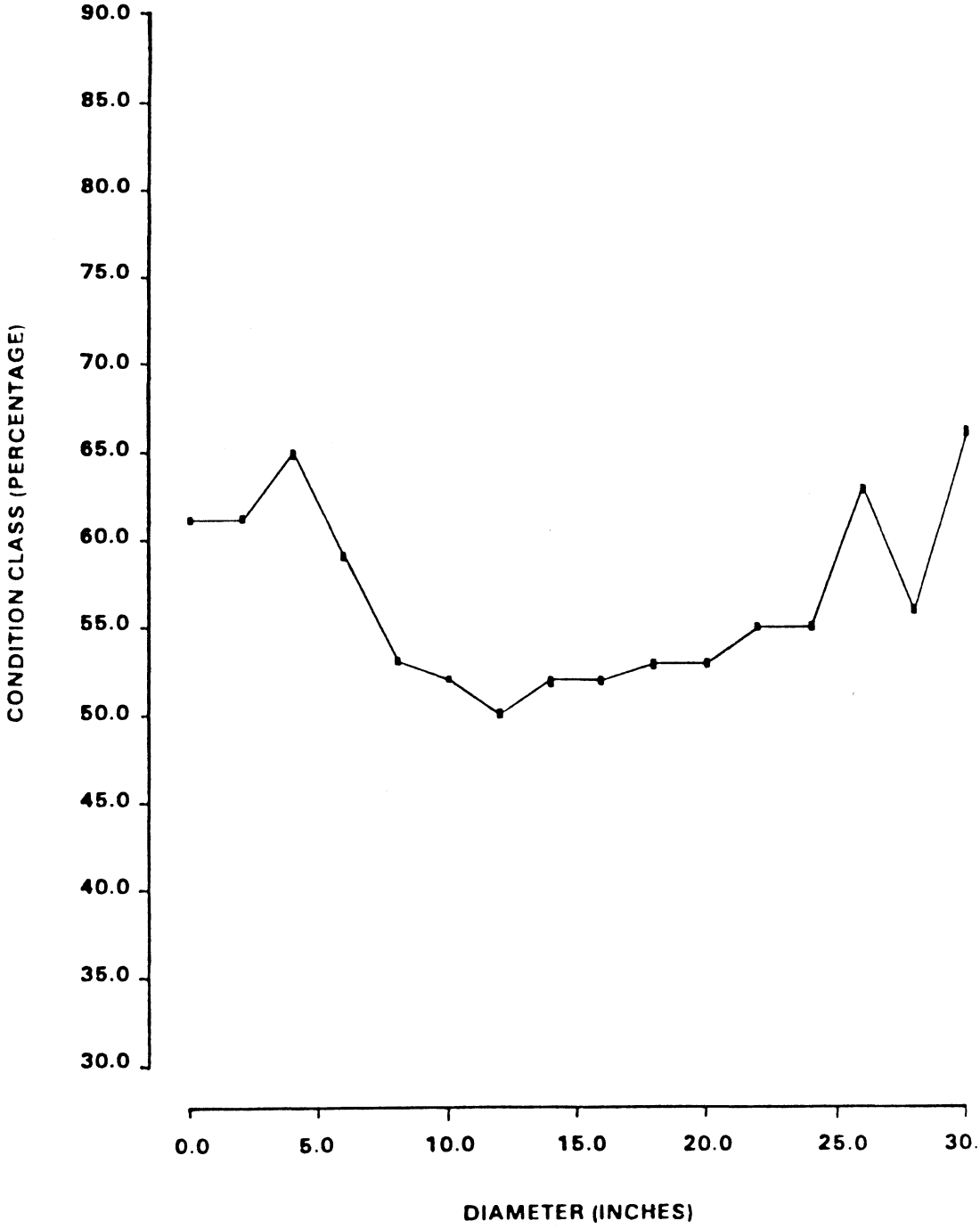

Figure 9. Condition class - size distribution for Wisconsin Rapids.

Table 8. Frequency, average diameter and average condition class of species and cultivars in Wisconsin Rapids.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
American elm	897	16.3	52.0
Red maple	301	10.3	52.8
Silver maple	273	15.5	60.1
White ash	57	8.0	53.7
Siberian elm	36	13.8	48.9
Sugar maple	35	7.3	66.9
Boxelder	32	15.3	39.4
Norway maple cv.emerald queen	31	8.2	53.5
Basswood	24	11.2	63.3
Hackberry	17	15.6	62.4
Norway maple cv. schwedler	16	4.4	62.5
Catalpa	13	8.3	55.4
Littleleaf linden	10	7.6	50.0
Green ash cv. marshall's	8	1.8	62.5
Mountain ash	7	7.2	54.3
Green ash	6	8.0	60.0
Norway maple cv. superform	6	2.0	43.3
Crabapple	4	4.8	70.0
Littleleaf linden cv. greenspire	4	6.5	40.0
Poplar	4	1.8	60.0
White oak	3	12.0	80.0
Norway maple cv. cleveland	3	8.0	60.0
Oak spp.	2	11.5	0.0
Elm spp.	2	15.5	30.0
Maple spp.	1	10.1	80.0
All others	126	5.9	63.3
TOTALS	1918	13.4	54.5

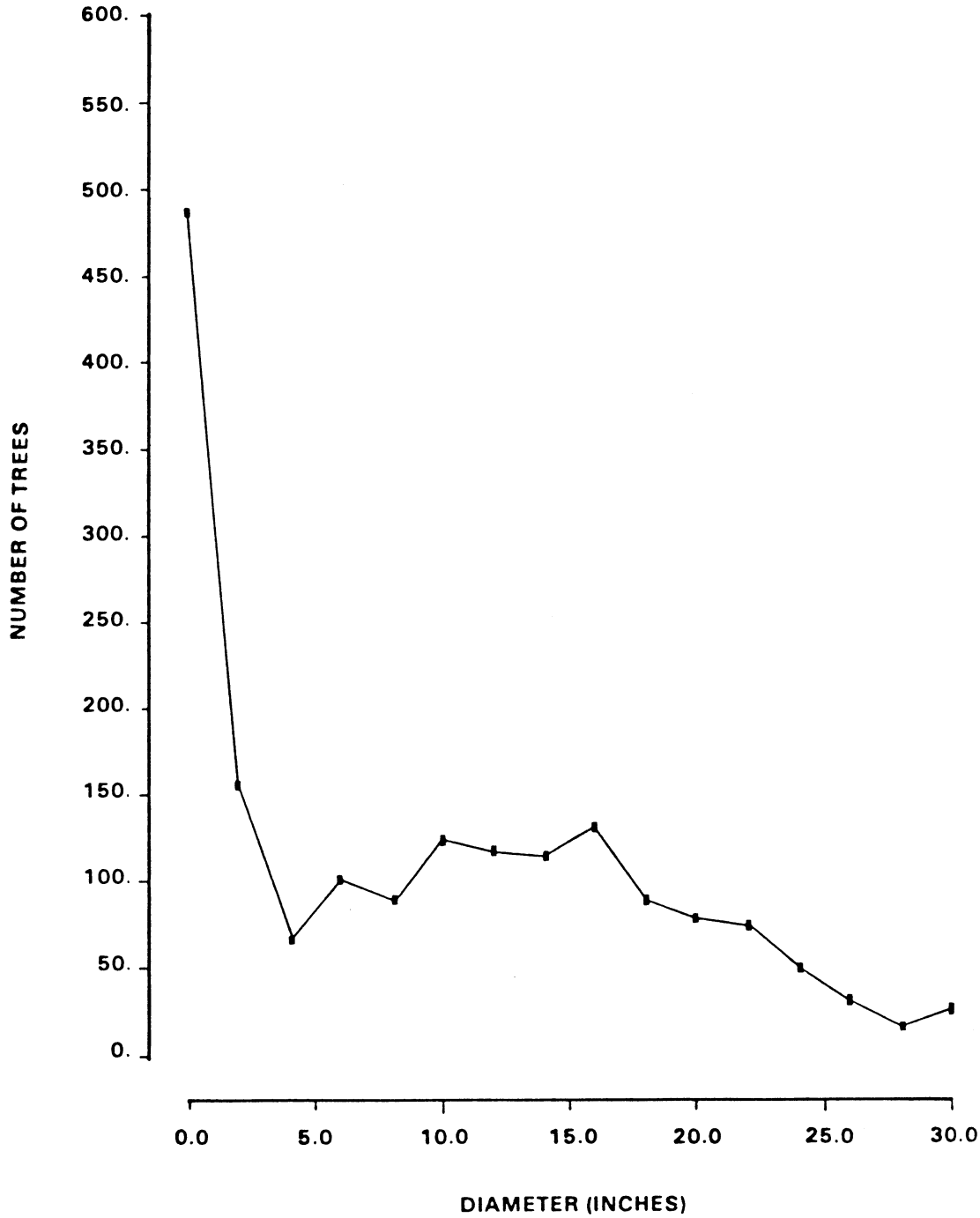

Figure 10. Population - size distribution for Bloomer.

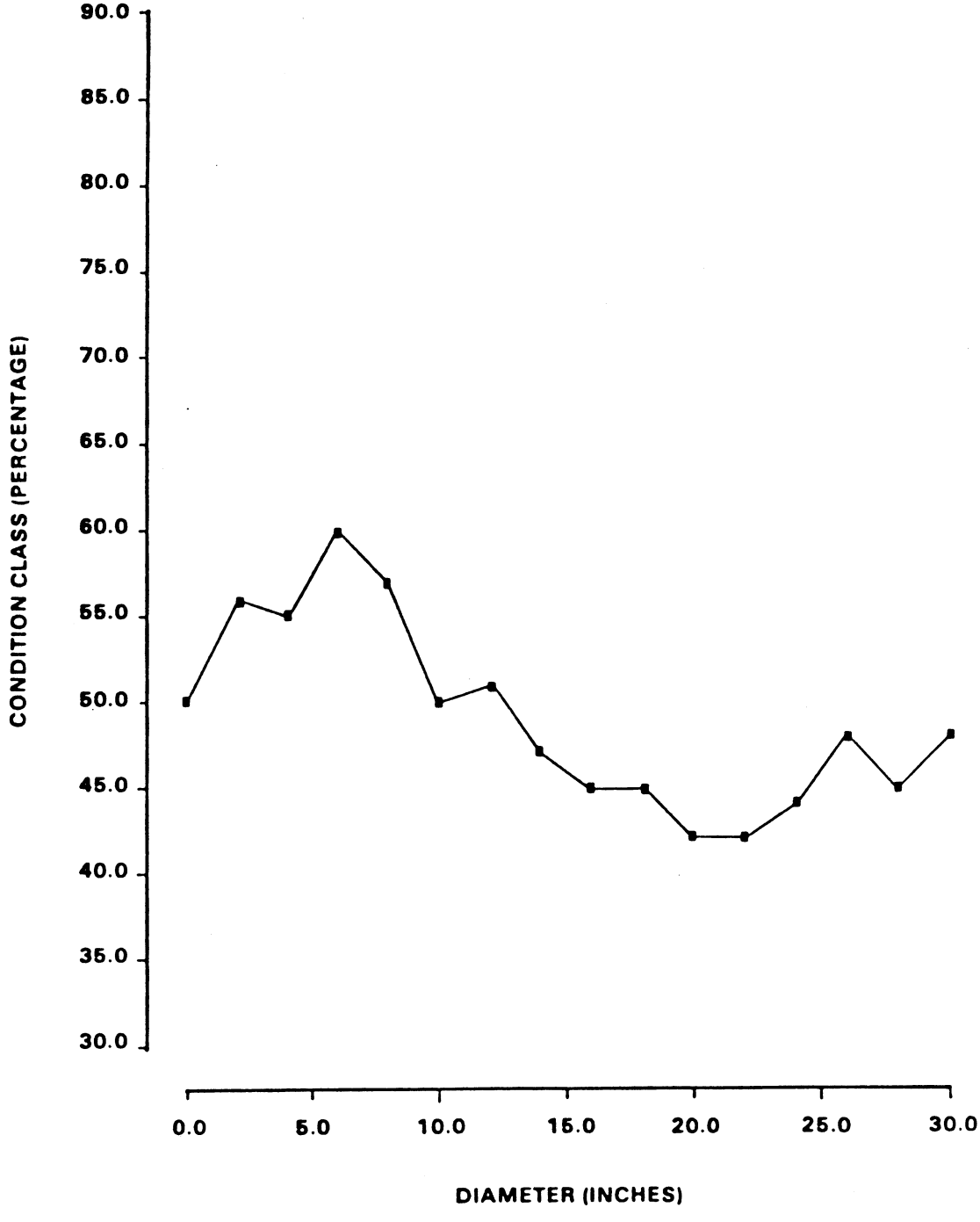

Figure 11. Condition class - size distribution for Bloomer.

Table 9. Frequency, average diameter and average condition class of species and cultivars in Bloomer.

SPECIES	TOTAL NUMBER OF TREES	AVERAGE DIAMETER (INCHES)	AVERAGE CONDITION CLASS (PERCENT)
American elm	406	18.2	42.1
Silver maple	241	12.9	54.6
Red maple	186	9.8	47.6
Hackberry	147	6.0	47.8
Sugar maple	142	3.2	50.3
Norway maple cv.emerald queen	100	2.0	51.6
White ash	88	2.3	49.8
Green ash cv. marshall's	67	1.4	56.7
Basswood	53	13.8	60.0
Norway maple cv. schwedler	53	5.4	47.5
Siberian elm	34	13.5	38.8
Red pine	33	9.4	60.0
White spruce	29	9.0	77.2
Red oak	27	1.2	57.8
Norway maple	24	5.7	62.5
Mountain ash	16	6.1	45.0
Boxelder	15	17.2	37.3
Norway spruce	9	20.1	60.0
Cedar spp.	8	12.6	27.5
White oak	6	2.7	30.0
Catalpa	3	7.5	46.7
Green ash	2	17.5	50.0
White pine	2	14.0	60.0
Crabapple	1	1.0	20.0
All others	78	7.9	59.5
TOTALS	1770	10.0	49.8

along with average condition class percentages and average diameters by species. American elm still dominates the population with 406 (22.9%) trees. Following American elm is silver maple (13.6%), red maple (10.5%) and Norway maple (10.0%).

Species Comparison

When determining which species should be used as a replacement for the elm, it is important to remember: no one species should be exclusively planted to replace the American elm. As many well-adapted tree species as possible should be planted on our city streets. Comparison in this study is based on botanical classification beginning at the family level and progressing down to species and cultivated variety, when adequate data is available. Appendix 3 shows relative position of each tree species in the study, by city, on an average condition class percentage continum.

Aceraceae

Trees of the maple family are the most common among the five cities with 60,791 of the 102,303 trees inventoried belonging to the family Aceraceae and the genus Acer. In the inventoried cities five species from the genus Acer were analyzed: silver maple, Norway maple, sugar maple, red maple and boxelder (Table 10).

Norway maple and its cultivars are the highest rated of the maples in terms of condition class. Norway maple is a relatively fast-growing, long-lived species. Many cultivars of this introduced species have been developed to control growth habit and color of foliage. The success of this

Table 10. Comparison of species and cultivars of the family Aceraceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Sugar maple	74.6	60.6	55.3	66.9	50.3
Silver maple	68.6	53.2	56.4	60.1	54.6
Red maple	65.5	59.6	59.9	52.8	47.6
Norway maple	75.8	65.2	71.3		62.5
'Jade glen'		73.0			
'Columnare'	75.6	70.1			
'Emerald queen'		69.2		53.5	51.6
'Cleveland'		68.8			
'Schwedleri'	77.0	66.6		62.5	47.5
'Crimson king'		66.1			
'Faasen'	73.7				
Boxelder	65.1	51.8	50.5	39.4	37.3

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Sugar maple	100.32	92.24	86.27	122.75	101.00
Silver maple	92.25	80.97	87.99	110.28	109.64
Red maple	88.08	90.72	93.45	96.88	95.58
Norway maple	101.94	99.24	111.23		125.50
'Jade glen'		111.11			
'Columnare'	101.67	106.70			
'Emerald queen'		105.33		98.17	103.61
'Cleveland'		104.72			
'Schwedleri'	103.55	101.37		114.68	95.38
'Crimson king'		100.61			
'Faasen'	99.11				

Table 10. Continued.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Boxelder	87.55	78.84	78.78	72.29	83.19

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

species in the harsh city street environment has led to overplanting of Norway maple by some Wisconsin cities.

Sugar maple ranks from first to fourth in condition class rating, by city, for the five species of maple. Red maple ranks below the city average condition class for each city. Both sugar and red maple require moist, rich soils of low pH to thrive. They also both tend to be intolerant of city conditions. Soils of Milwaukee and Waukesha, with the highest soil reaction rates of five cities, tend to limit success of both red and sugar maple. Urban sugar maples in Wisconsin have been subject to a progressive decline problem commonly known as "maple decline". Drilias (1980) has isolated two root collar fungi on declining sugar maples in Wisconsin which, along with other environmental factors, appears to be causing at least part of this decline.

Silver maple is a fast growing, weak-wooded species, commonly used as a street tree in the past. It is prone to damage by wind and ice storms, and tends to heave sidewalks and block sewers. Ratings by city for condition class show silver maple below city averages in Milwaukee, Waukesha and Stevens Point. The above average city condition ratings in Wisconsin Rapids and Bloomer appears to be more a result of the old, poorly maintained, remnant street tree populations than the value of the species for street planting. Boxelder is rated last of the maples in each of the five cities. Although easily transplanted, it is a fast-growing, weak-wooded tree which is also very short-lived. Boxelder, like silver maple is an undesireable street tree.

In an overall view of the family Aceraceae, the best adapted tree species for city streets is Norway maple. It has been the overwhelming choice for planting in Milwaukee, Waukesha and Stevens Point. Care must be taken not to overplant with maples, especially Norway maples. Boxelder and silver maple are often more of a liability than an asset to most street tree populations. Sugar and red maple are both relatively long-lived, strong-wooded species but tend to do poorly under urban street conditions.

Oleaceae

The family Oleaceae is represented by the single genus: Fraxinus. Three species and six cultivars of Fraxinus are present making up 15 percent of the 102,303 trees in the study. The three species of ash are: white ash, green ash and European ash (Table 11).

White ash ranks below the city average condition class for the cities of Milwaukee, Waukesha and Wisconsin Rapids. The cultivars of white ash, 'Autumn purple' and 'Modesto', also rate very low in both Milwaukee and Waukesha. 'Autumn purple' white ash is a variety cultivated for deep purple fall foliage color. This cultivar has had problems with graft incompatability between scion and rootstock, which causes girdling of the tree at the point of the graft.

Green ash is the fastest growing of the three ashes. It ranks above the city average condition class in both Milwaukee and Stevens Point. The most favorable green ash ratings are for its cultivars.

Table 11. Comparison of species and cultivars of the family Oleaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivars	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
White ash	67.6	51.9	73.3	53.7	49.8
'Autumn purple'		52.8			
'Modesto'	61.2				
Green ash	74.7		66.4		
'Marshall's seedless'		67.4	82.2		56.7
'Summit'		75.8			
European ash					
'Hessi'	73.7	68.1			
'Rancho'		50.2			

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
White ash	90.91	78.99	114.35	98.53	100.00
'Autumn purple'		80.36			
'Modesto'	82.30				
Green ash	100.46		103.59		
'Marshall's seedless'		102.59	128.24		113.85
'Summit'		115.37			
European ash					
'Hessi'	99.11	103.65			
'Rancho'		76.41			

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

'Marshall's seedless' green ash and 'Summit' green ash are both sterile varieties with uniform pyramidal form. 'Marshall's seedless' has been a commonly planted street tree in many Wisconsin cities in recent years. Although the average diameters of the 'Marshall's seedless' ash in each of the cities are small (indicating young populations), condition class ratings indicate that it is a well adapted street tree. 'Summit' green ash is a relatively new cultivar, now being planted in Waukesha. The study shows the 'Summit' ash to be as good or better than the 'Marshall's seedless' variety.

European ash is represented by 'Hessi' and 'Rancho cultivars. These trees, especially the 'Rancho', have been hard hit by the lilac-ash borer (Podosesia syringae) in Waukesha in recent years.

The best adapted species of ash presented in this study is green ash. Both the 'Marshall's seedless' and 'Summit' cultivars are good choices for street tree planting. The white ash 'Autumn purple' cultivar and European ash 'Rancho' cultivar should be avoided.

Tiliaceae

The genus Tilia is the sole representative of the family Tiliaceae in this study. Tilia makes up from two to 14 percent of the total populations of the five inventoried cities. The species of Tilia compared in this study include: basswood, littleleaf linden and Crimean linden. Table 12 shows comparison results.

Table 12. Comparison of species and cultivars of the family Tiliaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Basswood	74.1	58.8	62.2	63.3	60.0
Crimean linden 'Redmond'		68.9			
Littleleaf linden	73.0		80.0	50.0	
'Stewart'	78.1				
'Greenspire'		66.7			
'Chancellor'		68.8			
'Rancho'		66.6			

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Basswood	99.65	89.50	97.04	116.15	120.48
Crimean linden 'Redmond'		104.87			
Littleleaf linden	98.17		124.80	91.74	
'Stewart'	105.03				
'Greenspire'		101.52			
'Chancellor'		104.72			
'Rancho'		101.37			

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

Basswood, the only native linden, has the lowest average condition ratings for the three species of Tilia in Milwaukee, Waukesha and Stevens Point. The population summaries show that, as a general rule, basswoods in each city are trees of advanced age and large diameters.

Many cities have begun using the smaller more uniform growing cultivars of the introduced European lindens as street trees. The species indentified in this study are the littleleaf linden and Crimean linden. Littleleaf linden is found in four of the five inventoried cities. The condition class averages for littleleaf linden are higher than those for basswood in three of the four cities. The cultivars 'Greenspire', 'Chancellor' and 'Rancho' are present in Waukesha and 'Stewart' in Milwaukee. The Crimean linden cultivar 'Redmond' is being used in Waukesha with signs of success. This is in light of some increasing problems of planting mortality in Waukesha with bareroot littleleaf linden cultivars. Silver linden (Tilia tomentosa), another introduced species, has been suggested for street planting by Hasselkus (1980), but it only adapted to hardiness zone five or greater (southern and eastern Wisconsin).

Urticacea

Ulmus and Celtis are the two genera of the family Urticaceae found in the cities of this study. The elms (Ulmus) dominated city street plantings in Wisconsin until Dutch elm disease reached the state. The elm population has been reduced drastically by mortality due to Dutch elm

disease. Hackberry (Celtis) has been suggested by some as a logical replacement for American elm. Hackberry has a population making up from less than one percent to greater than nine percent of the total tree populations in the cities inventoried.

The elms in this study are of four species: American elm, Siberian elm, red (or slippery) elm and Busiman elm. The American elm is the traditional vase-shaped tree that has canopied our streets in the past. Red elm is similar in shape to that of American elm, but is a smaller tree with a faster growth rate. Red elm shares with American elm and all the North American elms, the high succeptibility to Dutch elm disease.

Asian elms, having a lower succeptibility to Dutch elm disease, have been introduced as ornamentals to replace the American elm. Siberian elm is the most common of the Asian elms planted in the cities studied. The Siberian elm is a much smaller, faster growing tree with a broad oval crown. Table 13 shows condition class ratings for Siberian elm fall below the mean city condition class in each city.

Attempts have been made to create hybrids of disease resistant, vase-shaped elms by crossing American elm and Asian elm species. Busiman elm is a result of this type of project, although it may or may not be resistant to Dutch elm disease. Table 13 shows it to be one of the worst trees, in terms of condition class, in the study.

Hackberry is a relatively small, slow-growing tree species. It is easily transplanted and tolerates a variety

Table 13. Comparison of species and culitvars of the family Urticaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Siberian elm	64.4	57.7	55.4	48.9	38.8
Busiman elm		43.3			
Red elm		56.0			
American elm	70.0	58.6	59.8	52.0	42.1
Hackberry	62.2	64.4	70.8	62.4	47.8
	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Siberian elm	86.61	87.82	86.43	89.72	77.91
Busiman elm		65.91			
Red elm		85.24			
American elm	70.03	89.19	93.29	95.41	84.54
Hackberry	83.65	98.02	110.45	114.50	95.98

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

of soil conditions. Hackberry is, however, prone to insect attack and is subject to "witches broom" disease (caused by either mildew fungus or mites), which deforms growth. These problems generally affect only appearance and are not very serious. Table 13 shows varying results for hackberry. In Milwaukee the condition rating is just 83.65 percent of the city average; but in the other cities the ratings are near or above the city averages. The urban heartiness of hackberry and the lack of any other adequate species from the Urticaceae family, make it a species to be seriously considered for street planting.

Fagaceae

The oaks (Quercus) as a group, make up a minor portion of the inventoried tree populations; ranging from 0.2 percent of Milwaukee to 1.9 percent of Bloomer. Oaks are slow growing, long-lived trees that are generally difficult to transplant. Oaks, especially white oak, are very sensitive to urban problems such as soil compaction and damage due to construction. Chlorosis due to micronutrient (iron or manganese) deficiency is common of oaks, particularly pin oak. This condition is common on heavy, alkaline soils of southern and eastern Wisconsin. The species of oak found in the five cities are: red oak, pin oak, white oak, bur oak and English oak.

The tree species of the red oak group involved in the study are pin oak and red oak. Along with the urban related problems, the red oak group is affected by oak wilt (Ceratocystis fagacearum). Oak wilt is a fungal vascular

disease, spread by root graphs and insect vectors, much like Dutch elm disease. While no cure is available, this problem is not nearly as critical as Dutch elm disease in the inventoried street tree populations because of the very low number of individuals present and slower rate of spread. Table 14 shows the comparison of oak species in the inventoried cities. The red and pin oak condition class ratings in Milwaukee and Waukesha fall below the city averages. Pin oak in Bloomer has a condition class average of 57.8 percent, well above the city average.

White, bur and English oak are the species of the white oak group. Although the white oaks are sensitive to soil compaction and construction damage, they are more resistant than the red oaks to oak wilt. Table 14 compares condition ratings for oak species. The white oaks, with the exception of English oak in Waukesha, are also below city averages.

When looking closely at the oaks in this study, a general pattern of negative correlation between size and condition class percent is evident. The very low average condition class percentages are representative of the oak populations with large diameters. English oak is being planted in both Milwaukee and Waukesha. Officials from cities are pleased with the results of this species. At the time of the inventory, Waukesha had experienced no morality of the 22 English oaks they have planted.

Leguminosae

Honeylocust (Gleditsia) is a long-lived, rapid-growing tree that is easily transplanted. The variety inermis

Table 14. Comparison of species and cultivars of the family Fagaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Red oak	63.8	52.0			
Pin oak		58.2			
White oak	65.3	48.4			
Bur oak	70.7	58.5			
English oak	64.4	67.3			
Oak spp.			62.3		

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Red oak	85.80	79.15			
Pin oak		88.58			
White oak	87.80	73.67			
Bur oak	95.08	89.04			
English oak	86.61	102.44			
Oak spp.			97.19		

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

(thornless) is commonly planted on city streets in Wisconsin. Honeylocust makes up 9.5 percent of the street tree population in Milwaukee, 6.8 percent in Waukesha and 2.1 percent in Stevens Point. Waukesha has, through planting records, broken the species into specific cultivars. Table 15 shows condition class percentages for honeylocust and its cultivars, and compares these ratings with the city averages. Honeylocust has above average condition ratings in both Milwaukee and Stevens Point. Waukesha, using a weighted average of the four cultivars, has a condition rating 98.8 percent of the city average. Honeylocust is a consistantly good performer in street planting situations.

Kentucky coffeetree, another species of the family Leguminosae, is suggested by Hasselkus (1980) for street planting in Wisconsin. Kentucky coffeetree is present in Milwaukee and Stevens Point, but was not included in the species analysis comparison because of less than ten trees in either city. Those present have better than city average condition class percentages.

Rosacea

The family Rosaceae consists of six species in this study. Waukesha has the largest population of the Rosaceae family, with crabapple, cherry, calley pear, hawthorn and mountain ash making up 2.7 percent of the Waukesha street tree population. In Milwaukee, the species of this family make up less than 1.0 percent of the city totals. The Rosaceae family in Stevens Point consists of 91 shubert cherry

Table 15. Comparison of species and cultivars of the family Leguminosae in each of the 5 inventoried cities.

Condition class (%) by city

Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Honeylocust	75.7		68.2		
'Skyline'		78.7			
'Shademaster'		71.8			
'Maxwell'		65.2			
'Sunburst'		59.3			

Condition rating* by city

Species/cultivars	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Honeylocust	101.80		106.40		
'Skyline'		119.79			
'Shademaster'		109.28			
'Maxwell'		99.24			
'Sunburst'		90.26			

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

trees on their streets. Bloomer has 16 mountain ash trees. Table 16 has condition class and condition rating percentages for the species of the Rosaceae family. The condition class average for shubert cherry in Stevens Point is well above the city average in terms of overall condition. Mountain ash, in Milwaukee and Waukesha, is above city averages but is below city average in Bloomer. Mountain ash does poorly on sandy, droughty soils such as those in Stevens Point, Wisconsin Rapids, and Bloomer. The remainder of the species of Rosaceae all fall below city average condition class percentages. The species of Rosaceae in this study fit into two basic categories: 1) Those trees planted by city officials in situations where overhead wires require trees of small stature (shubert cherry and calley pear); 2) Trees planted, mostly by homeowners, for the flower or fruit produced (crabapple, cherry spp., hawthorn and mountain ash).

Sapindaceae

The two species of the family Sapindaceae and genus Aesculus in this study are found, in sufficient numbers, in only Milwaukee. The Ohio buckeye, native to the mideastern United States, and the introduced horsechestnut represent less than one-half of one percent of Milwaukee's 80,598 street trees. Average condition class percentages for each of the two species are slightly higher than the average condition class of 74.4 percent for all species in Milwaukee (Table 17).

Betulaceae

Ironwood in Milwaukee, and paper birch in Stevens Point are minor portions of each city's street tree population.

Table 16. Comparison of species and cultivars of the family Rosaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Crabapple	67.6	63.8			
Cherry spp.		45.1			
Schubert cherry			71.9		
Calley pear	60.0	61.4			
Hawthorn		39.1			
Mountain ash	75.6	68.0			45.0

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Crabapple	90.91	97.11			
Cherry spp.		68.65			
Schubert cherry			112.17		
Calley pear	80.69	93.46			
Hawthorn		59.51			
Mountain ash	101.67	103.50			90.36

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

Table 17. Comparison of species and cultivars of the family Sapindaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Ohio buckey	78.7				
Horsechestnut	74.5				

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Ohio buckeye	105.84				
Horsechestnut	100.19				

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

Each makes up less than 1 percent of the city total. Ironwood, a slow-growing, medium-sized tree, ranks above the Milwaukee city condition class average (Table 18). Paper birch is a short-lived, pioneer species plagued by birch leaf minor (Fenusa pusilla) and bronze birch (Agrilus anxius). Stevens Point shows a below city average condition rating for paper birch (Table 18).

Juglandaceae

Hickory and walnut represent the family Juglandaceae in this study. Hickory is present in Milwaukee with 11 individuals. Waukesha street tree inventory shows 31 walnut trees. Both of these genera show results below their respective city averages (Table 19). Nut bearing trees have been discouraged for use as street trees by Hasselkus (1980) and others because of the litter of the fruit on the street.

All other families

The remaining six species found in the cities studied are all of minor importance in one or more of the cities and include the families; Platanus, Salicaceae, Bignoniaceae, Ginkgoceae, Simarubaceae and Phellodendron. The species are: sycamore, populus spp., catalpa, ginkgo, ailanthus and Amur corktree.

Sycamore, present in Milwaukee and Waukesha, shows below city average condition ratings (Table 20). Anthracnose disease (Gnomonia veneta) is very common with sycamore, but is seldom more than an unsightly problem. The London plane (Platanus x acerifolia) is somewhat more resistant to the

Table 18. Comparison of species and cultivars of the family Betulaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Ironwood	76.7				
Paper birch			58.5		

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Ironwood	103.15				
Paper birch			91.26		

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

Table 19. Comparison of species and cultivars of the family Juglandaceae in each of the 5 inventoried cities.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Walnut		54.2			
Hickory	70.9				

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Walnut		82.50			
Hickory	95.35				

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

Table 20. Summary of condition class and condition rating for minor families with one species present: Platanus, Salicaceae, Bignoniaceae, Ginkgoaceae, Simarubaceae and Phellodendron.

	Condition class (%) by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Sycamore	65.4	64.4			
Populus spp.	42.3		65.5		
Catalpa	62.1	58.9	58.0	55.4	
Ginkgo	74.9				
Ailanthus	72.0				
Amur corktree		62.6			

	Condition rating* by city				
Species/cultivar	Milwaukee	Waukesha	St.Point	WisRapds	Bloomer
Sycamore	87.95	98.02			
Populus spp.	56.89		102.18		
Catalpa	83.51	89.65	90.48	101.65	
Ginkgo	100.73				
Ailanthus	96.83				
Amur corktree		95.28			

*Condition rating values based on each city's average condition class being assigned a value of 100 and species condition classes computed as greater than or less than 100.

insect and disease problems of the native sycamore. Both are at the northern most extreme of their distribution in hardiness zone five.

Species of populus, evaluated in both Milwaukee and Stevens Point, show mixed results. Populus in Milwaukee have a species average just 56.69 percent of the city average, but in Stevens Point results show an above city average rating (Table 20). Species of populus are most often rejected as street trees because of the very weak wood and short longevity.

Catalpa rates from 83.51 percent of Milwaukee's city average to 101.65 percent of the city average in Wisconsin Rapids (Table 20). Each of the cities, with the exception of Bloomer, report catalpa trees on their streets. The large pod-like fruit (cylindrical capsule) produced by the catalpa often makes this species undesireable for street planting.

Ginkgo is a slow-growing, decidous conifer with fan-shaped leaves. Hasselkus (1980) recommends ginkgo for planting on Wisconsin streets in hardiness zone five. Milwaukee reports a condition class percentage of 74.9 for 332 ginkgos, slightly higher than the city average (Table 20). The three ginkgos on the streets of Waukesha also have a slightly above city mean, condition class average. Stevens Point, although in hardiness zone four, has five ginkgos with a very high average condition class rating. The odor and mess created by the fruit of the ginkgo warrant the planting of the staminate trees only.

Ailanthus, or tree-of-heaven, has a reputation as a weed tree species. It is a fast-growing, weak-wooded, introduced species of uncontrolled growth habit. It is, however, tolerant of city conditions. Ailanthus in Milwaukee has a condition rating 96.83 percent of the city average (Table 20).

Amur corktree is a medium-sized, fast-growing shade tree. Waukesha has 39 Amur corktrees, with an average diameter of 3.7 inches. The species average condition class for this tree is 95.28 percent of the Waukesha city mean (Table 20). Amur corktree is reportedly tolerant of dry soil and may prove to be a very good street tree for Wisconsin cities in the future.

General Discussion

American elms lost to Dutch elm disease have been most commonly replaced by Norway maple, green ash and honeylocust in Milwaukee and Waukesha. Red maple, Silver maple and Norway maple are most often used in Wisconsin Rapids, Bloomer and Stevens Point.

Comparison of study results with those of Hasselkus (1980) show many similarities and some discrepancies. Table 21 describes study results and Hasselkus' recommendations for many of the same species.

On the basis of this study, Norway maple, green ash, littleleaf linden and honeylocust are recommended for planting on city streets in Wisconsin. Hasselkus names each of the four

Table 21. Comparison of street tree species recommended, and to be avoided for Wisconsin streets; between Hasselkus (1980) and results from this study.

	Schuman (1984)		Hasselkus (1980)
Ailanthus	(VQ)	-	
American elm		-	-
Amur corktree	(VQ)	-	+
Basswood	(MR)	-	
Black oak	(MR)	-	
Boxelder		-	-
Bur oak	(MR)	-	
Busiman elm		-	-
Callery pear	(VQ)	-	+
Catalpa		-	-
Crabapple	(VQ)	-	+
Crimean linden	(SP)	+	+
English oak	(SP)	+	
European ash	(MR)	-	
Ginkgo	(SP)	+	+
Green ash		+	+
Hackberry	(SP)	+	+
Hawthorn	(VQ)	-	+
Hickory	(VQ)	-	-
Honeylocust		+	+
Horsechestnut	(SP)	+	+
Ironwood	(SP)	+	+
Littleleaf linden		+	+
Mountain ash	(SP)	+	
Norway maple		+	+
Ohio buckeye	(SP)	+	
Paper birch	(VQ)	-	
Pin oak	(MR)	-	+
Poplar	(VQ)	-	-
Red elm		-	-
Red maple	(MR)	-	+
Red oak	(MR)	-	+
Shubert cherry	(SP)	+	

Table 21. Continued.

	Schuman (1984)	Hasselkus (1980)
Siberian elm	-	-
Silver maple	-	-
Sugar maple	(MR) -	-
Sycamore	(VQ) -	-
Walnut	(VQ) -	-
White ash	(MR) -	+
White oak	(MR) -	

+Recommended for Wisconsin streets.

-Should be avoided for street planting in Wisconsin.

(VQ) - Very Questionable (Species of minor importance with well below average condition class).

(MR) - Mixed Reviews and better adapted species from the same botanical family indicate limited use.

(SP) + Show Promise (Species with somewhat mixed reviews or limited occurance, but show promise).

species in the "Street Trees for Wisconsin" recommended species list. Boxelder, silver maple, elms and catalpa are those tree species which should not be planted on city streets in Wisconsin. These recommendations also agree with those made by Hasselkus. Contradictions between recommendations are found with the oaks (except English oak, which is not mentioned by Hasselkus), red maple, white ash, amur corktree calley pear, crabapple and hawthorn.

Species results of this study are largely what were expected at the outset of this project. Exceptions included the low ratings for red maple, white ash and the oaks (except English oak). Speculation after the fact indicates that the oaks are rated relatively low because they are represented by an older, less well-maintained population. Categorizing red maple and white ash in the "mixed results" grouping appears to be mostly a result of the outstanding performances of green ash seedless cultivars and Norway maple cultivars rather than extremely poor actual performance by either species.

This study has shown a general trend of decreasing condition class percentages as tree diameters increase. In my opinion this trend is due to better overall tree care for street trees in these cities in recent years. Large, older trees did not have the benefit of the present care when they were developing structure, shape and general health they now have.

The major shortcoming of this study was the lack of

specific tree mortality data in the analysis. For example, a species population with a high condition class and also a high mortality rate could be confusing. The tree mortality does not show up on the computer analysis and the species may appear superior. In this study, tree mortality was strictly input by comments of city foresters. To make street tree mortality data available to researchers some type of standardized reporting method must be implemented.

Results of this study are based upon actual data from Wisconsin city streets and so are applicable to Wisconsin cities and, to some degree, cities of the upper mid-west. Implications of this study may be to reinforce or somewhat alter the thinking of urban forest managers on specific species used for street planting. Also, more importantly, this study may stimulate objective methods of evaluating street tree species performance. Much work needs to be done, on a continous basis, to evaluate new and existing species and cultivars; and to update results as the urban forest continues to grow and change.

Another interesting project would be to compare dollars spent on street tree maintenance with average conditon class, for a number of cities. This may determine if a coorelation exists and how important tree care may be. Data such as this, however, may also be difficult to obtain as many cities do not keep specific enough data along these lines.

V. SUMMARY

Street tree inventory results from the Wisconsin cities of Milwaukee, Waukesha, Stevens Point, Wisconsin Rapids and Bloomer show 55 species of 32 genera and 18 families. American elm, while declining in numbers, still makes up from 2.9 to 46.8 percent of the total street tree populations in these communities. Of those species now replacing the once dominate American elm; Norway maple, green ash and honeylocust are the most common in Milwaukee and Waukesha. Wisconsin Rapids, Bloomer and Stevens Point inventories show red maple, silver maple and Norway maple to be the most common elm replacement species.

Species performance analysis shows a good deal of continuity of results between cities. Of those species present in sufficient numbers in most cities the following are considered the best adapted to urban conditions on Wisconsin streets:

Norway maple
Green ash (esp. cultivars)
Littleleaf linden (esp. cultivars)
Honeylocust

Species which, according to condition class comparisons, should not be planted on city streets, are the following:

Boxelder
Silver maple
Elms
Catalpa

The remaining species of the study fall somewhere between the first two categories. Species, with either mixed reviews, or

limited occurance, and show promise are:

English oak

Hackberry

Crimean linden

Shubert cherry

Ginkgo

Ironwood

Horsechestnut

Ohio buckeye

Mountain ash

Some species, because others in the same botanical family are better adapted and mixed results point toward below average performance, should be planted in limited numbers. Those species which display these results are the following:

Red maple

Sugar maple

Basswood

Oaks (except English oak)

White ash

European ash

Many species of minor importance in one or two of the inventoried cities are well below average, in terms of condition class. As a result, although not sufficient enough data is available to place them on the list of trees to be avoided, the following species should be considered very questionable:

Popular

Paper birch

Walnut

Hickory

Crabapple

Cherry spp.

Calley pear

Hawthorn

Sycamore

Ailanthus

Amur corktree

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APPENDICES

Appendix 1. Findings of the Shade Tree Evaluation Studies at the Ohio Agricultural Research and Development Center.

Trees Recommended for Street Tree Planting:

Small Trees

Hedge maple (*Acer compestre*)

Thicket hawthorn (*Crataegus intricata*)

Lavalle hawthorn (*Crataegus lavallei*)

Tree form Washington hawthorn (*Crataegus phaenopyrum* 'Tree Form')

Winter king hawthorn (*Crataegus viridis* 'Winter King')

Snowdrift crabapple (*Malus* 'Snowdrift')

Tschonoski crabapple (*Malus* 'Tschonoski')

Van Eseltine crabapple (*Malus* 'Van Eseltine')

Hophornbeam (*Ostrya virginiana*)

Medium Trees

Crimson king Norway maple (*Acer platanoides* 'Crimson King')

Autumn flame red maple (*Acer rubrum* 'Autumn Flame')

Shademaster honeylocust (*Gleditsia triacanthos* inermis 'Shademaster')

Sargent cherry (*Prunus sargenti*)

Bradford Callery Pear (*Pyrus calleryana* 'Bradford')

Regent Japanese pagoda tree (*Sophora japonica* 'Regent')

Mongolian linden (*Tilia mongolica*)

Chancellor littleleaf linden (*Tilia cordata* 'Chancellor')

Greenspire linden (*Tilia cordata* 'Greenspire')

Rancho linden (*Tilia cordata* 'Rancho')

XP110 littleleaf linden (*Tilia cordata* 'XP110')

Appendix 1 cont.

Pallida common linden (Tilia europaea 'Pallida')

Silver linden (Tilia tomentosa)

Large Trees

Cleveland Norway maple (Acer platanoides 'Cleveland')

Emerald queen maple (Acer platanoides 'Emerald Queen')

Summershade maple (Acer platanoides 'Summershade')

October glory red maple (Acer rubrum 'October Glory')

Red sunset red maple (Acer rubrum 'Red Sunset')

Tilford red maple (Acer rubrum 'Tilford')

Improved white ash (Fraxinus americana 'Autumn Purple')

Hesse European ash (Fraxinus excelsior 'Hessei')

Marshall green ash (Fraxinus pennsylvanica lanceolata 'Marshall Seedless')

Low-gro honeylocust (Gleditsia triacanthos inermis 'Imperial')

Shademaster honeylocust (Gleditsia triacanthos inermis 'Shademaster')

Pyramidal honeylocust (Gleditsia triacanthos inermis 'Skyline')

Moraine sweetgum (Liquidambar styraciflua 'Moraine')

London planetree (Platanus acerifolia)

Upright or Fastigiate Trees

Columnar Norway maple (Acer platanoides 'Columnare')

Armstrong red maple (Acer rubrum 'Armstrong')

Bowhall red maple (Acer rubrum 'Bowhall')

Columnar sargent cherry (Prunus sargenti 'Columnaris')

Upright English oak (Quercus robur 'Fastigiata')

Appendix 1. cont.

Upright bigleaf linden (Tilia playtphyllos 'Fastigiata')

Trees Not Recommended for Street Tree Planting

Boxelder (Acer negundo)

Silver maple (Acer saccharinum)

Ohio buckeye (Aesculus glabra)

Horsechestnut (Aesculus hippocastanum)

Tree-of-heaven (Ailanthus altissima)

Paper, gray and european birch (Betula papyrifera, populifolia, and alba)

Catalpa (Catalpa speciosa)

Black walnut (Juglans nigra)

Crabapples (Malus spp.)

Mulberry (Morus spp.)

Cottonwood (Populus spp.)

Black locust (Robinia pseudoacacia)

Willow (Salix spp.)

American elm (Ulmus americana)

Siberian elm (Ulmus pumila)

Appendix 2. "Street Trees For Wisconsin".

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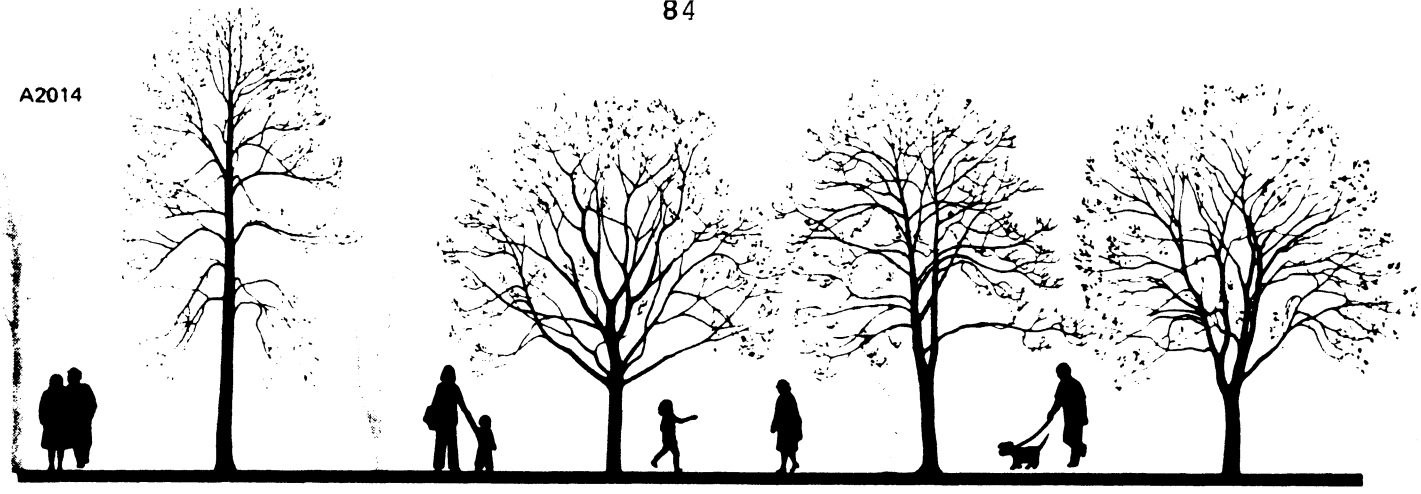


Street Trees for Wisconsin

E. R. Hasselkus

Street trees bring nature into our everyday environment. They modify summer temperatures, control winds, deaden traffic noises and help purify polluted air. Trees soften the harsh lines of the man-made elements in our landscape. Colorful flowers and fruits, textural qualities of foliage, autumn foliage color and patterns of branches and bark provide an ever-changing seasonal interest. Loss of American elms to Dutch elm disease has forcefully demonstrated the aesthetic and economic value of street trees in numerous Wisconsin communities.

WHEN SELECTING STREET TREES . . .

Plant Several Species

This will help avoid monotony and insure your community against having most of its trees wiped out by an insect or disease invasion. Diversified street tree plantings may be accomplished with identical trees on one street and using other tree species on adjacent streets.

In areas with curved streets or with many existing trees, several kinds of trees might be combined if their forms, textures and colors are compatible.

Plant Species Suited to the Particular Site

Factors to watch for include:

- Winter hardiness
- Optimum height and spread at maturity. Fit the tree to the space available.
- Tolerance to pollutants. Trees vary in their tolerance to soot, gases, smoke, salt and other chemicals.
- Soil fertility, available moisture, soil alkalinity and a restricted root area may limit your choice of tree species.
- Tolerance of exposure to reflected heat, high winds or dense shade.

Plant Species Inexpensive to Maintain

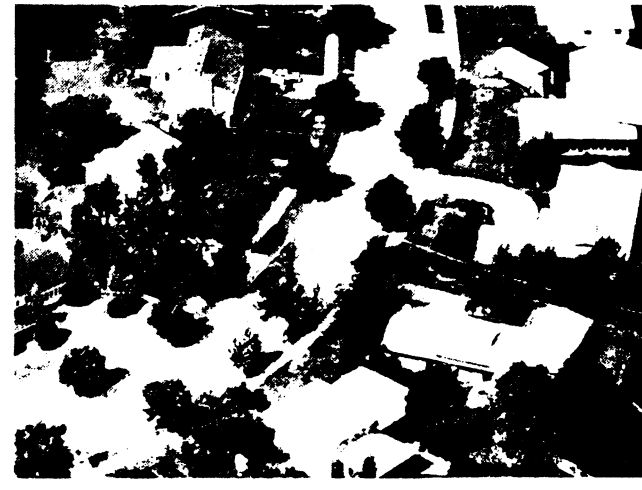
These species include those with the following characteristics:

- Easy to transplant and establish.
- High resistance to serious diseases and insects.
- Long lived and strong wooded.
- Minimal litter, such as faded flowers, messy fruits or seed pods, which may be a nuisance.
- Roots that will not block sewers and drains or heave pavements.
- Tap root systems and filtered shade patterns allowing grass to grow.

Consider Proper Spacing

Keep space between trees at least one-half of their total spread. To allow motorists' visibility at intersections, plant trees no closer than 25 feet from the corner. Overhead utility lines may limit your choice to low-growing species.

If interplanting between existing trees, consider the shade cast by overhead branches as well as the competition from roots of adjacent trees.



BOTANICAL AND COMMON NAME	HEIGHT	SPREAD	GROWTH RATE	REMARKS
Acer platanoides Norway Maple	50'	50'	Medium	Greenish-yellow flowers before leaves. Avoid using in areas where turf is to be maintained; withstands salt and adverse city conditions.
cv. 'Cleveland' or 'Emerald Queen'	40–50'	30'	Fast	Upright oval-headed forms of the species with superior branching habit.
cv. 'Columnare' or 'Erectum' Columnar Norway Maples	40'	10–15'		Dense, columnar forms of the species.
cv. 'Globosum' Globe Norway Maple	20'	20'	Slow	Low-crowned globe from of the species. Not readily available from nurseries.
Acer rubrum Red Maple	50–60'	30–40'	Fast	Requires moist acid soil; bright red flowers before leaves; brilliant autumn foliage color; smooth gray bark. Intolerant of salt.
cv. 'Autumn Flame'	50–60'	30–40'		Develops an early display of scarlet autumn foliage.
cv. 'Armstrong' or 'Columnare' Columnar Red Maples	40'	10–20'		Columnar forms of the species.
cv. 'Bowhall' Bowhall Red Maple	40–50'	30'		Oval form of the species with orange autumn foliage color.
Aesculus hippocastanum 'Baumannii' Baumann Horsechestnut	30–60'	30'	Medium	Bears double white sterile flowers. Casts dense shade. Tolerant of salt. Not readily available from nurseries.
Celtis occidentalis Common Hackberry	30–50'	40'	Slow	Interesting pebbled bark; hard black fruits; "witch's broom" may be a problem; similar in habit to elm. Tolerant of both dry and wet soils. Sensitive to salt spray.
Crataegus phaenopyrum Washington Hawthorn	20–30'	15–20'	Medium	Bears thorns; white flowers, tiny orange fruits and red to orange autumn foliage display. Tolerant of adverse city conditions.
Fraxinus americana White Ash	50–80'	50'	Medium	Broad-headed tree with diamond-shaped fissures in bark and yellow to purple autumn foliage color.
cv. 'Autumn Purple' or 'Rosehill' Seedless White Ashes	50'	50'		Seedless forms of the species with orange-purple autumn foliage color.
Fraxinus pennsylvanica Green Ash	50–60'	30–40'	Fast	Dark green, glossy foliage turning yellow in autumn; variable in form. Tolerant of salt and both dry and wet soils.
cv. 'Marshall's Seedless' or 'Summit' Seedless Green Ashes				Seedless forms of the species; uniformly pyramidal in form.
**Ginkgo biloba* Ginkgo	60'	30–40'	Slow	Picturesque growth habit; fan-shaped leaves turn yellow in autumn; tolerant of city conditions.
*cv. 'Fastigiata' Sentry Ginkgo	60'	10–15'		Narrow columnar form of the species.

BOTANICAL AND COMMON NAME	HEIGHT	SPREAD	GROWTH RATE	REMARKS
Gleditsia triacanthos inermis cvs. 'Imperial' Honeylocust 'Shademaster' Honeylocust 'Skyline' Honeylocust	60'	40'	Fast	Podless and thornless varieties; fine textured foliage that casts a light shade. Tolerant of salt, adverse city conditions and both dry and wet soils.
Gymnocladus dioica Kentucky Coffeetree	60'	40'	Medium	A picturesque tree with unusual deep furrowed twigless branches.
Malus cvs. Flowering Crabapples:	20–30'	18–20'	Medium	Use only where fruits up to 3/4" in diameter can be tolerated.
'Centurion'				Rose-red flowers; glossy red, persistent fruits 5/8" in diameter; disease resistant
'Sentinel'				Pink flowers; red, persistent fruits 3/8" - 1/2 " in diameter; slightly susceptible to scab and fire blight.
Ostrya virginiana Hophornbeam or Ironwood	25'	20'	Slow	Similar in appearance to American elm, but much more refined; interesting fruits. Tolerant of dry soil and shade, but intolerant of salt.
Phellodendron amurense Amur Corktree	45'	30'	Fast	A sturdy tree with ash-like leaves with yellow autumn color and a thick corky bark. Tolerant of dry soils.
Pyrus calleryana 'Select' Select Callery Pear	30'	16'	Medium	Narrow pyramidal form; glossy green leaves turn red-orange to maroon in autumn; early, white flowers.
Quercus palustris Pin Oak	40–50'	30–40'	Medium	Symmetrical in form; fine autumn color; avoid using on alkaline soils. Tolerant of wet soils.
Quercus rubra Red Oak	60'	40–50'	Medium	Dark red autumn foliage color. Intolerant of heavy or poorly drained soils.
Tilia cordata Littleleaf Linden	40'	30'	Medium	Oval to pyramidal in form; tolerates adverse city conditions.
cv. 'Chancellor' or 'Greenspire' Pyramidal Littleleaf Lindens				Uniformly pyramidal in form.
Tilia x euchlora 'Redmond' Redmond Linden	50'	40–50'	Medium	Pyramidal form; coarse lustrous foliage.
*Tilia tomentosa Silver Linden	40'	30'		Dense pyramidal form; tolerant of hot, dry conditions.

*Adapted only to southern and eastern Wisconsin

AVOID THESE TREES:

Black Locust	Subject to borers.
Boxelder	Weak wooded, female trees attract the boxelder bug.
Catalpa	Litter of flowers, fruits and leaves.
Elms	Subject to Dutch elm disease.
Poplar	Roots block sewers, weak wooded, litter of fruits.
Silver Maple	Weak wooded, buttress roots heave pavements.
Sugar Maple	Intolerant of urban conditions
Sycamore	Subject to anthracnose disease.
Willows	Roots block sewers, weak wooded, litter of twigs.
Nut bearing trees	Litter of nuts.

Plant the Right Tree in the Right Place

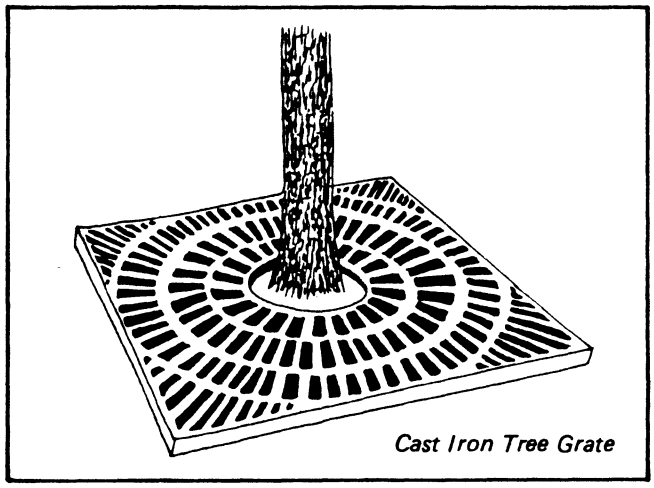
Because of space limitations, some sites are not suitable for growing a tree. Other sites can support a tree only if special provisions are made.

If the width of the area between the curb and sidewalk is less than 3 feet, the terrace probably will not accommodate a tree. If the tree does survive, it may damage the sidewalk or curb.

The distance between the planting site and an adjacent building is also an important consideration. In situations where the distance between the curb and building is less than 12 feet, only plant trees with a columnar form.

A tree planted in an opening in concrete pavement requires special attention in order to survive in this confining site. Cast iron grates placed around the tree can benefit it in several ways. The grates allow for soil aeration and reduce the chance for soil compaction by providing a surface to walk on. The grates also facilitate watering and fertilization.

The list of trees recommended in this publication for planting in Wisconsin include trees of various sizes, forms, growth rates and environmental tolerance. Those marked with asterisks are adapted only to southern and eastern Wisconsin.



Cast Iron Tree Grate

For more information on insects, diseases, the dangers posed by construction and other tree care concerns, consult the following University of Wisconsin-Extension publications:

A7791025	*Urban Forestry: Bringing the Forest to Our Communities*
A3070	*How Trees Benefit Communities*
A3066	*Landscaping for Energy Conservation*
A3071	*Dutch Elm Disease—A Lesson in Urban Forestry Planning*
A3067	*Selecting, Planting and Caring for Your Shade Trees*
A1817	*Caring for Your Established Shade Trees*
A3072	*Preserving Trees During House Construction*
A3073	*Identifying Shade Tree Problems*
A2079	*Recognizing Common Shade Tree Insects*
A7791105	*Selecting an Arborist and Other Tree Professionals*
A7791106	*How to Develop a Community Forestry Program*
A2865	*A Guide to Selecting Landscape Plants for Wisconsin*
A2392	*Dutch Elm Disease in Wisconsin*
A2842	*Homeowner's Guide to Controlling Dutch Elm Disease with Systemic Fungicides*
A1771	*Deciduous Shrubs: Pruning and Care*
A1730	*Evergreens—Planting and Care*
G1609	*Landscape Plants that Attract Birds*
A2970	*Salt Injury to Landscape Plants*
A2308	*Fertilization of Trees and Shrubs*

Please contact your county Extension agent for films, slide sets, posters and other publications about trees.

This publication is part of the urban forestry series, developed to help in the reforestation of our towns and cities struck by Dutch elm disease.

Edward R. Hasselkus is professor of horticulture, College of Agricultural and Life Sciences, University of Wisconsin-Madison and the Divison of Economic and Environmental Development, University of Wisconsin-Extension.

COOPERATIVE EXTENSION PROGRAMS

UNIVERSITY OF WISCONSIN–EXTENSION

University of Wisconsin-Extension, Gale L. VandeBerg, director, in cooperation with the United States Department of Agriculture and Wisconsin counties, publishes this information to further the purpose of the May 8 and June 30, 1914 Acts of Congress; and provides equal opportunities in employment and programming including Title IX requirements. This publication is available to **Wisconsin residents** from county Extension agents. It's available to **out-of-state purchasers** from Agricultural Bulletin Building, 1535 Observatory Drive, Madison, Wisconsin 53706. **Editors, before publicizing, should contact the Agricultural Bulletin Building to determine its availability. Order by serial number and title;** payment should include prices plus postage.

APRIL 1980

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Appendix 3. Street tree species of the 5 inventoried cities, listed by average condition class percentage.

CC%	MILWAUKEE	WAUKESHA	ST. POINT	WIS. RAPIDS	BLOOMER
84					
82			MS ASH		
80			LL LINDEN		
	BUCKEYE	SKY HONEY			
78	SI LINDEN				
	SCH NORWAY IRONWOOD				
76	NORWAY MAPLE HONEY COL NORWAY MT ASH GINKGO GREEN ASH SUGAR MAPLE H CHESTNUT	GS ASH			

CC%	MILWAUKEE	WAUKESHA	ST. POINT	WIS. RAPIDS	BLOOMER
Con't					
74	BASSWOOD				
	FAA NORWAY				
	HESSE ASH				
			WHITE ASH		
	LL LINDEN	JG NORWAY			
72	AILANTHUS				
		SM HONEY	SH CHERRY		
			NORWAY		
	HICKORY		HACKBERRY		
	BUR OAK				
70	AM ELM	COL NORWAY			
		EQ NORWAY			
		RD LINDEN			
		CH LINDEN			
	SI MAPLE	CLV NORWAY			
		HESSE ASH	HONEY		
68		MT ASH			
	WHITE ASH				
	CRAB	MS ASH			
		ENG OAK		SUGAR MAPLE	
		GS LINDEN			
		SCH NORWAY			
		RA LINDEN	GREEN ASH		

CC%	MILWAUKEE	WAUKESHA	ST. POINT	WIS. RAPIDS	BLOOMER
Con't					
66		CK NORWAY			
	RED MAPLE				
	SYCAMORE				
	WHITE OAK	MAX HONEY	POPLAR		
	BOX ELDER	NORWAY			
	SI ELM				
	ENG OAK	HACKBERRY			
		SYCAMORE			
64	RED OAK	CRAB			
				BASSWOOD	
		AMUR CORK		SCH NORWAY	
	HACKBERRY		OAK	HACKBERRY	NORWAY
	CATALPA		BASSWOOD		
62					
		PEAR			
	MO ASH				
		SUGAR MAPLE			
60	PEAR		RED MAPLE	SI MAPLE	BASSWOOD
		RED MAPLE	AM ELM		
		SUN HONEY			
		CATALPA			
		BASSWOOD			
		AM ELM	P BIRCH		
		BUR OAK			
		PIN OAK	CATALPA		RED OAK
58		SI ELM			

CC%	MILWAUKEE	WAUKESHA	ST. POINT	WIS. RAPIDS	BLOOMER
Con't					
					MS ASH
			SI MAPLE		
56		RED ELM			
			SI ELM	CATALPA	
			SUGAR MAPLE		
					SI MAPLE
		WALNUT			
54				WHITE ASH	
				EQ NORWAY	
		SI MAPLE			
		AP ASH		RED MAPLE	
52		RED OAK		AM ELM	
		WHITE ASH			EQ NORWAY
		BOXELDER			
			BOXELDER		SUGAR MAPLE
		RA ASH		LL LINDEN	
50					WHITE ASH
				SI ELM	
		WHITE OAK			HACKBERRY
					RED MAPLE
					SCH NORWAY
46					
		CHERRY			MT ASH
44		BUSI ELM			

CC%	MILWAUKEE	WAUKESHA	ST. POINT	WIS. RAPIDS	BLOOMER
Con't					
	POPLAR				AM ELM
42					
40				BOX ELDER	
		HAWTHORN			SI ELM
38					
					BOXELDER