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Title THE STREET TREE PROBLEM FOR THE PACIFIC NORTHWEST

Abstract approved Henry T. Hartman
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A regional analysis of the street tree problem has been undertaken in order to evolve a system of tree classification which would be useful to city planners, arborists, and landscape architects who have the responsibility of selecting trees to fulfil their design requirements for the city street. Three lines of approach to the problem were followed: ecological considerations, an analysis of the controlled conditions of the city environment, and a classification of the various tree characteristics which might affect their selection.

The most significant factors of environment in relation to the selection and use of trees are climate and soil. Of these, separate classifications have been made under the major headings of soil, water, temperature, light and atmosphere. An analysis of the apparent reactions of the various trees to these factors in the Pacific Northwest has been undertaken and suitable trees, from the list of 245 species and varieties, considered as possibilities for street use, have been placed in the classification.

The controlled conditions of the city environment have been considered under the headings: types of streets, street widths, building setbacks, planting strips, overhead obstructions, underground services, and building heights. Trees have been selected to suit these city factors and classified under the above headings.

The morphological and other characteristics of trees which might affect their selection for street use are: shape, size, root systems, rate of growth, longevity, resistance or susceptibility to diseases and pests, tolerance of city conditions and extremes of environment, flowering and fruiting habits, specific effects (especially seasonal effects), mass and texture. Trees have been selected to suit a classification based on these characteristics.

The punched card system of classification has been used to assemble the results of the three lines of approach to the problem, the code having been prepared from the above factors.

THE STREET TREE PROBLEM FOR THE PACIFIC NORTHWEST

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TABLE OF CONTENTS

THE STREET TREE PROBLEM FOR THE PACIFIC NORTHWEST

CHAPTER I

INTRODUCTION

Statement of the Problem

The streets of every city of the Pacific Northwest bear evidence of the fact that a street planting problem exists - the problem of selection of suitable trees and the development of a satisfactory plan for their use on the city street. Some streets are devoid of trees and could be improved by their use. Others have too many and the appearance of the city is marred by an overcrowding effect, or by the unsightly aspect of rows of large trees, which may have been trimmed to accommodate overhead wires or reduced in size to improve the views. Many streets have trees which are not suited to the climate of the Northwest, or to the restrictions of the city.

There is no easy solution to this problem. There is, however, a need for full consideration to be given to all factors of environment, both natural and artificial, since the various species and varieties of trees differ in their responses to them. The design and utility value of all possible trees must be appraised in terms of their morphological and other characteristics, which might affect their selection. The influence of the factors of environment on these characteristics must also be considered. A regional analysis of the problem has therefore been undertaken, in order to provide a guide to landscape architects, municipal arborists, city foresters, park superintendents and others, who have the task of selecting and maintaining trees on the city streets.

Definition of the Area

The Pacific Northwest, for purposes of this analysis, has been defined, roughly, as that portion of the northwest section of the United States and southwestern British Columbia which lies between the 43rd and 50th degrees of latitude and between the 117th and 124th degrees of longitude. This area includes a range of cities from Eugene, Oregon in the south to Vancouver, British Columbia, in the north and from Spokane, Washington, in the east to Victoria, British Columbia in the west.

Purpose of the Analysis

There is evidence of considerable lack of organization and planning in many of the street plantings in the Pacific Northwest cities. Few municipalities have followed any plan for selection of suitable types of trees and for their maintenance (85, p.3). As a result, many streets are lined with trees which are ill-suited to their location. This may be because they are not readily adapted to the natural and artificial conditions of their environment or because they are not of a suitable type to fulfil their function as an integral part of the design of the street.

Early settlers in the cities of the Northwest brought with them memories of the old established streets of the eastern United States and Europe. They attempted to duplicate these effects by selecting the same trees and the same arrangement of them in this district. Others chose indigenous western species for street use. Some of the imported trees proved to be unsuited to the climate, while native trees, such as <u>Acer macrophyllum</u>, were not suited to the conditions of the city. Unfortunate examples of these misfits are still common in almost every city.

With the development of city zoning regulations and the transition to faster vehicular traffic, most cities have undergone a change. Rapid traffic arteries have been constructed, commerical areas have been restricted to business purposes, usually without planting, and certain residential districts have been developed as exclusive areas, free from business and fast moving traffic.

Few cities, however, have undertaken to reorganize and control the street planting program. This would involve the removal of unsuitable species and the assumption of responsibility for installation and subsequent maintenance of better types. If each city could take complete control of its street planting, the qualified arborist, city forester, or park superintendent should be able to effect an overall improvement in the appearance of the cities, just as the city engineer is doing.

Some municipalities have attempted to remedy the situation by the introduction of small trees, particularly flowering types, into the street scene (100, pp.196-201). Small trees are more easily fitted into the available space on the narrow street, or into the remaining space when a street has been widened (29, pp.65-69) and (55, pp.26-27). Their mass is in suitable proportion to the adjacent, low contemporary architectural structures of the West Coast. They are less expensive than large trees to replace, when their span of usefulness has been completed. They usually are more short-lived, however. If their branches are low, they may interfere with traffic. They may be too small to be in proper scale with their surroundings. For these reasons, they should not be considered to represent the complete solution to the street tree problem of the Northwest, but should be given careful consideration in the attempt to find the right tree for any particular situation.

Special importance should be placed on the relation between street trees and public utility services (6, pp.70-73). The small tree is well adapted to fit under power lines. Careful consideration of the spacing and layout of the trees, however, may make it possible to use larger trees, where the design requirements are such that a larger form, or more significant mass, is called for. Larger types of trees should not be used if such drastic pruning is necessary that the natural form of the tree is sacrificed (32, pp.118-119).

Because of the proximity of many cities of the Northwest to mountains and sea, every care should be given to the preservation of views. The need for this may make it impossible to use trees on certain streets. However, more consideration should be given to the possibility of using street trees to enhance the views by the creation of vistas. This may be accomplished by careful group or block placement and wider spacing on the street. It would also obviate the practice of pollarding, sometimes followed for this purpose.

The ecological amplitude of each species and variety of tree, for street use, must also be determined, in order that a selection of trees may be made from those which should respond favorably to the various factors of environment.

The analysis of the problem, assembled in a suitable form for reference, should be of value to city planners and arborists, assisting them to select the right trees for the city streets of the Pacific Northwest. The solution of the individual problem of designing the street tree layout for any city should be accomplished by the landscape architect who, too, should find this thesis helpful.

CHAPTER II

ANALYSIS OF THE PROBLEM

The Approach to the Problem

The ecological approach to the problem consisted of a consideration of the climatic, edaphic and physiographic factors of the Pacific Northwest. Of these, five factors were selected: soil, water, temperature, light and atmosphere. Two hundred and forty five species and varieties of broadleaved trees were selected from the general list of recommended trees of Wyman, (109, pp.103-355) and considered as possibilities for street use in the Pacific Northwest. From this list, trees of known response to these environmental factors were selected.

The second approach to the problem consisted of an analysis of the artificial, or controlled, conditions of environment. These included the types of streets, their widths, the setback of buildings, size of planting strips, overhead obstructions, underground services and the height of buildings. Trees were selected according to their suitability or adaptability to these city conditions.

The final approach to the problem was to classify the trees according to their morphological (99, pp.1-90) and (46, pp.85-88) and other characteristics, which might make them suitable or unsuitable for any city situation. The specific characteristics considered were their size, shape, root system, rate of growth, longevity, their susceptibility or resistance to diseases and pests, their tolerance of extremes of environment, their flowering and fruiting habits, their specific effects (especially seasonal), their mass and texture.

The Punched Card Index System of Classification

The punched card index system of classification was selected as a means of recording all of the available information on the suggested street trees. A master code was prepared, with three major groups of headings: 1, ecological factors, 2, controlled or artificial conditions of environment, 3, morphological and other characteristics of trees. These groups were divided into a total of 24 divisions. Each division was then subdivided according to the individual factors of environment or tree characteristics. Lists of trees were prepared from the 245 suggested species and varieties for each of these subdivisions. The information, thus assembled, was transferred to the card index system. The system of nomenclature of Rehder (73, p.xi) was followed for all trees in the classification.

A set of coded cards was prepared, one for each factor or characteristic. The trees which had been selected for that factor or characteristic were listed on the card.

The set of cards was designed to be useful to the arborist who might be looking for suitable trees for a certain set of conditions. A "dial" would release all of the cards bearing the names of trees which suited each condition. By dialing for each of the factors and desired characteristics, trees, which should be ideally suited to his set of conditions, could be found quickly.

Master Code

Summary of Divisions - Divisions 1 to 5, Ecological Factors; Divisions 6 to 12, Controlled or Artificial Conditions of Environment; Divisions 13 to 24, Morphological and Other Characteristics of Trees.

List of Divisions

1 - The Edaphic Factor
2 - The Water Factor
3 - The Temperature Factor
4 - The Light Factor
5 - The Atmospheric Factor
6 - Types of Streets
7 - Street Widths
8 - Building Setbacks
9 - Planting Strips
10 - Overhead Obstructions
11 - Underground Services
12 - Building Heights
13 - Tree Size
14 - Tree Shape
15 - Root Structure
16 - Rate of Growth
17 - Longevity
18 - Diseases and Pests
19 - Tolerance
20 - Flowering Habits
21 - Fruiting Habits
22 - Specific Effects
23 - Mass
24 - Textures

<u>Division 1 - The Edaphic Factor</u> - Selection of trees in relation to their suitability or adaptability to the various soil conditions.

1.0 General
1.1 Favoring clay and clay loam
1.2 Favoring medium loam
1.21 Favoring shallow medium loam
1.22 Favoring deep medium loam
1.3 Favoring sandy or gravelly loam
1.31 Favoring shallow sandy or gravelly loam
1.32 Favoring deep sandy or gravelly loam
1.4 Indifferent as to soil type
1.5 pH preference
1.51 Favoring acid soil
1.52 Favoring alkaline soil
1.6 Requiring well drained soil
1.7 Withstanding poor drainage conditions

<u>Division 2 - The Water Factor</u> - Selection of trees in relation to their suitability or adaptability to the various natural moisture conditions.

2.0 General
2.1 Rainfall
2.11 Favoring low rainfall area (less than 25 inches per year)
2.12 Favoring medium rainfall area (25 to 40 inches per year)
2.13 Favoring high rainfall area (over 40 inches per year)
2.2 Seasonal aspects of moisture
2.21 Favoring a "dry summer" area
2.22 Favoring a "summer rainfall" area
2.23 Favoring a "winter rainfall" area
2.24 Trees with special spring moisture requirements
2.25 Trees indifferent to seasonal moisture conditions
2.3 Snowfall
2.31 Favoring areas with only occasional light snow
2.32 Favoring or withstanding conditions of non-persistent heavy snowfall
2.33 Favoring or withstanding conditions or persistent heavy annual snowfall

2.4 Humidity during growing season
2.41 Favoring high humidity
2.42 Favoring low humidity
2.5 Ice conditions
2.51 Withstanding ice storms
2.52 Susceptible to damage from ice storms

Division 3 - The Temperature Factor - Selection of trees in relation to their suitability or adaptability to the various conditions of natural temperature.

3.0 General
3.1 Temperature Zones
3.11 Limit of Zone 9
3.12 Limit of Zone 8
3.13 Limit of Zone 7
3.14 Limit of Zone 6
3.15 Limit of Zone 5
3.16 Limit of Zone 4
3.17 Limit of Zone 3 and under
3.2 Requiring over 200 annual frost-free days for growing period
3.3 Summer maximums
3.31 Withstanding over 100° F maximums
3.32 Favoring 80° to 100° F maximums
3.33 Favoring maximum temperatures of less than 80° F

Division 4 - The Light Factor - Selection of trees in relation to their suitability or adaptability to the various conditions of daylight.

4.0 General
4.1 Intensity
4.11 Favoring full sunlight
4.12 Favoring partial shade
4.2 Daylength
4.21 "Short-day" species
4.22 "Long-day" species

Division 5 - The Atmospheric Factor - Selection of trees in relation to their suitability or adaptability to various atmospheric conditions.

5.0 General
5.1 Prevailing winds
5.11 Trees which exhibit growth abnormalities as a result of consistent exposure to winds
5.12 Trees not affected in habit of growth by prevailing winds
5.2 Storms
5.21 Subject to mechanical injury from wind storms
5.22 Not subject to mechanical injury from wind storms
5.3 Needing protection from winds

Division 6 - Types of Streets - Selection of trees in relation to the type of street, as determined by use or by zoning regulation.

6.0 General
6.1 Residential streets
6.11 Areas restricted to one-family dwellings
6.12 Multiple-family areas
6.2 Business and industrial streets
6.3 Highway entrances
6.4 Divided boulevards

Division 7 - Street Widths - Lists of trees suitable for streets of various widths.

7.0 General
7.1 20 foot roadway
7.2 25 foot roadway
7.3 30 foot roadway
7.4 40 foot roadway
7.5 Over 40 foot roadway

Division 8 - Building Setbacks - Selection of trees in relation to the regulations for setback of buildings (feet from the roadway).

8.0 General
8.1 Under 20 feet
8.2 20 to 30 foot building line
8.3 31 to 40 foot building line
8.4 Building setback of more than 40 feet

Division 9 - Planting Strips - Selection of trees in relation to the width of the planting strip, (area between roadway and sidewalk).

9.0 General
9.1 4 to 6 foot strip
9.2 8 foot strip
9.3 10 foot strip
9.4 12 foot strip
9.5 Over 12 foot strip

Division 10 - Overhead Obstructions - Selection of trees in relation to overhead obstructions.

10.0 General
10.1 Streets with lines and cables 25 to 35 feet high
10.2 Streets with lines and cables 35 to 50 feet high
10.3 Streets with trolly wires only

Division 11 - Underground Services - Selection of trees in relation to underground services.

11.0 General
11.1 Streets with shallow sewers
11.2 Streets with deep sewers
11.3 Trees to keep away from all sewers, septic tank tile beds, footing drains, etc.

Division 12 - Building Heights - Selection of trees in relation to the height of buildings.

12.0 General
12.1 One-story buildings
12.11 City residential streets
12.12 Suburban residential streets
12.2 Two-story buildings
12.21 City residential streets
12.22 Suburban residential streets
12.3 Streets with multiple-storied buildings

<u>Division 13 - Tree Size</u> - Lists of trees selected according to ultimate size.

13.0	General
13.1	Height
13.11	Over 60 feet
13.12	40 to 60 feet
13.13	25 to 39 feet
13.14	15 to 24 feet
13.15	Less than 15 feet
13.2	Spread
13.21	Over 60 feet
13.22	40 to 60 feet
13.23	25 to 39 feet
13.24	15 to 24 feet
13.25	Less than 15 feet

<u>Division 14 - Tree Shape</u> - Lists of trees selected according to natural habit of growth.

14.0	General
14.1	Rounded-globose
14.2	Tall oval
14.3	Flat oval
14.4	Pyramidal
14.5	Columnar
14.6	Weeping
14.7	Horizontal branching
14.8	Tall open

<u>Division 15 - Root Structure</u> - Lists of trees selected according to habit of root growth.

15.0	General
15.1	Fibrous
15.11	Fibrous, widespreading
15.12	Fibrous, concentrated
15.2	Non-fibrous
15.21	Non-fibrous, shallow
15.22	Non-fibrous, tap rooted

<u>Division 16 - Rate of Growth</u> - Lists of trees selected according to their rate of growth in their first ten years after planting.

16.0 General
16.1 Rapid (over 2 feet per year, first ten years)
16.2 Medium (1 to 2 feet per year, first ten years)
16.3 Slow (less than 1 foot per year, first ten years)

Division 17 - Longevity - Lists of trees selected according to their normal life expectancy or span of usefulness.

17.0 General
17.1 100 years or more
17.2 60 to 99 years
17.3 40 to 59 years
17.4 Less than 40 years

Division 18 - Diseases and Pests - Selection of trees with special consideration for their resistance or susceptibility to disease and insect infestations.

18.0 General
18.1 Disease susceptibility or resistance
18.11 Subject to virus infection
18.12 Subject to fungus infection
18.13 Subject to bacterial infection
18.14 Not subject to serious disease
18.2 Insect attack
18.21 Subject to aphis infestation
18.22 Subject to borers
18.23 Subject to foliage injury from insects
18.24 Subject to mites
18.25 Subject to scale attack
18.26 Not subject to serious insect troubles
18.3 Susceptible trees satisfactory for use with moderate control measures

Division 19 - Tolerance - Selection of trees in relation to their tolerance of smoke and gas, shade, transplanting, salt in the atmosphere, extreme pH, drought.

19.0 General
19.1 Smoke and gas
19.11 Susceptible to injury from city smoke and gas
19.12 Tolerant to city conditions

19.2 Tolerant of shade
19.3 Transplanting
19.31 Trees which transplant readily at any age
19.32 Trees which must be established in seedling stage
19.33 Trees difficult to transplant at useful size
19.4 Tolerant of salt spray
19.5 Tolerant of extremes in pH
19.51 Tolerant of acidity
19.52 Tolerant of alkalinity
19.6 Tolerant of drought

Division 20 - Flowering Habits - Selection of trees according to season, color and type of inflorescence.

20.0 General
20.1 Season of bloom
20.11 January - February
20.12 March - April
20.13 May - June
20.14 Summer months
20.15 Autumn
20.2 Color of bloom
20.21 White
20.22 Pink
20.23 Red
20.24 Mauve and purple
20.25 Yellow
20.3 Type of inflorescence
20.31 Solitary, single
20.32 Solitary, double
20.33 Flowers in multiple heads

Division 21 - Fruiting Habits - Selection of trees according to fruit persistence, desirability and color.

21.0 General
21.1 Persistence
21.11 Persistent, desirable
21.12 Persistent, objectionable
21.13 Non-persistent, desirable
21.14 Non-persistent, objectionable
21.2 Color of fruit
21.21 Red
21.22 Yellow or orange
21.23 Blue
21.24 Black

21.3 Dioecious trees
21.4 Trees which bear fruit at early age

<u>Division 22 - Specific Effects</u> - Selection of trees according to specific effects: bark, foliage colors, persistence of foliage, seasonal change.

22.0 General
22.1 Interesting bark
22.2 Interesting branching habit
22.3 Interesting foliage
22.31 Foliage light green
22.32 Foliage grey-green
22.33 Foliage blue, purple or copper colored
22.34 Foliage especially glossy
22.35 Foliage especially dull
22.4 Foliage persistence
22.41 Half-evergreen
22.42 Evergreen
22.5 Seasonal effects
22.51 Striking foliage colors in the Spring
22.52 Yellow autumn color
22.53 Orange-red autumn color
22.54 Bronze autumn color
22.55 Purple autumn color
22.6 Variegated foliage

<u>Division 23 - Mass</u> - Trees classified according to their effect of mass.

23.0 General
23.1 Heavy mass
23.2 Medium mass
23.3 Light mass

<u>Division 24 - Texture</u> - Trees classified according to texture.

24.0 General
24.1 Coarse texture
24.2 Medium texture
24.3 Fine texture

Coded Lists of Trees

Division 1 - The Edaphic Factor

1.1 Favoring clay and clay loam

Alnus spp. and vars.
Betula spp.
Carya Pecan
Fagus grandifolia
Gleditsia triacanthos
Kalopanax pictus
Liquidambar Styraciflua
Liriodendron Tulipifera
Malus spp. and vars.
Nyssa sylvatica
Platanus orientalis
Quercus agrifolia

1.21 Favoring shallow medium loam

Amelanchier spp.
Ulmus spp.

1.22 Favoring deep medium loam

Acer spp.
Aesculus spp.
Catalpa spp.
Cercidiphyllum japonicum
Cladrastis lutea
Kalopanax pictus
Phellodendron amurense
Platanus spp.
Quercus borealis
Quercus palustris
Stewartia spp.
Zelkova serrata

1.31 Favoring shallow sandy or gravelly loam

Albizzia julibrissin
Arbutus Menziesii
Celtis australis
Corylus Colurna
Ostrya virginiana
Quercus Carryana
Quercus Kelloggii
Quercus montana
Styrax japonica

1.32 Favoring deep sandy or gravelly loam

Carya glabra
Cercis spp.
Cornus florida
Cornus mas
Crataegus crus-galli
Davidia involucrata
Diospyros virginiana
Fagus sylvatica
Halesia monticola
Magnolia spp.
Malus baccata
Prunus spp.
Quercus coccinea
Quercus Kelloggii
Robinia Pseudoacadia
Sassafras albidum
Sophora japonica
Ulmus parvifolia

1.4 Indifferent as to soil type

Acer Ginnala
Acer saccharum
Ailanthus altissima erythrocarpa
Amelanchier spp.
Aralia elata
Celtis spp.
Chioanthus virginicus
Cladrastis lutea
Cornus spp.
Crataegus Phaenopyrum
Davidia involucrata
Euonymus spp.
Ginkgo biloba
Gleditsia triancanthos
Koelreuteria paniculata
Laburnum watereri
Lagerstroemia indica
Ligustrum lucidum
Malus spp. and vars.
Magnolia virginiana
Phellodendron Lavallei
Robinia Pseudoacacia
Sorbus spp.
Tilia spp.
Ulmus spp.

1.51 Favoring acid soil

Arbutus Menziesii
Arbutus Unedo
Clethra spp.
Franklinia alatamaha
Halesia monticola
Liquidambar Styraciflua
Magnolia grandiflora
Nyssa sylvatica
Oxydendrum arboreum
Quercus palustris
Stewartia koreana
Stewartia Pseudocamellia
Styrax japonica

1.52 Favoring alkaline soil

Albizzia julibrissin
Cornus mas
Fagus spp.
Franklinia alatamaha
Fraxinus velutina
Sorbus spp.

1.6 Requiring well-drained soil

Acer campestre
Acer palmatum
Arbutus Menziesii
Carya spp.
Celtis spp.
Cercidiphyllum japonicum
Cercis spp.
Cladrastis lutea
Clethra barbinervis
Clethra Delavayi
Crataegus spp.
Davidia involucrata
Diospyros virginiana
Franklinia alatamaha
Ginkgo biloba
Halesia spp.
Juglans spp.
Magnolia spp.
Oxydendrum arboreum
Prunus spp.
Quercus spp.
Sorbus spp.
Ulmus spp.
Zelkova serrata

1.7 Withstanding poor drainage conditions

Acer circinatum
Acer rubrum
Alnus spp.
Carya Pecan
Lagerstroemia indica
Liquidambar Styraciflua
Magnolia virginiana
Nyssa sylvatica
Quercus bicolor
Quercus palustris
Sassafras albidum

Division 2 - The Water Factor

2.11 Favoring low rainfall area (less than 25 inches per year)

Celtis australis
Fraxinus velutina

2.12 Favoring medium rainfall area (25 to 40 inches per year)

Acer circinatum
Acer rubrum
Arbutus Menziesii
Betula nigra
Carpinus caroliniana
Catalpa spp.
Cerdidiphyllum japonicum
Cornus spp.
Franklinia alatamaha
Fraxinus pennsylvanica lanceolata
Kalopanax pictus
Liquidambar Styraciflua
Nyssa sylvatica
Quercus borealis
Quercus palustris
Robinia Pseudoacacia
Tilia spp.
Ulmus americana

2.13 Favoring high rainfall area (over 40 inches per year)

Alnus spp.
Halesia monticola
Laburnum watereri

2.21 Favoring a "dry summer" area

Arbutus Menziesii
Catalpa speciosa
Cercis spp.
Cornus Nuttallii
Corylus Colurna
Fraxinus velutina
Lagerstroemia indica
Phellodendron amurense
Quercus Garryana
Quercus Kelloggii

2.22 Favoring a "summer rainfall" area

Acer Ginnala
Acer palmatum
Crataegus spp.
Franklinia alatamaha
Kalopanax pictus
Lagerstroemia indica
Tilia spp.

2.23 Favoring "winter rainfall" area

Alnus glutinosa
Alnus rubra
Arbutus Menziesii
Arbutus Unedo
Cornus spp.

2.24 Trees with special spring moisture requirements

Franklinia alatamaha
Halesia monticola
Styrax japonica

2.25 Trees indifferent to seasonal moisture conditions

Ailanthus altissima erythrocarpa
Chionanthus virginicus

2.31 Favoring areas with only occasional light snow

Quercus robur

2.32 Favoring or withstanding conditions of non-persistent heavy snowfall

Acer platanoides Schwedleri
Ulmus spp.

2.33 Favoring or withstanding conditions of persistent heavy annual snowfall

Acer platanoides
Acer saccharum
Ailanthus altissima
Ailanthus altissima erythrocarpa
Catalpa spp.
Celtis spp.
Ginkgo biloba
Gleditsia triacanthos
Phellodendron amurense
Tilia spp.
Zelkova serrata

2.41 Favoring high humidity

Alnus spp.
Cornus spp.
Crataegus spp.
Halesia monticola
Laburnum watereri
Magnolia grandiflora
Prunus lusitanica
Umbellularia californica

2.42 Favoring low humidity

Ailanthus altissima
Celtis spp.
Fraxinus Ornus
Fraxinus velutina
Gleditsia triacanthos
Koelreuteria paniculata
Robinia Pseudoacacia
Ulmus pumila

2.51 Withstanding ice storms

Acer saccharum
Carpinus Betulus
Crataegus spp.
Fagus spp.
Ginkgo biloba
Gymnocladus dioicus
Juglans nigra
Nyssa sylvatica
Quercus spp.
Zelkova sp.

2.52 Susceptible to damage from ice storms

Acer rubrum
Acer saccharinum
Ailanthus altissima erythrocarpa
Cercis canadensis
Evodia Daniellii
Fraxinus spp.
Gleditsia triacanthos inermis
Koelreuteria paniculata
Populus spp.
Salix spp.
Tilia spp.
Ulmus spp.

Division 3 - The Temperature Factor

3.11 Limit of Zone 9

Acer floridanum

3.12 Limit of Zone 8

Arbutus Unedo
Cornus capitata

3.13 Limit of Zone 7

Albizzia julibrissin
Arbutus Menziesii
Cercis racemosa
Clethra Delavayi
Cornus Nuttallii
Fraxinus velutina
Lagerstroemia indica
Ligustrum lucidum
Magnolia grandiflora
Platanus racemosa
Prunus lusitanica
Quercus chrysolepis
Quercus Kelloggii
Quercus laurifolia
Quercus virginiana
Umbellularia californica

3.14 Limit of Zone 6

Acer macrophyllum
Celtis australis
Cercis chinensis
Cercis Siliquastrum
Cornus macrophylla
Davidia involucrata
Fraxinus oregona
Laurus nobilis
Platanus orientalis
Prunus Mume
Prunus Sargentii vars.
Quercus Garryana
Ulmus alata

3.15 Limit of Zone 5

Acer argutum
Acer carpinifolium
Acer circinatum
Acer griseum
Acer nikoense
Acer palmatum
Acer Pseudoplatanus
Betula albo-sinensis
Betula mandshurica szechuanica
Betula populifolia
Carpinus Betulus
Carpinus Betulus fastigiata
Carya Pecan
Celtis Bungeana
Celtis jessoensis
Celtis laevigata
Clethra barbinervis
Cornus controversa
Cornus Kousa
Cornus officinalis
Crataegus coccinioides
Crataegus pinnatifida major
Euonymus latifolia
Euonymus sanguinea
Evodia Daniellii
Franklinia alatamaha
Fraxinus Ornus
Halesia monticola
Koelreuteria paniculata
Laburnum Watereri
Magnolia cordata
Magnolia denudata
Magnolia salicifolia
Magnolia Soulangeana
Magnolia stellata
Malus Halliana Parkmanii
Malus toringoides
Platanus acerifolia
Prunus blireiana
Prunus Hally Jolivette
Prunus nipponica
Prunus Sargentii vars.
Prunus subhirtella
Prunus yedoensis
Quercus Phellos
Quercus robur

Sorbus alnifolia
Sorbus Folgneri
Stewartia koreana
Styrax japonica
Tilia euchlora
Ulmus parifolia
Ulmus procera
Zelkova serrata

3.16 Limit of Zone 4

Acer campestre
Acer mandshuricum
Acer platanoides Schwedleri
Acer tataricum
Ailanthus altissima erythrocarpa
Alnus rubra
Amelanchier canadensis
Amelanchier grandiflora
Amelanchier laevis
Carya spp.
Castanea spp.
Catalpa spp.
Cerdidiphyllum japonicum
Cercis canadensis
Chionanthus virginicus
Cornus florida
Cornus mas
Corylus Colurna
Crataegus arnoldiana
Crataegus crus-galli
Crataegus Lavallei
Crataegus mollis
Crataegus monogyna
Crataegus nitida
Crataegus Oxyacantha
Crataegus Phaenopyrum
Crataegus pruinosa
Crataegus punctata
Crataegus viridis
Diospyros virginiana
Fagus sylvatica vars.
Ginkgo biloba
Gleditsia triacanthos
Gymnocladus dioicus
Halesia carolina
Kalopanax pictus
Laburnum alpinum
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia acuminata
Magnolia Loebneri
Malus arnoldiana
Malus Bob White
Malus Cowichan
Malus Dawsoniana
Malus floribunda
Malus hupehensis
Malus magdeburgensis
Malus micromalus
Malus purpurea vars.
Nyssa sylvatica
Ostrya virginiana
Oxydendrum arboreum
Prunus Maximowiczii
Prunus Sargentii
Quercus alba
Quercus borealis
Quercus coccinea
Quercus montana
Quercus palustris
Sassafras albidum
Sophora japonica
Syringa amurensis japonica
Ulmus carpinifolia vars.
Ulmus glabra
Ulmus pumila

3.17 Limit of Zone 3 and under

Acer Ginnala
Acer pennsylvanicum
Acer platanoides
Acer rubrum
Acer saccharum
Aesculus carnea Briotii
Aesculus Hippocastanum Baumannii

Aesculus octandra
Alnus glutinosa
Aralia elata
Betula papyrifera
Betula pendula
Betula pendula fastigiata
Cladrastis lutea
Crataegus succulenta
Euonymus europaea vars.
Fagus grandifolia
Fraxinus americana
Fraxinus excelsior lanceolata
Malus baccata
Malus ionensis plena
Malus prunifolia Rinki
Phellodendron amurense
Prunus avium plena
Prunus cerasifera atropurpurea
Robinia Pseudoacacia
Sorbus aucuparia
Tilia cordata
Tilia europaea
Ulmus avericana

3.2 Requiring over 200 annual frost-free days for growing period

Cercidiphyllum japonicum
Phellodendron amurense
Prunus cerasifera atropurpurea

3.31 Withstanding over 100° F. maximums

Ailanthus altissima erythrocarpa
Carya Pecan
Catalpa speciosa
Celtis australis
Fraxinus velutina
Lagerstroemia indica
Phellodendron amurense
Robinia Pseudoacacia
Sophora japonica
Zelkova serrata

3.32 Favoring 80° - 100° F. maximums

Acer platanoides
Acer rubrum

3.33 Favoring maximum temperatures of less than 80° F.

Acer platanoides Schwedleri
Acer saccharum
Arbutus Menziesii
Cercidiphyllum japonicum

Division 4 - The Light Factor

4.11 Favoring full sunlight

Acer circinatum
Acer Pseudoplatanus
Amelanchier spp.
Cercis spp.
Chionanthus virginicus
Cladrastis lutea

Crataegus Phaenopyrum
Davidia involucrata
Euonymus spp.
Franklinia alatamaha
Gleditsia triacanthos
Koelreuteria paniculata
Lagerstroemia indica
Liquidambar Styraciflua
Malus spp. and vars.
Oxydendrum arboreum
Prunus avium plena
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus Mume vars.
Prunus serrulata vars.
Prunus subhirtella
Prunus yedoensis
Sophora japonica

4.12 Favoring partial shade

Acer palmatum
Aralia elata
Oxydendrum arboreum
Stewartia spp.
Styrax japonica

4.21 "Short-day" species

no trees selected

4.22 "Long-day" species

no trees selected

5.11 Trees which exhibit growth abnormalities as a result of consistent exposures to winds

Aesculus spp.
Cercidiphyllum japonicum
Liquidambar Styraciflua

5.12 Trees not affected in habit of growth by prevailing winds

Acer rubrum
Acer saccharum
Ailanthus altissima erythrocarpa
Celtis spp.

5.21 Subject to mechanical injury from wind storms

Acer saccharinum
Ailanthus altissima erythrocarpa
Albizzia julibrissin
Carya spp.
Crataegus Phaenopyrum
Evodia Daniellii
Fraxinus spp.
Gleditsia triacanthos
Koelreuteria paniculata
Lagerstroemia indica
Liriodendron Tulipifera

Populus spp.
Quercus laurifolia
Robinia Pseudoacacia
Salix spp.
Sassafras albidum
Ulmus spp.

5.22 Not subject to mechanical injury from wind storms

Acer spp.
Betula spp.
Carpinus Betulus
Celtis spp.
Cladrastis lutea
Ginkgo biloba
Juglans nigra
Kalopanax pictus
Liquidambar Styraciflua
Liriodendron Tulipfera
Nyssa sylvatic
Quercus spp.
Tilia spp.

5.3 Needing protection from winds

Magnolia grandiflora

Division 6 - Types of Streets

6.11 Areas restricted to one-family dwellings

Acer argutum
Acer campestre
Acer carpinifolium
Acer circinatum
Acer Ginnala
Acer griseum
Acer mandshuricum
Acer tataricum
Amelanchier grandiflora
Amelanchier laevis
Albizzia julibrissin
Arbutus Unedo
Carpinus caroliniana
Carpinus Betulus fastigiata
Carpinus Betulus globosa
Cercis spp.
Chionanthus virginicus
Clethra spp.
Cornus Kousa
Cornus mas
Crataegus arnoldiana
Crataegus coccinioides
Crataegus crus-galli
Crataegus Lavallei
Crataegus mollis
Crataegus monogyna and vars.
Crataegus nitida
Crataegus Oxyacantha and vars.
Crataegus Phaenopyrum
Crataegus pinnatifida major
Crataegus pruinosa
Crataegus punctata
Crataegus succulenta
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Franklinia alatamaha
Fraxinus Ornus
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Lagerstroemia indica
Laurus nobilis
Ligustrum lucidum
Magnolia cordata
Magnolia salicifolia
Magnolia Soulangeana

- Magnolia stellata
- Malus arnoldiana
- Malus "Bob White"
- Malus floribunda
- Malus Halliana Parkmanii
- Malus hupehensis
- Malus magdeburgensis
- Malus micromalus
- Malus prunifolia Rinki
- Malus purpurea Lemoinei
- Malus toringoides
- Prunus blireiana
- Prunus cerasifera atropurpurea
- Prunus "Hally Jolivette"
- Prunus Mume
- Prunus nipponica
- Prunus serrulata vars.
- Prunus subhirtella vars.
- Sorbus Folgneri
- Styrax japonica
- Stewartia koreana
- Syringa amurensis japonica

6.12 Multiple-family areas

- Acer nikoense
- Acer pennsylvanicum
- Amelanchier canadensis
- Betula spp.
- Carpinus Betulus
- Carpinus japonica
- Catalpa bignonioides
- Cercidiphyllum japonicum
- Cladrastis lutea
- Cornus florida
- Cornus macrophylla
- Corylus Colurna
- Diospyros virginiana
- Fraxinus oregona
- Fraxinus pennsylvanica lanceolata
- Fraxinus velutina
- Ginkgo biloba fastigiata
- Gleditsia triacanthos inermis 'Moraine'
- Halesia monticola
- Kalopanax pictus
- Liriodendron Tulipifera fastigiatum
- Magnolia denudata
- Magnolia Loebneri
- Malus baccata
- Malus 'Cowichan'
- Malus Dawsoniana
- Nyssa sylvatica
- Ostrya virginiana
- Prunus lusitanica
- Prunus Maximowiczii
- Prunus yedoensis
- Quercus borealis
- Quercus chrysolepis
- Quercus Phellos
- Sophora japonica
- Sorbus alnifolia
- Sorbus aucuparia
- Tilia cordata
- Tilia euchlora
- Tilia europaea
- Ulmus alata
- Ulmus carpinifolia sarniensis
- Ulmus carpinifolia umbraculifera
- Ulmus parvifolia

6.2 Business and industrial streets

- Ailanthus altissima erythrocarpa
- Aralia elata
- Arbutus Menziesii
- Carpinus Betulus
- Ginkgo biloba
- Gleditsia triacanthos
- Prunus Sargentii columnaris
- Quercus borealis
- Quercus chrysolepis
- Quercus laurifolia

Quercus robur fastigiata
Sophora japonica
Sorbus spp.
Tilia cordata
Tilia euchlora
Tilia europaea
Ulmus procera
Zelkova serrata

6.3 Highway Entrances

Acer macrophyllum
Acer platanoides
Acer Pseudoplatanus
Acer rubrum
Acer saccharum
Amelanchier canadensis
Arbutus Menziesii
Betula spp.
Carya spp.
Catalpa speciosa
Celtis spp.
Cercis spp.
Chionanthus virginicus
Cladrastis lutea
Cornus controversa
Cornus florida
Cornus macrophylla
Cornus Nuttallii
Crataegus spp.
Fagus grandifolia
Fagus sylvatica and vars.
Fraxinus americana
Fraxinus excelsior
Gleditsia triacanthos
Gymnocladus dioicus
Liriodendron Tulipifera
Liquidambar Styraciflua
Magnolia acuminata
Nyssa sylvatica
Oxydendrum arboreum
Platanus acerifolia
Platanus orientalis
Prunus avium plena
Prunus Sargentii
Prunus yedoensis
Quercus alba
Quercus Garryana
Quercus Kelloggii
Quercus palustris
Quercus robur
Quercus virginiana
Robinia Pseudoacacia
Sassafras albidum
Sophora japonica
Ulmus americana
Ulmus glabra
Umbellularia californica

6.4 Divided Boulevards

Acer nikoense
Acer platanoides
Acer Pseudoplatanus
Acer rubrum
Acer saccharum
Carya spp.
Catalpa speciosa
Cerdidiphyllum japonicum
Cornus Nuttallii
Davidia involucrata
Ginkgo biloba
Kalopanax pictus
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia grandiflora
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Prunus avium plena
Quercus alba
Quercus borealis
Quercus coccinea
Quercus palustris
Quercus virginiana
Sassafras albidum
Sophora japonica
Ulmus americana
Ulmus glabra
Ulmus procera

Division 7 - Street Widths

7.1 20 foot roadway

Acer argutum
Acer circinatum
Acer Ginalla
Acer griseum
Acer palmatum
Acer platanoides columnare
Acer saccharum monumentale
Aralia elata
Arbutus Unedo
Carpinus Betulus fastigiata
Carpinus Betulus globosa
Cercis spp.
Cornus Kousa
Cornus mas
Crataegus coccinioides
Crataegus Lavallei
Crataegus Oxyacantha and vars.
Crataegus pinnatifida major
Crataegus pruinosa
Crataegus succulenta
Crataegus monogyna stricta
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Ginkgo biloba fastigiata
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Lagerstroemia indica
Laurus mobilis
Ligustrum lucidum
Magnolia cordata
Magnolia salicifolia
Magnolia Soulangeana
Magnolia stellata
Malus arnoldiana
Malus 'Bob White'
Malus Halliana Parkmanii
Malus hupehensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Prunus blireiana
Prunus 'Hally Jolivette'
Prunus nipponica
Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Gyoike'
Prunus serrulata 'Jo-nioi'
Prunus serrulata 'Shogetsu'
Prunus serrulata 'Taki-nioi'
Quercus robur fastigiata
Sorbus aucuparia fastigiata
Stewartia koreana
Styrax japonica

7.2 25 foot roadway

Acer argutum
Acer carpinifolium
Acer mandshuricum
Acer pennsylvanicum
Acer platanoides columnare
Acer platanoides laciniatum
Acer saccharum monumentale
Acer tataricum
Amelanchier grandiflora
Albizzia julibrissin
Carpinus caroliniana
Catalpa bignonioides
Chionanthus virginicus

Clethra spp.
Cornus officinalis
Crataegus arnoldiana
Crataegus crus-galli
Crataegus mollis
Crataegus monogyna
Crataegus nitida
Crataegus Phaenopyrum
Crataegus punctata
Crataegus viridis
Franklinia alatamaha
Fraxinus Ornus
Fraxinus velutina
Malus floribunda
Malus magdeburgensis
Prunus cerasifera atropurpurea
Prunus Maximowiczii
Prunus Mume
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Prunus subhirtella
Prunus subhirtella autumnalis
Sorbus Folgneri
Syringa amurensis japonica

7.3 30 foot roadway

Acer carpinifolium
Acer mandshuricum
Acer nikoense
Acer pennsylvanicum
Acer platanoides columnare
Acer platanoides erectum
Acer platanoides laciniatum
Acer rubrum columnare
Acer saccharum monumentale
Amelanchier canadensis
Amelanchier laevis
Carpinus japonica
Cornus florida
Davidia involucrata
Fraxinus pennsylvanica lanciolata
Halesia monticola
Liriodendron Tulipifera fastigiatum
Magnolia denudata
Magnolia Loebneri
Malus baccata
Malus 'Cowichan' (Rosybloom)
Malus Dawsoniana
Ostrya virginiana
Oxydendrum arboreum
Phellodendron amurense
Prunus avium plena
Prunus lusitanica
Prunus yedoensis
Quercus chrysolepis
Quercus Phellos
Sorbus aucuparia
Ulmus alata
Ulmus carpinifolia sarniensis
Ulmus carpinifolia umbraculifera

7.4 40 foot roadway

Acer nikoense
Acer platanoides and vars.
Acer Pseudoplatanus and vars.
Acer rubrum

Acer saccharum
Ailanthus altissima erythrocarpa
Arbutus Menziesii
Carpinus Betulus
Celtis spp.
Cercidiphyllum japonicum
Cladrastis lutea
Cornus controversa
Cornus Nuttallii
Corylus Colurna
Diospyros virginiana
Fraxinus oregona
Ginkgo biloba
Gleditsia triacanthos
Kalopanax pictus
Magnolia acuminata
Magnolia grandiflora
Nyssa sylvatica
Prunus Sargentii
Quercus borealis
Quercus coccinea
Quercus laurifolia
Robinia Pseudoacacia
Robinia Pseudoacacia inermis
Sassafras albidum
Sophora japonica
Sorbus alnifolia
Tilia cordata
Tilia euchlora
Ulmus parvifolia
Ulmus pumila
Zelkova serrata

7.5 Over 40 foot roadway

Acer platanoides and vars.
Acer Pseudoplatanus and vars.
Acer rubrum and vars.
Acer saccharum and vars.
Carya spp.
Catalpa speciosa
Fagus grandifolia
Fagus sylvatica and vars.
Fraxinus americana
Fraxinus excelsior
Liquidambar Styraciflua
Liriodendron Tulipifera
Platanus acerifolia
Platanus orientalis
Quercus alba
Quercus Garryana
Quercus Kelloggii
Quercus palustris
Quercus robur
Quercus virginiana
Tilia europaea
Ulmus americana
Ulmus glabra
Ulmus procera

Division 8 - Building setbacks

8.1 Under 20 feet

Acer argutum
Acer palmatum and vars.
Acer platanoides columnare
Acer saccharum monumentale
Acer tataricum
Arbutus Unedo
Carpinus Betulus fastigiata
Cornus Kousa
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Ginkgo biloba fastigiata
Halesia carolina
Laburnum alpinum
Laburnum Watereri
Lagerstroemia indica
Laurus nobilis
Ligustrum lucidum
Magnolia salicifolia

Magnolia stellata
Malus arnoldiana
Malus 'Bob White' (zumi)
Malus Halliana Parkmanii
Malus Hupehensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Prunus 'Hally Jolivette'
Prunus nipponica
Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Gyoiko'
Prunus serrulata 'Jo-nioi'
Prunus serrulata 'Shogetsu'
Prunus serrulata 'Taki-nioi'
Quercus robur fastigiata
Sorbus aucuparia fastifiata
Sorbus Folgneri
Styrax japonica
Stewartia koreana
Ulmus americana ascendens
Ulmus avericana columnaris

8.2 20 to 30 foot building line

Acer argutum
Acer carpinifolium
Acer circinatum
Acer Ginnala
Acer griseum
Acer mandshuricum
Acer platanoides columnare
Acer platanoides erectum
Acer platanoides laciniatum
Acer saccharum monumentale
Acer spicatum
Acer tataricum
Ailanthus altissima erythrocarpa
Amelanchier canadensis
Albizzia julibrissin
Carpinus Betulus globosa
Cercis spp.
Chionanthus virginicus
Clethra spp.
Cornus florida
Cornus mas
Cornus officinalis
Crataegus spp.
Franklinia alatamaha
Fraxinus velutina
Koelreuteria paniculata
Liriodendron Tulipifera fastigiatum
Magnolia cordata
Magnolia Soulangeana
Malus Dawsoniana
Malus floribunda
Malus magdeburgensis
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus Mume
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Prunus subhirtella
Sorbus aucuparia
Syringa amurensis japonica
Ulmus carpinifolia sarniensis
Ulmus carpinifolia umbraculifera

8.3 31 to 40 foot building line

- Acer campestre
- Acer carpinifolia
- Acer mandshuricum
- Acer pennsylvanicum
- Acer platanoides erectum
- Acer platanoides globosum
- Acer platanoides laciniatum
- Acer rubrum columnare
- Acer saccharum
- Acer tataricum
- Amelanchier grandiflora
- Amelanchier laevis
- Betula spp.
- Carpinus caroliniana
- Catalpa bignonioides
- Cercidiphyllum japonicum
- Cladrastis lutea
- Cornus macrophylla
- Cornus controversa
- Davidia involucrata
- Fraxinus Ornus
- Fraxinus pennsylvanica lanceolata
- Halesia monticola
- Magnolia denudata
- Magnolia Loebneri
- Malus baccata
- Malus 'Cowichan'
- Nyssa Sylvatica
- Ostrya virginiana
- Oxydendrum arboreum
- Phellodendron amurense
- Prunus avium plena
- Prunus lusitanica
- Prunus Maximowiczii
- Prunus Sargentii
- Prunus yedoensis
- Quercus borealis
- Quercus chrysolepis
- Quercus coccinea
- Quercus laurifolia
- Quercus Phellos
- Robinia Pseudoacacia
- Robinia Pseudoacacia inermis
- Sassafras albidum
- Sorbus alnifolia
- Tilia cordata
- Tilia euchlora
- Ulmus alata
- Ulmus parvifolia
- Ulmus pumila

8.4 Building setback of more than 40 feet

- Acer nikoense
- Acer platanoides
- Acer Pseudoplatanus
- Acer rubrum
- Acer saccharum
- Carpinus Betulus
- Catalpa speciosa
- Celtis spp.
- Cornus Nuttallii
- Corylus Colurna
- Diospyros virginiana
- Fraxinus americana
- Ginkgo biloba
- Gleditsia triacanthos
- Kalopanax pictus
- Liquidambar Styraciflua
- Liriodendron Tulipifera
- Magnolia acuminata
- Magnolia grandiflora
- Platanus acerifolia
- Platanus orientalis
- Quercus alba
- Quercus palustris
- Sophora japonica
- Tilia europaea
- Ulmus americana
- Ulmus glabra
- Ulmus procera
- Zelkova serrata

Division 9 - Planting Strips

9.1 4 to 6 foot strip

Acer argutum
Acer circinatum
Acer palmatum
Acer platanoides columnare
Acer saccharum monumentale
Acer tataricum
Amelanchier grandiflora
Aralia elata
Arbutus Unedo
Carpinus Betulus pyramidalis
Cornus Kousa
Cornus mas
Crataegus monogyna stricta
Crataegus pinnatifida major
Crataegus succulenta
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Lagerstroemia indica
Laurus nobilis
Ligustrum lucidum
Magnolia salicifolia
Magnolia stellata
Malus Halliana Parkmanii
Malus micromalus
Malus prunifolia Rinki
Prunus 'Hally Jolivette'
Prunus nipponica
Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Jo-nioi'
Prunus serrulata 'Shogetsu'
Prunus serrulata 'Taki-nioi'
Quercus robur fastigiata
Sorbus aucuparia fastigiata
Stewartia koreana
Styrax japonica
Ulmus americana ascendens
Ulmus americana columnaris

9.2 8 foot strip

Acer argutum
Acer circinatum
Acer Ginnala
Acer griseum
Acer palmatum
Acer platanoides columnare
Acer saccharum monumentale
Acer tataricum
Albizzia julibrissin
Carpinus Betulus globosa
Cercis spp.
Chionanthus virginicus
Clethra spp.
Cornus officinalis
Crataegus arnoldiana
Crataegus coccinioides
Crataegus Lavallei
Crataegus mollis
Crataegus monogyna
Crataegus nitida
Crataegus Phaenopyrum
Crataegus pruinosa
Crataegus punctata
Franklinia alatamaha
Fraxinus Ornus
Fraxinus velutina
Ginkgo biloba fastigiata
Magnolia cordata
Magnolia Soulangeana
Malus arnoldiana
Malus 'Bob White' (zumi)
Malus hupehensis

Malus magdeburgensis
Malus purpurea Lemoinei
Malus toringoides
Phellodendron amurense
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus Mume
Prunus Sargentii columnaris
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Gyoiko'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Sorbus Folgneri
Syringa amurensis japonica

9.3 10 foot strip

Acer campestre
Acer carpinifolium
Acer Ginnala
Acer griseum
Acer platanoides columnare
Acer platanoides erectum
Acer rubrum columnare
Acer saccharum monumentale
Acer tataricum
Amelanchier canadensis
Amelanchier laevis
Betula spp.
Carpinus caroliniana
Cornus florida
Crataegus crus-galli
Crataegus viridis
Davidia involucrata
Fraxinus oregona
Fraxinus pennsylvanica lanceolata
Halesia monticola
Liriodendron Tulipifera fastigiatum
Magnolia denudata
Magnolia Loebneri
Malus Dawsoniana
Malus floribunda
Ostrya virginiana
Oxydendrum arboreum
Prunus lusitanica
Prunus Maximowiczii
Prunus subhirtella
Prunus yedoensis
Quercus borealis
Quercus chrysolepis
Quercus coccinea
Quercus laurifolia
Quercus Phellos
Sorbus aucuparia
Ulmus alata
Ulmus carpinifolia sarniensis
Ulmus carpinifolia umbraculifera

9.4 12 foot strip

Acer carpinifolium
Acer mandshuricum
Acer nikoense
Acer pennsylvanicum
Acer platanoides columnare
Acer platanoides erectum
Acer platanoides globosum
Acer platanoides laciniatum
Acer rubrum columnare
Acer tataricum
Carpinus Betulus
Celtis spp.
Cercidiphyllum japonicum
Cladrastis lutea
Cornus controversa
Cornus Nuttallii

Corylus Colurna
Diospyros virginiana
Ginkgo biloba
Kalopanax pictus
Malus baccata
Malus 'Cowichan' (Rosybloom)
Nyssa sylvatica
Prunus avium plena
Prunus Sargentii
Sassafras albidum
Sophora japonica
Sorbus alnifolia
Tilia cordata
Tilia euchlora
Tilia europaea
Ulmus parvifolia
Ulmus pumila
Zelkova serrata

9.5 Over 12 foot strip

Acer macrophyllum
Acer mandshuricum
Acer nikoense
Acer pennsylvanicum
Acer platanoides and vars.
Acer Pseudoplatanus
Acer rubrum
Acer saccharum
Acer tataricum
Ailanthus altissima erythrocarpa
Fraxinus americana
Fraxinus excelsior
Gleditsia triacanthos
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia acuminata
Magnolia grandiflora
Platanus acerifolia
Platanus orientalis
Quercus alba
Quercus Kelloggii
Quercus Garryana
Quercus robur
Quercus palustris
Quercus virginiana
Ulmus americana
Ulmus glabra
Ulmus procera

<u>Division 10 - Overhead Obstructions</u>

10.1 Streets with lines and cables 25 to 35 feet high

Acer argutum
Acer circinatum
Acer Ginnala
Acer griseum
Acer palmatum
Acer pennsylvanicum
Acer spicatum
Acer tataricum
Albizzia julibrissin
Amelanchier grandiflora
Amelanchier laevis
Aralia elata
Carpinus caroliniana
Cercidiphyllum japonicum
Cercis canadensis
Cercis chinensis
Cercis racemosa
Cercis Siliquastrum
Chionanthus virginicus
Clethra spp.
Cornus florida
Cornus Kousa
Cornus mas
Crataegus spp. and vars.
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Franklinia alatamaha
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri

Lagerstroemia indica
Laurus nobilis
Ligustrum lucidum
Magnolia cordata
Magnolia salicifolia
Magnolia Soulangeana
Magnolia stellata
Malus arnoldiana
Malus 'Bob White'
Malus floribunda
Malus Halliana Parkmanii
Malus hupehensis
Malus magdeburgensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus 'Hally Jolivette'
Prunus Mume
Prunus nipponica
Prunus serrulata vars.
Prunus subhirtella
Sorbus Folgneri
Stewartia koreana
Styrax japonica
Syringa amurensis japonica

10.2 Streets with lines and cables 35 to 50 feet high

Acer campestre
Acer carpinifolium
Acer Davidi
Acer mandshuricum
Acer nikoense
Acer pennsylvanicum
Acer tataricum
Aesculus carnea
Amelanchier canadensis
Arbutus Menziesii
Carpinus spp.
Cladrastis lutea
Cornus macrophylla
Fraxinus velutina
Magnolia denudata
Magnolia Kobus
Magnolia Loebneri
Malus baccata
Malus 'Cowichan' (Rosybloom)
Malus Dawsoniana
Ostrya virginiana
Oxydendrum arboreum
Phellodendron amurense
Sophora japonica
Ulmus alata
Ulmus carpinifolia sarniensis
Ulmus carpinifolia umbraculifera

10.3 Streets with trolly wires only

Acer platanoides columnare
Acer saccharum monumentale
Ailanthus altissima erythrocarpa
Arbutus Menziesii
Betula pendula
Celtis occidentalis
Crataegus Lavallei
Diospyros virginiana
Ginkgo biloba fastigiata
Quercus alba
Quercus robur fastigiata
Sassafras albidum

Division 11 - Underground Services

11.1 Streets with shallow sewers

Fagus spp.
Fraxinus spp.
Gleditsia triacanthos
Kalopanax pictus
Liriodendron Tulipifera
Oxydendrum arboreum
Phellodendron amurense
Quercus borealis
Quercus palustris
Ulmus spp.

11.2 Streets with deep sewers

Fagus spp.
Fraxinus spp.
Gleditsia triacanthos
Liriodendron Tulipifera
Phellodendron amurense
Quercus borealis
Quercus palustris
Quercus Phellos
Ulmus spp.

11.3 Trees to keep away from all sewers, septic tank tile beds, footing drains, etc.

Carya spp.
Quercus alba
Sassafras albidum

Division 12 - Building Heights

12.11 One-story buildings on city residential streets

Acer argutum
Acer circinatum
Acer Ginnala
Acer griseum
Acer palmatum
Acer tataricum
Amelanchier grandiflora
Amelanchier laevis
Aralia elata
Arbutus Unedo
Carpinus Betulus globosa
Chionanthus virginicus
Crataegus spp.
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Laburnum alpinum
Laurus nobilis
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus serrulata 'Amanogawa'

12.12 One-story buildings on suburban residential streets

Acer argutum
Acer campestre
Acer carpinifolium
Acer circinatum
Acer Ginnala
Acer griseum
Acer mandshuricum
Acer palmatum

Acer spicatum
Acer tataricum
Amelanchier grandiflora
Albizzia julibrissin
Carpinus Betulus fastigiata
Carpinus caroliniana
Catalpa bignonioides
Cercis spp.
Chionanthus virginicus
Clethra spp.
Cornus Kousa
Cornus mas
Crataegus spp.
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Franklinia alatamaha
Fraxinus velutina
Halesia carolina
Koelreuteria paniculata
Laburnum Watereri
Lagerstroemia indica
Ligustrum lucidum
Magnolia cordata
Magnolia salicifolia
Magnolia Soulangeana
Magnolia stellata
Malus arnoldiana
Malus 'Bob White'
Malus Halliana Parkmanii
Malus hupehensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Oxydendrum arboreum
Prunus 'Hally Jolivette'
Prunus Mume
Prunus nipponica
Prunus serrulata vars
Prunus subhirtella
Sorbus Folgneri
Stewartia koreana
Styrax japonica
Syringa amurensis japonica

12.21 Two-story buildings on city residential streets

Acer mandshuricum
Acer nikoense
Acer platanoides columnare
Acer platanoides erectum
Acer platanoides globosum
Acer platanoides laciniatum
Acer Pseudoplatanus
Acer tataricum
Ailanthus altissima erythrocarpa
Amelanchier canadensis
Arbutus Menziesii
Betula spp.
Carpinus Betulus
Cercidiphyllum japonicum
Crataegus crus-galli
Crataegus viridis
Davidia involucrata
Fraxinus Ornus
Fraxinus pennsylvanica lanceolata
Ginkgo biloba fastigiata
Gleditsia triacanthos inermis 'Moraine'
Nyssa sylvatica
Ostrya virginiana
Prunus lusitanica
Prunus Maximowiczii
Prunus Sargentii
Prunus Sargentii columnaris
Quercus borealis
Quercus chrysolepis
Quercus robur fastigiata
Sophora japonica
Tilia cordata
Tilia euchlora
Ulmus alata
Ulmus carpinifolia sarniensis
Ulmus carpinfolia umbraculifera

Division 12 - Building Heights

12.22 Two-story buildings on suburban residential streets

Acer carpinifolium
Acer macrophyllum
Acer mandshuricum
Acer nikoense
Acer pennsylvanicum
Acer platanoides erectum
Acer platanoides globosum
Acer Pseudoplatanus
Acer tataricum
Amelanchier canadensis
Caralpa speciosa
Celtis spp.
Cladrastis lutea
Cornus controversa
Cornus florida
Cornus Nuttallii
Corylus Colurna
Diospyros virginiana
Davidia involucrata
Ginkgo biloba fastigiata
Halesia monticola
Kalopanax pictus
Magnolia denudata
Magnolia Loebneri
Malus baccata
Malus 'Cowichan'
Malus Dawsoniana
Malus floribunda
Malus magdeburgensis
Oxydendrum arboreum
Phellodendron amurense
Prunus avium plena
Prunus yedoensis
Quercus laurifolia
Quercus Phellos
Sassafras albidum
Sophora japonica
Sorbus alnifolia
Sorbus aucuparia
Ulmus parvifolia
Ulmus pumila

12.3 Streets with multiple-storied buildings

Acer macrophyllum
Acer platanoides and vars.
Acer Pseudoplatanus
Acer rubrum
Acer saccharum
Aesculus spp. and vars.
Cornus Nuttallii
Fagus grandifolia
Fagus sylvatica and vars.
Ginkgo biloba
Gleditsia triacanthos
Kalopanax pictus
Magnolia grandiflora
Nyssa sylvatica
Platanus acerifolia
Platanus orientalis
Quercus alba
Quercus borealis
Quercus chrysolepis
Quercus palustris
Quercus robur
Sophora japonica
Sorbus alnifolia
Tilia europaea
Ulmus americana
Ulmus glabra
Ulmus procera
Zelkova serrata

Division 13 - Tree Size

13.11 Height over 60 feet

Acer macrophyllum
Acer platanoides and vars.
Acer Pseudoplatanus
Acer rubrum and vars.
Acer saccharum and vars.
Aesculus carnea Briotii

Aesculus Hippocastanum
  Baumannii
Alnus glutinosa
Alnus rubra
Arbutus Menziesii
Betula spp.
Carya spp.
Catalpa speciosa
Celtis spp.
Cornus Nuttallii
Corylus Colurna
Diospyros virginiana
Fagus grandifolia
Fagus sylvatica
Fraxinus americana
Fraxinus excelsior
Fraxinus oregona
Ginkgo biloba
Gleditsia triacanthos
Gymnocladus dioicus
Halesia monticola
Kalopanax pictus
Liriodendron Tulipifera
Liquidambar Styraciflua
Magnolia acuminata
Magnolia grandiflora
Nyssa sylvatica
Platanus acerifolia
Platanus orientalis
Prunus Sargentii
Quercus alba
Quercus borealis
Quercus coccinea
Quercus Garryana
Quercus Kelloggii
Quercus montana
Quercus palustris
Quercus robur
Robinia Pseudoacacia
Robinia Pseudoacacia
  inermis
Sophora japonica
Tilia cordata
Tilia europaea
Ulmus americana
Ulmus glabra
Ulmus procera
Ulmus pumila
Zelkova serrata

13.12 Height 40 to 60 feet

Acer nikoense
Ailanthus altissima
  erythrocarpa
Amelanchier canadensis
Alnus cordata
Carpinus Betulus
Carpinus japonica
Castanea mollissima
Catalpa bignonioides
Cercidiphyllum japonicum
  (male)
Cornus macrophylla
Cornus controversa
Davidia involucrata
Fraxinus Ornus
Fraxinus pennsylvanica
  lanceolata
Fraxinus velutina
Magnolia denudata
Magnolia Loebneri
Malus baccata
Malus 'Cowichan'
  (Rosybloom)
Oxydendrum arboreum
Phellodendron amurense
Prunus avium plena
Prunus Maximowiczii
Quercus chrysolepis
Quercus virginiana
Sassafras albidum
Sorbus alnifolia
Sorbus aucuparia
Tilia euchlora
Ulmus alata
Ulmus carpinifolia
  sarniensis
Ulmus carpinifolia
  umbraculifera
Ulmus parvifolia
Umbellularia californica

13.13 Height 25 to 39 feet

Acer campestre
Acer carpinifolium
Acer mandshuricum
Acer pennsylvanicum
Acer tataricum
Amelanchier laevis
Albizzia julibrissin
Aralia elata
Carpinus caroliniana
Carya tomentosa
Celtis yessoensis
Cercidiphyllum japonicum (female)
Cercis spp.
Chionanthus virginicus
Cladrastis lutea
Clethra spp.
Cornus florida
Crataegus arnoldiana
Crataegus crus-galli
Crataegus mollis
Crataegus monogyna
Crataegus nitida
Crataegus Phaenopyrum
Crataegus punctata
Crataegus viridis
Evodia Daniellii
Fagus sylvatica fastigiata
Franklinia alatamaha
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Laurus nobilis
Ligustrum lucidum
Magnolia cordata
Magnolia salicifolia
Magnolia Soulangeana
Malus Dawsoniana
Malus floribunda
Malus ionensis plena
Malus magdeburgensis
Malus purpurea Lemoinei
Malus toringoides
Ostrya virginiana
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus lusitanica
Prunus Mume
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Prunus subhirtella
Syringa amurensis japonica

13.14 Height 15 to 24 feet

Acer argutum
Acer circinatum
Acer Ginnala
Acer griseum
Acer palmatum
Acer spicatum
Amelanchier grandiflora
Arbutus Unedo
Cornus Kousa
Cornus mas
Crataegus coccinoides
Crataegus Lavallei
Crataegus Oxyacantha
Crataegus pinnatifida major
Crataegus pruinosa
Crataegus succulenta
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Ilex pedunculosa
Lagerstroemia indica
Magnolia stellata
Malus arnoldiana
Malus 'Bob White'(zumi)
Malus Halliana Parkmanii
Malus hupehensis
Malus micromalus
Malus prunifolia Rinki
Prunus 'Hally Jolivette'
Prunus nipponica

Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Gyoiko'
Prunus serrulata 'Jo-nioi'
Prunus serrulta 'Shogetsu'
Prunus serrulta 'Taki-nioi'
Prunus yedoensis
Sorbus Folgneri
Stewartia koreana
Styrax japonica

13.15 Less than 15 feet high

Euonymus spp.
Manolia stellata

13.21 Spread over 60 feet

Carya Pecan
Fagus grandifolia
Fagus sylvatica
Fraxinus americana
Fraxinus excelsior
Gleditsia triacanthos
Kalopanax pictus
Platanus acerifolia
Platanus orientalis
Quercus alba
Quercus Garryana
Quercus Kelloggii
Quercus robur
Quercus virginiana
Tilia europaea
Ulmus americana
Ulmus glabra
Ulmus procera
Zelkova serrata

13.22 Spread 40 to 60 feet

Arbutus Menziesii
Betula spp.
Carpinus spp.
Carya ovata
Celtis spp.
Corylus Colurna
Diospyros virginiana
Ginkgo biloba
Gymnocladus dioicus
Halesia monticola
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia acuminata
Nyssa sylvatica
Phellodendron amurense
Prunus Sargentii
Quercus borealis
Quercus chrysolepis
Quercus coccinea
Quercus laurifolia
Quercus palustris
Robinia Pseudoacacia
Sophora japonica
Tilia cordata
Tilia euchlora
Ulmus pumila
Ambellularia californica

13.23 Spread 25 to 39 feet

Amelanchier grandiflora
Amelanchier laevis
Betula spp. (some)
Celtis yessoensis
Cercidiphyllum japonicum (female)

Cladrastis lutea
Clethra spp.
Cornus controversa
Cornus macrophylla
Cornus Nuttallii
Davidia involucrata
Fraxinus Ornus
Fraxinus pennsylvanica lanceolata
Fraxinus velutina
Magnolia denudata
Magnolia grandiflora
Malus 'Cowichan' (Rosybloom)
Malus magdeburgensis
Ostrya virginiana
Oxydendrum arboreum
Prunus avium plena
Prunus Maximowiczii
Prunus yedoensis
Quercus Phellos
Sassafras albidum
Sorbus alnifolia
Sorbus aucuparia
Ulmus alata
Ulmus carpinifolia sarniensis
Ulmus carpinifolia umbraculifera
Ulmus parvifolia

13.24 Spread 15 to 24 feet

Amelanchier canadensis
Carya tomentosa
Cercidiphyllum japonicum (male)
Cercis spp.
Chionanthus virginicus
Cornus florida
Cornus mas
Cornus officinalis
Crataegus spp.
Franklinia alatamaha
Ginkgo biloba fastigiata
Halesia carolina
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Liriodendron Tulipifera fastigiatum
Magnolia cordata
Magnolia Loebneri
Magnolia Soulangeana
Magnolia stellata
Malus arnoldiana
Malus 'Bob White' (zumi)
Malus Dawsoniana
Malus floribunda
Malus hupehensis
Malus magdeburgensis
Malus prunifolia Rinki
Malus purpurea Lemoinei
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus lusitanica
Prunus Mume
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Gyoiko'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Prunus subhirtella
Sorbus Folgneri
Stewartia koreana
Styrax japonica
Syringa amurensis japonica
Ulmus americana ascendens
Ulmus americana columnaris

13.25 Less than 15 foot spread

Carpinus Betulus fastigiata
Cornus Kousa
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Lagerstroemia indica
Magnolia salicifolia
Malus Halliana Parkmanii
Malus micromalus
Malus toringoides
Prunus 'Hally Jolivette'
Prunus nipponica
Prunus Sargentii columnaris
Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'jo-nioi'
Prunus serrulata 'Shogetsu'
Prunus serrulata 'Taki-nioi'
Quercus robur fastigiata
Sorbus aucuparia fastigiata

Division 14 - Tree Shape

14.1 Rounded-globose

Acer campestre
Acer griseum
Acer macrophyllum
Acer mandshuricum
Acer nikoense
Acer palmatum
Acer platanoides
Acer platanoides globosum
Acer rubrum
Ailanthus altissima erythrocarpa
Alnus cordata
Carpinus Betulus
Carpinus caroliniana
Carya Pecan
Castanea spp.
Catalpa spp.
Celtis spp.
Cercidiphyllum japonicum (female)
Chionanthus virginicus
Cladrastis lutea
Cornus macrophylla
Cornus mas
Crataegus spp.
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Fraxinus americana
Fraxinus excelsior
Fraxinus Ornus
Fraxinus velutina
Gleditsia triacanthos
Halesia carolina
Magnolia denudata
Malus arnoldiana
Malus 'Bob White' (zumi)
Malus 'Cowichan' (Rosybloom)
Malus floribunda
Malus magdeburgensis
Malus prunifolia Rinki
Malus purpurea Lemoinei
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus 'Hally Jolivette'
Prunus lusitanica
Prunus Maximowiczii
Prunus Mume
Prunus nipponica

Prunus subhirtella
Quercus alba
Quercus borealis
Quercus Garryana
Quercus Kelloggii
Quercus laurifolia
Quercus robur
Sophora japonica
Sorbus alnifolia
Tilia euchlora
Tilia europaea
Ulmus alata
Ulmus carpinifolia umbraculifera
Ulmus parvifolia
Ulmus pumila
Umbellularia californica
Zelkova serrata

14.2 Tall oval

Acer argutum
Acer platanoides
Acer platanoides 'Cleveland'
Acer saccharum
Acer tataricum
Amelanchier canadensis
Alnus glutinosa
Alnus rubra
Betula spp.
Carya glabra
Carya ovata
Carya tomentosa
Cercidiphyllum japonicum (male)
Cornus Nuttallii
Crataegus Phaenopyrum
Diospyros virginiana
Fraxinus oregona
Fraxinus pennsylvanica lanceolata
Lagerstroemia indica
Malus Dawsoniana
Prunus Sargentii
Sassafras albidum
Ulmus procera

14.3 Flat oval

Acer carpinifolium
Acer circinatum
Acer pennsylvanicum
Acer Pseudoplatanus
Acer spicatum
Carpinus japonica
Cercis spp.
Koelreuteria paniculata
Prunus serrulata 'Shogetsu'
Prunus yedoensis
Quercus virginiana

14.4 Pyramidal

Acer platanoides erectum
Acer rubrum columnare
Carpinus Betulus fastigiata
Corylus Colurna
Davidia involucrata
Fagus grandifolia
Fagus sylvatica
Franklinia alatamaha
Halesia monticola
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia acuminata
Magnolia grandiflora
Magnolia Loebneri
Magnolia salicifolia
Malus baccata
Malus micromalus
Malus toringoides
Nyssa sylvatica
Ostrya virginiana
Oxydendrum arboreum
Prunus avium plena
Quercus palustris

Quercus Phellos
Stewartia koreana
Syringa amurensis japonica
Tilia cordata
Ulmus carpinifolia sarniensis

14.5 Columnar

Acer platanoides columnare
Acer platanoides laciniatum
Acer rubrum columnare
Acer saccharum monumentale
Carpinus betulus fastigiata
Crataegus monogyna stricta
Crataegus Phaenopyrum fastigiata
Fagus sylvatica fastigiata
Liriodendron Tulipifera fastigiata
Prunus Sargentii columnaris
Prunus serrulata 'Amanogawa'
Quercus robur fastigiata
Sorbus aucuparia fastigiata
Ulmus americana ascendens
Ulmus americana columnaris
Betula pendula fastigiata
Ginkgo biloba fastigiata
Malus baccata columnaris

14.6 Weeping

Betula pendula vars.
Carpinus Betulus pendula
Crataegus monogyna pendula
Fagus sylvatica pendula
Malus vars.
Sophora japonica pendula
Sorbus aucuparia pendula
Ulmus glabra Camperdownii
Ulmus glabra pendula

14.7 Horizontal branching

Amelanchier grandiflora
Amelanchier laevis
Albizzia julibrissin
Cercis canadensis
Cornus controversa
Cornus florida
Cornus Kousa
Crataegus spp.
Malus hupehensis
Nyssa sylvatica
Sorbus Folgneri
Styrax japonica

14.8 Tall open shape

Acer pennsylvanicum
Aralia elata
Arbutus Menziesii
Cercis spp.
Clethra spp.
Davidia involucrata
Ginkgo biloba
Gymnocladus dioicus
Kalopanax pictus
Laburnum alpinum
Laburnum Watereri
Ligustrum lucidum
Magnolia cordata
Magnolia Kobus borealis

Magnolia Soulangeana
Malus Halliana Parkmanii
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Gyoiko'
Prunus serrulata 'Jo-nioi'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Washino'
Quercus chrysolepis
Quercus coccinea
Robinia Pseudoacacia
Robinia Pseudoacacia inermis
Sorbus Aria
Sorbus aucuparia
Ulmus americana
Ulmus glabra

<u>Division 15 - Root Structure</u>

15.11 Fibrous, widespreading

Acer rubrum
Acer saccharum
Betula pendula
Cornus florida
Cornus Nuttallii
Fagus grandifolia
Fagus sylvatica
Kalopanax pictus
Nyssa sylvatica
Quercus borealis
Quercus palustris
Robinia Pseudoacacia
Ulmus spp.

15.12 Fibrous, concentrated

Fraxinus spp.
Oxydendrum arboreum
Phellodendron amurense

15.21 Non-fibrous, shallow

Acer macrophyllum
Acer platanoides
Aesculus spp.
Gleditsia triacanthos
Liriodendron Tulipifera
Magnolia spp.
Platanus occidentalis
Tilia spp.
Ulmus americana
Ulmus glabra

15.22 Non-fibrous, tap-rooted

Acer campestre
Acer Pseudoplatanus
Arbutus Menziesii
Carya spp.
Celtis occidentalis
Cladrastis lutea
Diospyros virginiana
Juglans spp.
Nyssa sylvatica
Quercus spp.
Sassafras albidum
Ulmus pumila

Division 16 - Rate of Growth

16.1 Rapid, (over 2 feet per year, first ten years)

Acer platanoides
Acer rubrum
Ailanthus altissima erythrocarpa
Betula spp.
Catalpa speciosa
Celtis spp.
Davidia involucrata
Fraxinus spp.
Gleditsia triacanthos
Gymnocladus dioicus
Ligustrum lucidum
Liriodendron Tulipifera
Magnolia spp.
Platanus acerifolia
Quercus borealis
Quercus coccinea
Quercus palustris
Quercus Phellos
Quercus virginiana
Robinia Pseudoacacia
Tilia spp.
Ulmus parvifolia
Zelkova serrata

16.2 Medium, (1 to 2 feet per year, first ten years)

Acer platanoides Schwedleri
Aesculus carnea Briotii
Cercidiphyllum japonicum
Crataegus Phaenopyrum
Franklinia alatamaha
Fraxinus Ornus
Fraxinus velutina
Laburnum Watereri
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Quercus robur
Sorbus spp.
Ulmus spp.

16.3 Slow, (less than 1 foot per year, first ten years)

Acer circinatum
Acer griseum
Acer palmatum
Acer platanoides 'Crimson King'
Albizzia julibrissin
Carpinus spp.
Celtis jessoensis
Chionanthus virginicus
Crataegus Oxyacantha
Ginkgo biloba
Koelreuteria paniculata
Lagerstroemia indica
Magnolia grandiflora
Nyssa sylvatica
Ostrya virginiana
Oxydendrum arboreum
Quercus alba
Quercus Garryana
Quercus virginiana
Sophora japonica
Styrax japonica
Umbellularia californica

Division 17 - Longevity

17.1 100 years or more

Acer platanoides
Acer Pseudoplatanus
Acer saccharum
Carya spp.
Fagus spp.
Ginkgo biloba

Gleditsia triacanthos
Lagerstroemia indica
Liquidambar Styraciflua
Liriodendrum Tulipifera
Magnolia grandiflora
Platanus acerifolia
Platanus orientalis
Quercus spp.
Ulmus spp.
Umbellularia californica

17.2 60 - 99 years

Acer circinatum
Acer Ginnala
Acer griseum
Acer palmatum
Acer tataricum
Quercus laurifolia

17.3 40 - 59 years

Betula spp.
Cercis canadensis
Laburnum Watereri
Prunus spp.

17.4 Less than 40 years

Evodia Daniellii
Koelreuteria paniculata

<u>Division 18 - Diseases and Pests</u>

18.11 Subject to virus infection

Robinia Pseudoacacia
Ulmus americana

18.12 Subject to fungus infection

Acer spp.
Aesculus spp.
Albizzia julibrissin
Betula spp.
Castanea dentata
Catalpa spp.
Cercis canadensis
Crataegus spp.
Fraxinus spp.
Lagerstroemia indica
Platanus spp.
Prunus spp. and vars.
Quercus spp.
Ulmus spp.

18.13 Subject to bacterial infection

Crataegus crus-galli
Crataegus Oxyacantha
Malus spp. (some)
Sorbus spp.
Ulmus americana

18.14 Not subject to serious disease

Ailanthus altissima erythrocarpa
Amelanchier spp.
Carpinus spp.
Carya spp.
Celtis spp.

Cercidiphyllum japonicum
Cercis spp.
Cornus spp.
Fagus spp.
Ginkgo biloba
Gleditsia triacanthos
Halesia spp.
Kalopanax pictus
Ligustrum lucidum
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia spp.
Ostyra virginiana
Phellodendron amurense
Phellodendron Lavallei
Robinia Pseudoacacia
Robinia Pseudoacacia inermis
Sassafras albidum
Sophora japonica
Sorbus spp.
Styrax japonica
Stewartia koreana
Syringa amurensis japonica
Tilia spp.
Ulmus procera
Zelkova serrata

18.21 Subject to aphis infestation

Acer platanoides
Alnus rubra
Catalpa spp.
Crataegus spp.
Liriodendron Tulipifera
Tilia cordata
Tilia euchlora
Tilia europaea

18.22 Subject to borers

Betula spp.
Crataegus spp.
Malus spp. and vars.
Prunus spp. and vars.
Quercus spp.
Robinia Pseudoacacia and vars.
Sorbus spp.
Syringa amuransis japonica

18.23 Subject to foliage injury from insects

Alnus rubra
Crataegus spp.
Quercus spp.
Robinia Pseudoacacia vars.
Ulmus spp.

18.24 Subject to mites

Clethra spp.
Crataegus spp.
Sorbus spp.

18.25 Subject to scale attack

Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Fraxinus spp.
Magnolia Soulangeana
Malus spp. and vars.

Prunus spp. and vars
Sorbus spp.
Syringa amurensis
  japonica
Ulmus spp.

18.26 Not subject to serious insect troubles

Acer spp. and vars.
Ailanthus altissima
  erythrocarpa
Amelanchier spp.
Carpinus spp.
Carya spp.
Celtis spp.
Cercidiphyllum japonicum
Cercis spp.
Cornus spp.
Diospyros virginiana
Fagus spp.
Ginkgo biloba
Gleditsia triacanthos
Halesia spp.
Kalopanax pictus
Koelreuteria paniculata
Laburnum spp.
Lagerstroemia indica
Ligustrum lucidum
Liriodendron Tulipifera
Liquidambar Styraciflua
Magnolia spp.
Ostrya virginiana
Phellodendron amurense
Sassafras albidum
Sophora japonica
Stewartia koreana
Styrax japonica
Ulmus parvifolia
Zelkova serrata

18.3 Susceptible trees satisfactory for use with moderate control measures

Crataegus spp.
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Malus spp. and vars.
Prunus spp. and vars.
Quercus spp.
Syringa amurensis
  japonica
Tilia spp.

<u>Division 19 - Tolerance</u>

19.11 Susceptible to injury from city smoke and gas

Acer rubrum
Acer saccharum
Carya spp.
Fagus grandifolia
Fagus sylvatica
Liriodendron Tulipifera
Tilia spp.
Ulmus americana

19.12 Tolerant of city conditions

Acer campestre
Acer platanoides
Acer Pseudoplatanus
Aesculus spp.
Ailanthus altissima
  erythrocarpa
Albizzia julibrissin
Amelanchier spp.

Aralia elata
Betula spp.
Carpinus spp.
Catalpa spp.
Cercidiphyllum japonicum
Cornus spp.
Crataegus monogyna
Crataegus Oxyacantha
Crataegus Phaenopyrum
Euonymus europaea
Fraxinus spp.
Ginkgo biloba
Gleditsia triacanthos
Koelreuteria paniculata
Magnolia grandiflora
Magnolia Soulangeana
Malus spp.
Phellodendron amurense
Platanus spp.
Quercus borealis
Quercus macrocarpa
Sophora japonica
Ulmus procera
Ulmus pumila

19.2 Tolerant of shade

Acer circinatum
Acer rubrum
Amelanchier spp.
Cercis spp.
Cornus spp.
Ostrya virginiana

19.31 Trees which transplant readily at any age

Acer spp.
Aesculus spp.
Betula spp.
Celtis spp.
Euonymus europaea
Fagus spp.
Fraxinus spp.
Ginkgo biloba
Gleditsia triacanthos
Halesia spp.
Laburnum Watereri
Liriodendron Tulipifera
Phellodendron amurense
Phellodendron Lavallei
Platanus spp.
Prunus spp. and vars.
Quercus borealis
Quercus palustris
Robinia Pseudoacacia
Sorbus spp.
Tilia spp.
Ulmus spp.

19.32 Trees which must be established in seedling stage

Arbutus Menziesii
Carya spp.
Umbellularia californica

19.33 Trees difficult to transplant at useful size

Carpinus spp.
Celtis spp.
Cercidiphyllum japonicum
Cercis spp.
Cornus spp.
Crataegus spp.
Kalopanax pictus
Lagerstroemia indica
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia spp.
Nyssa sylvatica
Ostrya virginiana
Prunus Sargentii

Quercus alba
Quercus coccinea
Sassafras albidum
Stewartia spp.
Styrax japonica

19.4 Tolerant of salt spray

Acer macrophyllum
Acer platanoides
Acer Pseudoplatanus
Acer rubrum
Aesculus Hippocastanum
Ailanthus altissima erythrocarpa
Amelanchier canadensis
Arbutus Menziesii
Betula papyrifera
Crataegus crus-galli
Crataegus Oxyacantha
Fraxinus velutinus
Gleditsia triacanthos
Liquidambar Styraciflua
Magnolia grandiflora
Nyssa sylvatica
Platanus occidentalis
Platanus racemosa
Quercus borealis
Quercus virginiana
Robinia Pseudoacacia
Sassafras
Tilia cordata
Ulmus parvifolia
Ulmus pumila
Umbellularia californica

19.51 Tolerant of acidity

Arbutus Menziesii
Arbutus Unedo
Cornus Nuttallii
Oxydendrum arboreum

19.52 Tolerant of alkalinity

Acer macrophyllum
Ailanthus altissima
Celtis spp.
Franklinia alatamaha
Fraxinus velutina
Gleditsia triacanthos
Koelreuteria paniculata
Lagerstroemia indica
Platanus acerifolia
Robinia Pseudoacacia
Ulmus spp.

19.6 Tolerant of drought

Acer Negundo
Acer truncatum
Ailanthus altissima
Albizzia julibrissin
Amelanchier spp.
Castanea spp.
Catalpa spp.
Celtis spp.
Cercis spp.
Cladrastis lutea
Corylus Colurna
Crataegus spp.
Fraxinus Ornus
Fraxinus velutina
Gleditsia triacanthos
Koelreuteria paniculata
Malus ionensis plena
Ostrya virginiana
Phellodendron amurense
Phellodendron Lavallei
Prunus Mume
Quercus coccinea
Quercus Kelloggii
Robinia Pseudoacacia

Sassafras albidum
Sophora japonica
Tilia cordata
Ulmus pumila

Division 20 - Flowering Habits

20.11 January - February

Corylus Colurna
Crataegus monogyna

20.12 March - April

Amelanchier canadensis
Amelanchier laevis
Cercidiphyllum japonicum
Cornus Mas
Cornus Nuttallii
Cornus officinalis
Magnolia denudata
Magnolia Loebneri
Magnolia salicifolia
Magnolia stellata
Malus baccata mandshurica
Poncirus trifoliata
Prunus cerasifera
Prunus Davidiana
Prunus nipponica
Prunus Sargentii
Prunus subhirtella and vars.
Prunus yedoensis

20.13 May - June

Aesculus spp. and vars.
Amelanchier grandiflora
Arbutus Menziesii
Cercis spp.
Chionanthus virginicus
Cladrastis lutea
Cornus controversa
Cornus florida
Cornus Kousa
Crataegus spp.
Davidia involucrata
Exochorda Giraldii
Fraxinus Ornus
Halesia spp.
Laburnum alpinum
Laburnum Watereri
Liriodendron Tulipifera
Magnolia acuminata
Magnolia cordata
Magnolia denudata
Magnolia grandiflora
Magnolia Soulangeana and vars.
Malus arnoldiana
Malus baccata
Malus 'Bob White' (zumi)
Malus 'Cowichan' and other Rosyblooms
Malus Dawsoniana
Malus floribunda
Malus Halliana and vars.
Malus hupehensis
Malus magdeburgensis
Malus micromalus
Malus prunifolia and vars.
Malus purpurea vars.
Malus toringoides
Prunus avium plena
Prunus blireiana
Prunus 'Hally Jolivette'
Prunus Maximowiczii
Prunus Mume vars.
Prunus serrulata vars.
Robinia Pseudoacacia
Sorbus spp.
Styrax japonica
Syringa amurensis japonica

20.14 Summer months

Albizzia julibrissin
Aralia elata
Catalpa spp.
Clethra spp.
Cornus macrophylla
Evodia Daniellii
Kalopanax pictus
Koelreuteria paniculata
Lagerstroemia indica
Oxydendrum aroreum
Sophora japonica
Stewartia koreana

20.15 Autumn

Arbutus Unedo
Franklinia alatamaha
Prunus subhirtella autumnalis

20.21 White

Aesculus Hippocastanum Baumannii
Amelanchier spp.
Aralia elata
Arbutus Menziesii
Arbutus Unedo
Catalpa spp.
Cladrastis lutea
Clethra spp.
Cornus controversa
Cornus florida
Cornus Kousa
Cornus macrophylla
Cornus Nuttallii
Crataegus spp.
Davidia involucrata
Evodia Daniellii
Franklinia alatamaha
Fraxinus Ornus
Halesia spp.
Magnolia denudata
Magnolia grandiflora
Magnolia Loebneri
Magnolia salicifolia
Magnolia stellata
Malus baccata
Malus Dawsoniana
Malus toringoides
Oxydendrum arboreum
Prunus avium plena
Prunus 'Hally Jolivette'
Prunus lusitanica
Prunus Maximowiczii
Prunus serrulata 'Jo-nioi'
Prunus serrulata 'Sirotae'
Prunus serrulata 'Taki-nioi'
Prunus serrulata 'Washino'
Robinia Pseudoacacia
Sophora japonica
Sorbus alnifolia
Sorbus aucuparia
Stewartia koreana
Styrax japonica
Syringa amurensis japonica

20.22 Pink

Albizzia julibrissin
Cornus florida rubra
Crataegus Oxyacantha vars.
Lagerstroemia indica
Magnolia Soulangeana
Malus arnoldiana
Malus 'Bob White' (Zumi)
Malus floribunda
Malus hupehensis
Malus micromalus

Malus prunifolia Rinki
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus Mume
Prunus nipponica
Prunus Sargentii
Prunus serrulata 'Amanogawa'
Prunus serrulata 'Botan-zakura'
Prunus serrulata 'Fugenzo'
Prunus serrulata 'Kwanzan'
Prunus serrulata 'Shogetsu'
Prunus subhirtella
Prunus yedoensis

20.23 Red

Aesculus carnea Briotii
Lagerstroemia indica
Malus 'Cowichan' (Rosybloom)
Malus Halliana Parkmanii
Malus magdeburgensis
Malus purpurea Lemoinei

20.24 Mauve and purple

Cercia spp.

20.25 Yellow

Cornus mas
Cornus officinalis
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Liriodendron Tulipifera
Magnolia acuminata
Magnolia cordata
Prunus serrulata 'Gyoiko'

20.31 Solitary, single

Arbutus Unedo
Cornus spp.
Davidia involucrata
Franklinia alatamaha
Liriodendron Tulipifera
Magnolia spp.
Prunus spp.
Stewartia koreana

20.32 Solitary, double

Prunus spp.

20.33 Flowers in multiple heads

Aesculus spp. and vars.
Amelanchier spp.
Aralia elata
Arbutus Menziesii
Catalpa spp.
Chionanthus virginicus
Cladrastis lutea
Clethra spp.
Cornus macrophylla
Crataegus spp.
Evodia Daniellii
Fraxinus Ornus
Halesia spp.
Kalopanax pictus

Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Malus spp.
Oxydendrum arboreum
Prunus spp. and vars.
Robinia Pseudoacacia
Sophora japonica
Sorbus spp.
Styrax japonica
Syringa amurensis japonica

Division 21 - Fruiting Habits

21.11 Persistent, desirable

Acer Ginnala
Arbutus Menziesii
Arbutus Unedo
Cornus spp.
Crataegus spp.
Euonymus europaea vars.
Euonymus latifolia
Evodia Daniellii
Halesia spp.
Malus 'Bob White'
Oxydendrum arboreum
Phellodendron amurense
Sorbus spp.

21.12 Persistent, objectionable

Catalpa spp.
Gleditsia triacanthos

21.13 Non-persistent, desirable

Amelanchier spp.
Aralia elata
Carya spp.
Castanea spp.
Chionanthus virginicus
Diospyros virginiana
Eyonymus sanguinea
Kalopanax pictus
Malus arnoldiana
Malus baccata
Malus floribunda
Malus Halliana Parkmanii
Malus hupehensis
Malus micromalus
Malus purpurea Lemoinei
Malus toringoides

21.14 Non-persistent, objectionable

Aesculus spp. and vars.
Albizzia julibrissin
Ginkgo biloba
Liquidambar Styraciflua
Malus 'Cowichan' (Rosybloom)
Malus Dawsoniana
Malus magdeburgensis
Malus prunifolia Rinki
Malus purpurea Eleyi

21.21 Red

Acer Ginnala
Ailanthus altissima erythrocarpa
Amelanchier laevis
Arbutus Menziesii
Arbutus Unedo

Cornus florida
Cornus Kousa
Cornus mas
Cornus Nattallii
Crataegus spp.
Euonymus europaea vars. (pink)
Euonymus latifolia
Euonymus sanguinea
Malus 'Cowichan' (Rosybloom)
Malus Halliana Parkmanii
Malus magdeburgensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Sorbus spp.

21.22 Yellow or orange

Malus arnoldiana
Malus baccata
Malus 'Bob White' (Zumi)
Malus Dawsoniana
Malus floribunda
Malus hupehensis
Malus toringoides

21.23 Blue

Amelanchier spp.
Chionanthus virginicus

21.24 Black

Amelanchier grandiflora
Aralia elata
Cornus macrophylla
Cornus controversa
Evodia Daniellii
Kalopanax pictus
Phellodendron amurense

21.3 Dioecious trees

Acer spp.
Ailanthus altissima
Broussonetia papyrifera
Castanea mollissima
Cercidiphyllum japonicum
Chionanthus virginicus
Cotinus coggygria
Diospyros virginiana
Ginkgo biloba
Gleditsia triacanthos
Ilex spp.
Nyssa sylvatica
Phellodendron amurense

21.4 Trees which bear fruit at early age

Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Oxydendrum arboreum

<u>Division 22 - Specific Effects</u>

22.1 Interesting bark

Acer griseum
Acer pennsylvanicum
Amelanchier laevis
Arbutus Menziesii
Arbutus Unedo
Betula spp.

Carpinus caroliniana
Cladrastis lutea
Cornus florida
Cornus Kousa
Diospyros virginiana
Fagus spp.
Gymnocladus dioicus
Lagerstroemia indica
Parrotia persica
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Prunus Sargentii
Quercus Suber
Stewartia spp.
Styrax japonica
Syringa amurensis
  japonica
Ulmus parvifolia

22.2 Interesting branching habit

Ailanthus altissima
  erythrocarpa
Albizzia julibrissin
Aralia elata
Arbutus Menziesii
Carpinus caroliniana
Clethra spp.
Cornus controversa
Ginkgo biloba
Gymnocladus dioicus
Kalopanax pictus
Malus baccata
Malus Halliana Parkmanii
Malus hupehensis
Malus toringoides
Phellodendron amurense
Quercus palustris
Sassafras albidum
Tilia euchlora
Ulmus americana

22.31 Foliage light green

Catalpa spp.
Liriodendrom Tulipifera

22.32 Foliage grey-green

Cornus florida
Tilia tomentosa

22.33 Foliage blue-purple or copper colors

Acer palmatum
  atropurpureum
Acer platanoides
  Schwedleri
Acer Pseudoplatanus
  purpureum
Fagus sylvatica
  atropunicea
Prunus blireiana
Prunus cerasifera
  atropurpurea
Ulmus glabra
  atropurpurea

22.34 Foliage especially glossy

Arbutus Menziesii
Magnolia grandiflora
Nyssa sylvatica
Quercus borealis

22.41 Half-evergreen

Ligustrum lucidum
Quercus acutissima
Quercus laurifolia
Quercus virginiana

22.42 Evergreen

Arbutus Menziesii
Arbutus Unedo
Ilex pedunculosa
Laurus nobilis
Magnolia grandiflora
Prunus lusitanica
Quercus chrysolepis
Quercus Suber
Umbellularia californica

22.51 Striking foliage colors in the Spring

Acer campestre
Acer griseum
Acer platanoides Schwedleri
Amelanchier canadensis
Amelanchier grandiflora rubescens
Amelanchier laevis
Prunus serrulata 'Kwanzan'

22.52 Yellow autumn color

Acer macrophyllum
Acer platanoides
Amelanchier spp.
Betula spp.
Cercidiphyllum japonicum
Cercis spp.
Chionanthus virginicus
Cladrastis lutea
Diospyros virginiana
Fraxinus americana
Fraxinus pennsylvanica lanceolata
Ginkgo biloba
Halesia spp.
Liriodendron Tulipifera
Malus Dawsoniana
Ostrya virginiana
Prunus nipponica
Quercus Phellos

22.53 Orange-red autumn color

Acer spp.
Cornus florida
Cornus Nuttallii
Crataegus Lavallei
Crataegus Phaenopyrum
Euonymus europaea vars.
Euonymus latifolia
Euonymus sanguinea
Franklinia alatamaha
Kalopanax pictus
Liquidambar Styraciflua
Malus 'Cowichan'
Malus Dawsoniana
Nyssa sylvatica
Oxydendrum arboreum
Quercus borealis
Quercus coccinea
Quercus palustris
Prunus Maximowiczii
Prunus Sargentii
Sassafras albidum
Sorbus spp.
Stewartia koreana

22.54 Bronze autumn color

Carya spp.
Fagus spp.

22.55 Purple autumn color

Quercus alba
Stewartia Pseudo-camellia

22.6 Variegated foliage

Cornus Nuttallii Eddiei

Division 23 - Mass

23.1 Heavy mass

Acer campestre
Acer circinatum
Acer Ginnala
Acer macrophyllum
Acer nikoense
Acer palmatum
Acer platanoides
Acer Pseudoplatanus
Acer rubrum
Acer saccharum
Acer tataricum
Aesculus spp. and vars.
Castanea spp.
Catalpa spp.
Cladrastis lutea
Crataegus spp.
Davidia involucrata
Fraxinus americana
Fraxinus oregona
Fraxinus Ornus
Fraxinus pennsylvanica lanceolata
Kalopanax pictus
Lagerstroemia indica
Laurus nobilis
Ligustrum lucidum
Liquidambar Styraciflua
Liriodendron Tulipifera
Magnolia acuminata
Magnolia denudata
Magnolia grandiflora
Magnolia Loebneri
Magnolia salicifolia
Malus arnoldiana
Malus baccata
Malus 'Bob White' (zumi)
Malus 'Cowichan' (Rosybloom)
Malus Dawsoniana
Malus floribunda
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Nyssa sylvatica
Ostrya virginiana
Prunus avium plena
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus 'Hally Jolivette'
Prunus lusitanica
Prunus Maximowiczii
Prunus nipponica
Prunus Sargentii
Prunus serrulata vars.
Prunus subhirtella
Prunus yedoensis
Quercus alba
Quercus borealis
Quercus coccinea
Quercus Garryana
Quercus Kelloggii
Quercus robur

Sassafras albidum
Sorbus alnifolia
Stewartia koreana
Tilia europaea
Umbellularia californica

23.2 Medium mass

Acer carpinifolia
Acer griseum
Acer mandshuricum
Acer pennsylvanicum
Cercidiphyllum japonicum
Cornus spp.
Fagus spp.
Franklinia alatamaha
Fraxinus excelsior
Fraxinus velutina
Gleditsia triacanthos
Koelreuteria paniculata
Laburnum alpinum
Laburnum Watereri
Magnolia cordata
Malus Halliana Parkmanii
Malus hupehensis
Malus magdeburgensis
Oxydendrum arboreum
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Prunus Mume
Quercus palustris
Quercus Phellos
Quercus virginiana
Sophora japonica
Sorbus aucuparia
Sorbus Folgneri
Syringa amurensis japonica
Tilia cordata
Tilia euchlora
Ulmus spp.
Zelkova serrata

23.3 Light mass

Ailanthus altissima erythrocarpa
Albizzia julibrissin
Aralia elata
Betula spp.
Cercis spp.
Ginkgo biloba
Gymnocladus dioicus
Robinia Pseudoacacia
Styrax japonica

Division 24 - Texture

24.1 Coarse texture

Acer griseum
Acer macrophyllum
Acer mandshuricum
Acer pennsylvanicum
Acer platanoides
Acer Pseudoplatanus
Aesculus spp. and vars.
Ailanthus altissima erythrocarpa
Aralia elata
Catalpa spp.
Davidia involucrata
Franklinia alatamaha
Gymnocladus dioicus
Kalopanax pictus
Koelreuteria paniculata
Laurus nobilis
Ligustrum lucidum
Liriodendron Tulipifera
Liquidambar Styraciflua
Magnolia spp.
Oxydendrum arboreum
Phellodendron amurense
Platanus acerifolia
Platanus orientalis
Prunus avium plena

Prunus lusitanica
Prunus Maximowiczii
Prunus serrulata vars.
Prunus yedoensis
Quercus alba
Quercus borealis
Quercus Garryana
Quercus Kelloggii
Quercus robur
Sassafras albidum
Stewartia koreana
Syringa amurensis japonica
Tilia euchlora
Tilia europaea

24.2 Medium texture

Acer campestra
Acer carpinifolium
Acer circinatum
Acer nikoense
Acer palmatum
Acer rubrum
Acer saccharum
Acer tataricum
Castanea dentata
Castanea mollissima
Cercidiphyllum japonicum
Cladrastis lutea
Cornus spp.
Crataegus spp.
Gleditsia triacanthos
Laburnum alpinum
Laburnum Watereri
Magnolia salicifolia
Magnolia stellata
Malus baccata
Malus 'Cowichan' (Rosybloom)
Malus Dawsoniana
Malus Halliana Parkmanii
Malus hupehensis
Malus magdeburgensis
Malus micromalus
Malus prunifolia Rinki
Malus purpurea Lemoinei
Malus toringoides
Nyssa sylvatica
Ostrya virginiana
Prunus blireiana
Prunus cerasifera atropurpurea
Prunus Mume
Prunus Sargentii
Quercus coccinea
Sophora japonica
Sorbus spp.
Tilia cordata
Ulmus spp.
Umbellularia californica
Zelkova serrata

24.3 Fine texture

Acer Ginnala
Acer palmatum dissectum
Albizzia julibrissin
Betula spp.
Cercis spp.
Fagus spp.
Ginkgo biloba
Lagerstroemia indica
Malus 'arnoldiana'
Malus 'Bob White'
Malus floribunda
Prunus 'Hally Jolivette'
Prunus subhirtella
Quercus palustris
Quercus Phellos
Quercus virginiana
Robinia Pseudoacacia
Styrax japonica

CHAPTER III

ECOLOGICAL CONSIDERATIONS AFFECTING SELECTION OF TREE SPECIES

Introduction

Ecological considerations are of considerable importance in selecting suitable trees for the streets of Pacific Northwest cities. The most significant factors of environment are climate and soil, to which the chosen trees must be suited.

The Pacific Northwest has a characteristically dry summer - wet winter climate, moderated by the Pacific Ocean, and more particularly by the warm Japan Current (40, pp.20-28). It is further modified by the topography

of the area, which consists of an exposed coastline, coastal mountains, the Puget-Willamette Lowland plains, the Columbia Basin, the Cascade Mountains and major river valleys. There is also a diversity of soils, the parent materials of which are of glacial, alluvial, volcanic and loess origins.

The autecological approach to the street tree problem for the Pacific Northwest closely follows the general approach of Daubenmeier (31, pp.4-296). Supporting information has been obtained from the Yearbook of Agriculture, 1938 (5, pp.979-1001) and (96, pp.1019-1161), the Yearbook of Agriculture, 1941 (44, pp.292-305), 49, pp.685-699), (102, pp.1075-1086) and (37, pp.1170-1181), Transactions of the British Columbia Natural Resources Conferences (24, pp.8-54) and (34, 14-22), and the various sources of information on the 245 species and varieties listed in the card index system.

The principal factors of environment in relation to the selection and use of trees on the city streets are edaphic, climatic and physiographic, (31, p.2) as mentioned previously. Of these, separate classifications have been made under the major headings of soil, water, temperature, light and atmosphere. These factors do not operate independently, however, and each must be considered in relation to all others and to the trees which might be selected to grow in the environmental complex.

Soil is necessary as a support for trees and as a source of water and nutrients. It is composed of mineral and organic matter, air and water, the proportions of which determine the type of soil. In relation to soil, trees have specific requirements or adaptations. It is possible, therefore, to classify some of them according to their known requirements.

The principal source of water for plants is from the soil. While the entire Northwest has a dry summer -

wet winter type of climate, the rainfall pattern is varied, ranging from over 100 inches per year in certain coastal districts (102, p.1078) to as low as six inches per year in parts of the Interior (37, p.1173). Consideration of the entire region is essential to determine the relations between the water factor and the total and seasonal requirements of the various tree species.

The effects of low winter temperatures have formed the basis for determining the hardiness of trees. Application of this factor to the Pacific Northwest provides a basis for designation of hardiness zones, comparable to those of Rehder (73, pp.xii-xiii) and Wyman (109, p.6). All trees suggested for street use have been classified according to these zones and suitable selections can be made for each region. Other effects of temperature are extremes of heat (31, pp.208-209) and, indirectly, length of the growing season (31, pp.201-202), both of which may serve as a basis in the selection of trees.

The light conditions of the Northwest vary with the degree and consistency of cloud cover and the density of smoke and other particles in the air above the cities. Some trees require partial shade and others require full sunlight for suitable growth and development.

The final climatic consideration is the atmospheric factor. The direction and force of prevailing winds, the prevalence of wind storms and the effects of these on the growth of trees must be considered. Storms coming off the ocean are frequent in the fall, winter and early spring (37, p.1180). Deformation may result from consistent exposure to the winds on the coast or at high altitudes. Tornadoes are rare in the Pacific Northwest (37, p.1180), but heavy winds may cause severe breakage.

The Edaphic Factor

In any ecological study, the medium in which or on which the organism grows is of primary importance. Since this thesis is concerned with trees, which take root in and draw their water and nourishment from the soil, a discussion of the edaphic factor (31, p.5) and an analysis of the apparent reactions of the various trees to different soils are of fundamental importance. Tree roots normally occupy a very large volume of soil. This is necessary for anchorage and to provide an adequate amount of surface contact between the soil and the plant for the uptake of water and nutrients.

Trees and soil are strongly influenced by each other. The type of tree, its size, shape, and root system are all strongly influenced by the nature of the soil. Differences of soil have been know to affect the vigor, the date of flowering, the amount of inflorescence, viability of seeds, the susceptibility to drought, cold injury, pest, and disease injury (31, pp. 6-7). Trees, on the other hand, by the actions and interactions of the physical and chemical processes associated with growth, absorption of nutrients, interchange of gases, and decay, may affect the development and properties of the soil (31, pp.76-78).

Each environmental factor has a potential influence on the growth of trees, yet all are not equally important at one time. Each factor assumes greater importance and becomes more limiting when it begins to tax the ability of the plant either to tolerate it in greater intensity or to survive under a lower intensity (31, p.3). Each type of tree, then, has an optimum within its ecological amplitude. Although this optimum is of great importance in tree selection, it must be recognized that it is often possible to alter or modify the soil to meet the specific requirement of the tree. The soil factor differs from all other factors of environment in this respect.

Modification of the soil has been the basis of most management practices for a wide range of agricultural crops. Because of the nature and extent of the tree root system, it is seldom economically feasible to carry out extensive alterations; hence, the characteristics of the soil at the site of planting is of great importance.

Several great soil groups are represented in the area under study (5, p.987). In the north are the gray-brown podsolic soils of glacial origin; further south, the alluvial valley soils. On the higher elevations of the Coast Range and the western slopes of the Cascades are the gray-brown podsolic soils of basaltic and sandstone origin. Red and yellow podsols are represented in the south. East of the mountains are found the chernozem soils of the Palouse region and chestnut soils of the Walla Walla area. These are of loess origin and are fairly typical of the various soils of this region.

The cities of Seattle, Bellingham and Vancouver, B. C., lie within the Everett-Alderwood series (5, p.1036), described as: slightly acid, podsolic or leached, light-colored soils, some places very thin, with a slightly developed gray ashy layer beneath the dark organic surface layer. They are mostly gravelly sandy loams and stony loams, but there are some areas of finer texture. These soils contain numerous small dark brown rounded aggregates, cemented by oxides of iron and aluminum and containing phosphorus in an unavailable form. The characteristic profile is: 1. loose forest litter, 2. thin dark brown surface layer, 3. gray-brown, pale reddish brown or yellow-brown friable material, 4. subsoil of pale yellow-gray or light gray, irregularly stratified, loose porous, sandy and gravelly materials, with excessive drainage and low moisture-holding capacity. The silecious cemented gray substratum or hardpan layer is relatively impermeable to moisture and roots.

Olympic-Melbourne soils (3, p.1045) are found on the hilly and mountainous areas of Western Washington, Western Oregon and Southwestern British Columbia. The city of Victoria, B. C., lies within the Melbourne area. Soils are described as: dark brown, friable surface soils, beneath a superficial layer of forest litter, becoming rich brown below and grading into moderately compact plastic subsoils, yellow and mottled with reddish-brown in the Melbourne and brown to reddish-brown in the Olympic. Clay loam and loam textures predominate. Soils and subsoils are moderate to strongly acid.

The city of Portland comes within the Willamette-Amity Dayton series (5, pp.1050-1051), which are closely associated with the alluvial Chehalis and Newberg soils of the stream bottoms. Soils are mildly to moderately acid, with moderate to low organic matter. The surface consists mostly of loams and clay loams, rich brown through gray-brown to light gray or nearly white. The well drained Willamette soil has a friable brown surface over mellow, permeable lighter brown soils. The Amity soils have slower drainage and consist of gray-brown surface with lighter colored subsoils. Dayton soils are poorly drained meadow podsols, with very thin gray or dark gray surface layer over light gray or white ashy sub-surface. Beneath these layers is a heavy, tough dark gray clay subsoil and substratum of light olive-gray lighter textured material.

The Palouse area is normally treeless, rolling upland. Soils are silt loam, with a mellow and granular very dark brown surface layer (5, pp.1079-1080). Subsoils are lighter brown, but heavier and more compact. Nearby are the Hyrum-Bingham-Avon soils (5, p.1081), brown to dark brown, mellow, granular, gravelly loams over very gravelly subsoils. These are cemented with lime one and a half to three feet down.

The Walla Walla soils (5, p.1083) are also treeless. They consist of brown to dark brown mellow floury surface soils over soft pervious light brown subsoils. They, too, have a lime concentration area which in this instance is five feet down.

Most of the prinicpal cities in that part of the Pacific Northwest under this study lie within the range of these soils. The kinds of soil have been limited to three for this classification: clay and clay loam, medium loam, and sandy or gravelly loam. These can be interpreted in the layman's language to mean: heavy, medium and light soils. A further breakdown to shallow and deep soils of each kind appears in the classification. This is of great importance in relation to the nature of the root system of the individual tree species.

It is evident that the root system does not always follow its typical form. Juglans nigra is known to be characterized by a deep tap root in its native habitat. Yet 18 to 20-foot specimens of this species, grown in the nursery at The University of British Columbia without root interference were shown to have no indication of tap root. The root system had developed into a widespread, fibrous structure in the light, shallow soil of the area.

Soil reaction is important in relation to tree selection (31, pp.53-55). Most of the soils of the coastal region and valleys west of the Cascades are slightly acid in reaction. Unless the acid condition is in the extreme, the selection is not severely limited. Many tree species have no definite pH requirements within a normal range. Extreme acid conditions are found in moist "bottom land" areas, where an extensive correction program must be undertaken, unless the selection is limited to oxylophytes. East of the Cascades, lower rainfall and volcanic parent material have resulted in alkaline conditions, often in the extreme (5, pp.1081-1083). Here the selection is limited to calciphytes, unless a correction is effected.

The Water Factor

It is impossible to separate the water factor entirely from the edaphic factor. Soil moisture is an important factor in the formation of soils. Water is made available to the plant through the soil, while the nature of the soil will affect its infiltration, rate of movement and its storage.

Water is essential to plant survival and growth, being the solvent which contains mineral nutrient elements from the soil. From an ecological standpoint, the processes involved in the movement of water through the plant are of little consequence (31, p.86), but the amount of intake and subsequent loss of water from the plant tissues and surrounding soil is extremely important. The actual use and loss of water is affected and often controlled by the environment in which the plant is growing.

The rainfall pattern of the Pacific Northwest is generally dependent on cyclonic precipitation (31, p.97). This is incident to the eastward movement of low pressure areas over British Columbia. The geographic distribution of rainfall is considerably affected by topography, extensive orographic precipitation (31, p.97) occurring on the windward side of the principal mountain ranges. Western Oregon, western Washington and southwestern British Columbia receive little convective precipitation, although some does occur in summer in the interior regions, especially in the vicinity of the lesser mountain ranges.

Precipitation increases from the coast to near the summit of the Coast Range, decreases in the western interior valleys, rises again on the western slopes of the Cascades, and drops off sharply east of these mountains.

Examples of an "approach effect" (31, p.105) of this precipitation pattern are frequent. Vancouver, British Columbia, which would be expected to have a western interior valley form of precipitation because of the protection afforded by Vancouver Island, gets an average of 60 inches per year which is deposited before the moist air rises over the Coast Range.

The range of average annual precipitation is from six inches in the central interior to something over 140 inches on the coast of Oregon, Washington and western Vancouver Island.

Seasonal distribution of precipitation follows a consistent pattern across the entire region. This is extremely important to plant growth (31, p.109), since the most critical period for water shortage in a plant species is the period during which it is making its most rapid growth. At this period precipitation in the Pacific Northwest is at its lowest.

Rainfall is important to trees only through its effect on the soil, since there is little absorption of moisture through the leaves (31, p.90). Not all precipitation is equally effective in increasing the soil moisture (31, pp.111-114). During prolonged rainy periods much of the moisture sinks below the effects of surface desiccation, where it is conserved for plant use. There is, however, less runoff from surface showers, but this moisture is quickly evaporated.

Figures of annual average precipitation are of little significance in an ecological study. The life cycle of a plant must be compatible with the climate, at least to allow for good vegetative growth. For many of the tree species, however, it is not necessary to provide for a complete life cycle, since the reporductive organs may not be required for the desired effect.

In low rainfall areas, where the water table is not too far below the surface, deep rooted trees may take advantage of water rising by capillary action (31, p.117). Hence such trees, once established, may be able to survive on this capillary water without additional supply. Deep rooted trees are likely to be the most successful for the drier regions of the area under study.

Many trees are readily adapted to consistent conditions of low annual rainfall, but if the precipitation is below normal even in such areas, drought conditions may seriously affect them. Results may be reduction in size, loss of vigor or death (31, p.143).

Snow may add to the total water supply for tree growth. This will depend on conditions of frost in the soil when melting and the rate of melting. While snow provides a protecting cover for many plants, it is of little protection to trees. On the contrary, it is more likely to cause deformation or breakage (31, p.101)

The ability of the various tree species to withstand conditions of snow has, therefore, been an important consideration in the selection of tree species for certain areas. In the interior regions of the Northwest, snow is usually dry and light, readily blown off the trees by the wind. In coastal regions and western interior valleys, snow is often heavy, sometimes being followed by ice conditions or heavy winds. Hence, breakage is more likely to occur.

Hail and sleet are insignificant as quantitative measures of soil moisture addition, but both may cause damage to the aerial parts of trees.

Ice is of more importance, not in regard to the addition of moisture, but in relation to breakage. Ice storms are not common in the Northwest, but when they occur, susceptible trees may be severely damaged.

There is little record of the needs of the various tree species for humidity. An outstanding example of the affiliation of a species with high humidity is *Sequoia sempervirens*. This species is naturally restricted to the "fog belt" of the northern California coast region.

Fog is common to much of the Northwest (37, p.1180). It arises from three sources: the fog belt of the coast from warm air passing over cold water currents in the sea, the subsequent fog drifting inland; fog on the mountain slopes, from warm air rising up the slope to meet cooler conditions; morning fogs of the western interior valleys, a result of the nocturnal radiation of heat and rapid cooling of the soil when there is little movement of air.

Coastal fog belts are most frequent in the summer; fogs on mountain slopes are frequent throughout the year; morning fogs are most frequent in the autumn.

Water vapor affects solar radiation by interception. This may have a favorable effect on species which cannot stand full sunlight. However, the action is more often unfavorable, especially in humid areas where light and heat may be inadequate for many species.

Atmospheric water is of little direct value to trees. Condensation may occur on leaf surfaces, but little of this is available to the plant. If the condensation is great enough to cause "fog drip," the species may derive some direct benefit. Condensation onto the surface of the soil is not of great importance, except for certain desert species with very shallow roots.

Extremely low humidity, causing increased evaporative power of the air is important to plants mainly through the influence on effectivity of precipitation in replenishing soil moisture. Drying of the soil below three decimeters is due mostly to absorption by the roots.

The Temperature Factor

Most meteorological data based upon temperatures are presented as the averages of maximum or minimum readings. These averages are misleading and of little value in an ecological study. In some cases the maxima may be of most importance, in others, minima. The extremes represented by the maximum and minimum readings together may have significance in relation to plant performance. This may be true for diurnal fluctuations as well as annual maximum and minimum readings.

The relative hardiness of the various tree species and varieties has been judged on the basis of their ability to withstand certain well-defined cold temperature limits.

The system of hardiness rating is based on the following classification: Zone 1, exceeding -50° F; Zone 2, -50° F. to -35° F; Zone 3, -35° to -20° F.; Zone 4,

-20° to -10° F.; Zone 5, -10° to -5° F.; Zone 6, -5° to 5° F.; Zone 7, 5° to 10° F.; Zone 8, 10° to 20° F.; Zone 9, 20° to 30° F. (73, pp.12-13) and (109, p.6).

Judgments of hardiness based on minimum temperatures alone are inadequate as many other factors affect survival and normal performance of plants. Some trees are not injured until they are frozen, and some species can endure periods when the tissues are frozen solidly and the temperature drops to the limits of Zone 1. All organs of the same plant are not necessarily equally resistant to low temperature at the same time. Leaves and roots are more sensitive to the same degree of frost than stems and buds. Few broad leaved evergreen trees are capable of withstanding extreme cold and are restricted to the more favorable zones.

Other conditions of environment may be equal in importance to minimum temperature in relation to winter injury (31, p.203). The nature and moisture content of the soil, the suddenness of the cold snap, the state of fertility, the direction and force of wind, the degree of cloud cover, if any, all may effect injury or killing of plant tissues, in association with extreme cold.

A detailed study has shown that representative Pacific Northwest cities fall into the following classifications: Zone 8 - Eugene, Oregon, and Victoria, B. C.;

Zone 7 - Portland and Corvallis, Oregon, Vancouver, Olympia, Tacoma, Seattle and Bellingham, Washington, and Vancouver, B. C.; Zone 6 - no principal cities; Zone 5 - Medford and The Dalles, Oregon, Yakima and Walla Walla, Washington, Penticton, Kelowna, and Vernon, B. C.; Zone 4 - Spokane and Pullman, Washington.

It is of interest to note that, if the lowest recorded temperature over the past forty years in each of the above cities were the criterion for classification, each city would appear one or two zones lower in the scale. There have been exceptional years which have resulted in the loss of or injury to some tree species. Average minimum figures are accepted by the nursery trade to be an adequate guide and are the basis of the above observations.

The most important factors related to geographic variation in temperature are latitude, altitude (31, p.203) and distance from large bodies of water (31, pp.182-184). It is proximity to the ocean that places much of the Pacific Northwest, west of the Cascades, into a common hardiness zone, offsetting the effect of the fairly high latitude. In the summer months, this marine climate has an occasional moderating effect on the interior regions as well, but in the winter, these regions are sometimes subjected to the effects of a continental climate, resulting in colder temperatures. In the coastal regions, the greater humidity associated with water acts as a shield against some of the heat radiated from the sun and as a blanket which slows the re-radiation from the earth.

High temperatures can kill plant tissue (31, pp.208-211). When the temperature rises above the maximum for growth, a plant becomes inactive. With further heating, a lethal level is reached. This thermal death point may be only slightly above the optimal temperature for growth. High temperatures may bring about a lack of balance between respiration and photosynthesis. The adverse effect of excess heat may be from desiccation.

Little work has been done toward classification of trees species and varieties in relation to their resistance to extreme heat. It has been difficult, therefore, to establish a quantitative basis for judgment of their tolerance of this factor. A simple classification of those species able to withstand temperatures exceeding 100° F. has been selected, with separate lists of those species which favor more moderate summer maxima.

Selection of trees for an area where optimum temperatures prevail is not altogether satisfactory, however, since these conditions may result in too rapid growth for the purpose for which the trees have been selected. This possibility must be taken into consideration when the selection of species is being made.

Each species of tree has its need for a certain amount of summer heat (87, p.16), in spite of its possible limit of tolerance of the extreme (87, p.15). Some species, although hardy enough to withstand the winter minima of the Northwest, do not thrive in the moderate summer temperatures of this region. An example of this is Lagerstroemia indica, which does well in Southern California. Its growth is unsatisfactory farther north and its blooming performance is poor, although it will withstand the cold extremes of the north.

In the same manner, lack of winter cold may adversely affect certain species (87, p.15). Many deciduous trees will be late in leafing out, following an exceptionally mild winter. This was the case with Catalpa speciosa, on the campus of The University of British Columbia in the summer of 1953, following a snow-free winter with little frost. It has been suggested (87, p.15) that this requirement for a definite amount of cold is a natural mechanism to prevent the buds from breaking during a mild spell in the middle of winter. After the buds have had their quota of cold hours, they are then ready to open only when their requirement for spring warmth has been met.

Reproductive processes are usually the first to suffer from insufficient heat or lack of winter cold. Since vegetative growth is all that is required from many species, lack of heat or cold may not be serious. Attempts have been made to establish a quantitative basis for evaluation of various species in terms of their requirements for heat and cold (87, p.16). A more detailed study of this factor is necessary before a definite relationship can be announced.

Most of the growth of deciduous trees takes place during the frost-free season (31, pp.201-202). The general performance of most species, however, bears no direct relation to this period. The term, therefore, is not synonymous with "growing season" (31, p.202). Little significance can be placed on the suggested classification according to frost-free season.

Length of frost-free season decreases with increasing altitude and with distance from oceanic influence. The editors of Sunset magazine (87, pp.18-21) have divided the Northwest into five zones: 1. Intermountain, with 170-180 frost-free days, comprising much of the interior of British Columbia, Washington and Oregon; 2. Columbia Basin, 200 frost-free days; 3. Cool Puget, 180 days, represented by the Bellingham area; 4. Puget Sound, 250 days, as in Seattle; 5. Willamette, 200 days as in Portland. Selection of trees for these regions, however, cannot be made, according to this frost-free classification, for it has been noted that winter minimum temperatures are of greater importance in limiting the selection.

The Light Factor

Light and temperature are closely related in their influence upon plants. Within limits, the efficiency of light energy increases with rising temperature (31, p.249). This is evidenced by the fact that in colder climates, species are less tolerant of shade.

The effect of various conditions of light depends to a great extent upon the stage of life cycle, the kind of plant and the particular plant function. With trees, especially in relation to their selection for use in cities, their ability to withstand the exposure of full sun, partial or deep shade, is most important. The fact that in the seedling stage, under natural conditions of environment, they are unable to survive in either sun or shade does not need to be considered. The relation between light conditions, temperature and other factors is important. The entire environmental complex must be considered, but in relation to the performance of the relatively mature plant.

All moisture in the atmosphere exerts a screening influence on light (31, pp.225-226). Intensity of light is much greater in dry than humid climates. Unless affected by cloud and fog, there is little significant difference in the effects of the variation in intensity. The coastal strip of the Pacific Northwest, having higher relative humidities than the interior regions, has lower light intensities. This condition is favorable for the growth of broad leaved evergreen species. Lower humidities and consequent higher light intensities in midsummer in many regions may be limiting, unless additional moisture is applied. It is the effect of low humidity, rather than high light intensity, in this instance, that is the limiting factor.

Solid particles in the air from smoke and dust, characteristic of many city districts, may have a significant screening effect. Smoke may cut off 90 per cent of the light (31, p.227), but adverse effects are more frequently due to subsequent accumulation of smoke and dust on the leaf surface, tending to close the stomata, although this film itself will decrease the intensity of light reaching plant tissues.

Trees differ in their ability to withstand city conditions and this is discussed in subsequent sections under "Tolerance."

There are few true heliophytes and sciophytes among the various tree species under consideration. Many are facultative heliophytes or facultative sciophytes, making this characteristic of lesser importance.

Examples of obligative or facultative sciophytes are most species of _Acer_, _Fagus_, _Tilia_ and _Quercus borealis_ (31, pp.236-237). Among the obligative or facultative heliophytes are _Acer saccharinum_, _Quercus macrocarpa_, _Salix_ and _Populus_ species, _Liriodendron Tulipifera_, and _Betula_ species.

Low light intensity may favor vegetative development at the expense of reproductive development (31, p.243). Certain species of trees which are valued for their flowers are therefore limited to regions of high light intensity. This relationship, however, cannot be divorced from the temperature factor, which may also have an effect on the production of flowers and fruit. Many species of trees which have inconspicuous flowers or fruit may be grown successfully under low light conditions, as the vegetative growth may be normal.

Length of day is of some importance in relation to the selection of trees. Species may be short-day, long-day, or may not be affected by daylength in relation to reproduction (31, pp.244-245). This factor is of importance only to those species which are important for their display of flowers or fruit. In certain deciduous trees, however, length of day controls leaf abscission and dormancy. In rare instances, trees subjected to artificial light from street lamps or floodlights may fail to drop their leaves and fail to enter a period of dormancy. This may lead to winter injury from frost or snow.

The Atmospheric Factor

Movement of the air is the most important atmospheric factor in relation to the use of trees. In the Pacific Northwest, the movement of winds is usually off the ocean. Winds of gale force are common on the exposed coast and part way inland. Consistent strong winds follow the storm systems which cross the coast during the fall, winter and early spring rainy seasons. Dry winds from polar air masses are more frequent in the winter east of the Cascades. In the summer, winds are usually dry when they reach the inland valleys and are exceptionally devoid of moisture when they reach the interior where higher temperatures prevail. Inland valleys west of the Cascades and coastal areas experience their highest temperatures in summer periods when easterly winds bring hot, dry air through the mountain passes and down the river gorges.

The protracted effect of dry winds can cause death of leaves and twigs (31, pp.282-284). Trees are more subject to injury from desiccation than lower forms of plant life.

Wind may injure plants in many ways, directly or in conjunction with other factors. At the same time the various tree species differ in their resistance to the effects of strong or consistent winds (31, p.286).

Injury or deformation from steady winds from one direction is in evidence along the exposed coastline. Some cities of the region, for example, Victoria, B. C., have streets exposed to the ocean. Here, examples can be found of abnormalities of various tree species. They may lean in one direction, be dwarfed, or low or spreading. Some species develop a fascicled system of branching because the tips of branches are killed and lateral buds produce vigorous growth. Similar forms of injury are in evidence at high altitudes, where dwarfing is frequent, and many tree species become almost prostrate.

Mechanical damage in the form of breakage from high winds is common (31, pp.289-290). Tornadoes are almost unknown in the Northwest, but exceptionally strong winds may cause this damage. The type of injury and the degree of loss sustained depend on the branching pattern. Damage will also be much more severe if tissues are frozen when the high winds occur. It is considerably increased when winds are accompanied by ice or wet snow.

Ice storms are infrequent, but wet snow is characteristic of most winters in the inland valley areas. It is important, therefore, to select species of trees that will withstand these conditions.

All species of *Populus* and some *Acer* species have soft wood that is brittle and will break easily. *Tilia* species have soft wood, but are less susceptible, owing to the presence of a strong sheath of phloem fibres surrounding the wood. *Ulmus americana* is not listed as a susceptible species in the eastern United States. It is, however, strongly susceptible to breakage under the conditions of the western portion of the Pacific Northwest. It is possible that a dry summer followed by a comparatively warm moist fall season have the effect of keeping the wood softer than is characteristic of the species in its normal habitat. Severe damage may result.

Uprooting of trees in high winds depends on the depth of roots (31, p.290). This is determined by species characteristics, the nature of the soil and the level of the water table.

Wind which carries soil or ice is strongly abrasive. Damage may occur in certain interior regions where these phenomena are more likely. Salt spray may have an injurious effect upon certain sensitive species.

CHAPTER IV

CONTROLLED CONDITIONS OF ENVIRONMENT AFFECTING THE SELECTION OF STREET TREES

Introduction

The environmental complex of the city, consisting of man-made, or controlled, forms and spaces, constitutes a set of conditions, each of which may affect the selection of trees. It is necessary, therefore, to consider these controlled conditions, in order that a suitable selection of trees can be made to satisfy them.

The layout of the city street may make planting impossible, particularly in business blocks (85, p.7). Planting may be highly desirable in other sections, however, but the choice of trees may be determined by the nature of the area or type of street. The width of street, building setback, width of planting strip, all place certain limitations on the choice of material, since the tree must fit into a restricted area. Overhead and underground service lines offer obstructions to the branching structure and the root system. Suitable forms of trees must be chosen to conform to these limitations.

The height and design of buildings may suggest the landscape effects which should be created by the use of trees in relation to them. Hence, they offer a controlling influence on the selection of suitable forms to carry out the required design effects.

In order to effect proper selection of trees, each of these factors must receive consideration.

Type of Streets

The principal cities of the Pacific Northwest have zoning regulations that restrict the type of development in each area or district. For instance, certain areas are planned to be exclusively residential, others business or commercial, still others industrial. The residential areas, in turn, are usually divided into single-dwelling districts and multiple-dwelling districts. Thus, there is some control over the type of building in each area and the city is developed in an organized fashion.

Under this heading, trees have been classified, in a very general manner, to suit this organizational pattern. Consideration has been given to the probable types of buildings, population densities, the volume of traffic and width of streets. The selection of trees represents broad groups which might be suitable for various sections of the city.

In one-family dwelling areas, the type of street planting depends upon the nature of the residential development. Many of the crowded low-cost housing areas have developed without careful planning and little room remains for street trees. Regular planting should not be undertaken in these districts, or if present, should be removed. Exclusive residential areas usually have been planned with more room for street trees. If there is space for such planting, trees can form an important part of the design of both types of street, providing a screen, giving shade and introducing an element of harmony in some cases, adding to the privacy and restfulness of others. Trees may be chosen to integrate the various architectural forms in any neighborhood.

Planting in relation to multiple-dwellings has been difficult. Massive apartment houses have been crowded onto the street in many districts, but the contemporary trend in design and layout is toward taller buildings with garden setbacks. This arrangement provides for extensive landscaped areas, where trees can be introduced. However, if there is sufficient room for them, tall, massive trees, not necessarily widespreading, should be used to integrate the huge architectural masses (26, p.xx).

Extensive planting is seldom possible in downtown business areas. There, streets are of various widths, with buildings of differing heights crowded onto the street, leaving little room for street trees. However, wherever trees are possible, they provide a welcome addition to the street, tending to unify the downtown scene, and to modify the pace of the crowds of people. Comparatively small trees, closely spaced, would be desirable from the pedestrian's standpoint, as they would be more in scale with him and spaced in relation to his speed. Suburban business blocks are often set out in such a way that trees can be used, providing a link with surrounding residential areas.

Many of the industrial areas of the city are being improved. Wherever new factories and warehouses are being built, the trend is toward more spaciousness. This is achieved through the provision of a greater building setback, with landscaped areas between the street and the buildings. Large trees, spaced by twice the width of the tree, are usually most suitable for this area, wherever room has been provided and where the width of the street is sufficient to support them (93, p.6).

For both the downtown areas and industrial districts, trees which are tolerant of city conditions must be chosen.

Highway entrances and divided boulevards are much alike in that the largest street trees can usually be accommodated. The entrances to the city are less formal, however, and planting sometimes can be used to provide a sense of transition from the countryside into the formality of the city. Traffic is moving into and out of the modern city faster with the development of wider streets, controlled lanes of traffic and graduated speed limit regulations. Planting should be planned in relation to the density of traffic and the speed (27, p.215) and (58, pp.145-146). More diversified planting, with trees in groups or widely spaced, is a logical choice where traffic is passing the rows of trees at a rapid rate.

The divided boulevard, or very broad residential street, is usually not intended for fast moving traffic. Neat rows of large trees, evenly spaced, provide the necessary formality, assuring a sense of balance to the street. Continuing interest can be assured by introducing blocks of contrasting forms or voids, the entire arrangement, however, remaining in scale with the width of the boulevard and the massiveness of the adjacent buildings.

Street Widths

Width of street usually determines the size of tree which can be accommodated on it (97, p.4). Final selection, however, may be governed by the desired design effect, the selection being made from those trees whose crown is not too extensive for the available room.

While the height of trees to be selected is most logically related to the height of nearby buildings, their spread should not be too great for narrow streets. Trees of medium size will not overhang the pavement too far and, if well formed, will provide the necessary canopy overhead. They are more in scale with the size of the street. If the small tree is chosen, it must not be too low-headed, as the lower branches might interfere with passing traffic. If tall, upright trees do not appear to be out of place on the narrow street, they might be favored for this reason. Tall, open trees might provide a suitable canopy overhead, but columnar trees are very effective for most narrow streets which need the effect of elevation.

Broader streets can support the larger trees, which seem to be more in suitable proportion to them. Their choice, as determined by height, may be based on the relationship of scale to height and massiveness of adjacent buildings. If there is room for them and their dominance is not out of place on a particular street, tall, widespread trees are well suited to the broad street.

Many other factors affect the choice of street trees, but the restrictions imposed on their selection by the width of streets are most limiting (74, pp.178-179).

<u>Building Setbacks</u>

The distance between the roadway and the leading edge of buildings along the street is known as the setback. This distance is governed by municipal regulation in most cities. It varies from district to district, depending on the depth of lot, the type of building allowed in the area and the use for which the buildings have been constructed. A standard setback rule has the effect of providing uniformity to the street, since most buildings are placed on the required building line. It also provides a uniform space for the growth and development of trees (54, pp.20-21).

The street tree is usually placed in the planting strip, between the roadway and sidewalk. If the sidewalk borders the roadway, leaving no planting strip, trees may be planted in the adjacent lawn area (109, p.81). This usually is possible only if mutual agreement between the city and the residents of the street has been obtained. In some instances, the road allowance includes a strip on the property side of the sidewalk. Trees should be placed in this strip, if possible, in order to present less interference with the street traffic. On streets which have very narrow planting strips, there may not be enough room for a row of trees, unless arrangement can be made, as above, for placing them in the lawn.

The consideration of trees in relation to setback is similar to the width of roadway, in that trees must be found to fit the space provided, the determining factor being spread rather than height. Where space is limited, small trees of all forms and larger trees of narrow habit of growth are most suitable. Where the setback is great enough to accommodate the full crown of larger trees, they might be selected, provided that other factors, equally related to their choice, are suitable for their selection.

Planting Strips

The strip of land between the bed of the roadway and the sidewalk is variously known as the planting strip, parking strip, boulevard strip or parkway. If trees are to be planted in it, it must be wide enough to accommodate them (103, p.109).

Minimum widths of the planting strip is four feet, even for the smallest of trees (97, p.7). If arrangements cannot be made for planting the trees on the property side of the sidewalk, where the planting strip is too narrow for them, no regular street trees should be used. The wider the strip the better for all types and sizes of trees. The major supply of moisture and nutrients from the surface is restricted to the area of the strip, since it is bordered on both sides by pavement. The crown of the trees have more room to spread if they are planted in a wider strip, making the accommodation of larger trees possible, with less need for drastic pruning to prevent interference with vehicular and pedestrian traffic. The size of the tree is therefore in direct proportion to the width of the planting strip. Tall, columnar trees might be used in narrow strips, indicating that amount of spread, rather than height, is the governing factor.

<u>Overhead Obstructions</u>

Overhead wires, still a familiar sight on many city streets, offer a major source of interference with a tree planting program. The planting strip is usually the area chosen for location of poles which carry overhead power and telephone lines. On the ideal city street, these services are underground. Unfortunately, few of the cities of the Pacific Northwest have been financially able to make the change and most streets continue to support a number of wires. In recent years, some relief has been given by the change from electrically powered street cars to motor busses, allowing for the removal of some overhead wires, although in some cities, for example, Vancouver, B. C., street cars have been replaced by trolley coaches, powered from overhead wires and the quantity of overhead lines has not been reduced.

The prevalence of overhead obstructions in any city depends upon its layout. For instance, buildings in most districts of Vancouver, B. C., are serviced from power and telephone lines which are placed in the service lane at the rear of the property. Where this is the case, the only overhead obstructions left for the street are the lighting standards. With suitable regard for their spacing, little interference is experienced from them when planning the street planting program.

If the overhead obstructions on the city street are too great, it may be necessary to delete the trees. This is usually an unfortunate choice, however, since it is agreed by most observers that power lines possess little aesthetic appeal on the city street.

Trees and overhead wires (6, pp.66-73) can coexist in most instances, if the wires are high enough to accommodate the smaller trees, or if a sensible pruning program is undertaken to allow the wires to go through the trees. Too often the choice is in favor of the large tree and a practice of annual or biennial removal of the majority of the upper structure of the tree to prevent interference. This is not only a costly practice, but an unsatisfactory one, since a street lined with such butchered trees presents an unsightly picture. This is especially true during the winter months, when deciduous trees are devoid of their leaf canopy. When the foliage is present, the effect is not so unfortunate, although the tree crowns frequently appear to be out of proportion to the heavy trunks and too rigidly controlled to be natural.

If the lines are present, the most satisfactory solution is to choose species which are small enough to grow under them without interference. Many of the smaller trees, particularly flowering types, are a suitable choice. They have been classified, according to height, as those suitable for use under 25 feet to 35 feet high wires and those for use under 35 feet to 50 feet high wires.

It is to be hoped that most cities of the Pacific Northwest will be able to dispense with overhead obstructions in the years to come. The street planting problem would be immensely simplified.

Underground Services

Most of the underground services on the city street are located either in the planting strip or along the curb line adjacent to it. Fortunately, many of the service lines are constructed of or enclosed in a solid conduit which cannot be penetrated by the roots of trees. Drains and sewers, however, are constructed of less permanent material. They can be broken or clogged by tree roots if placed too near them (94, p.7)

The minimum depth of sewers for any city is usually determined by the topography and the depth of frost experienced in that region, the line being placed well below the frost limit. In regions which have severe cold winters sewers are very deep. The principal cities of the Pacific Northwest have moderate winters, frost seldom penetrating more than a few inches below the surface. Shallow sewers are common and interference from tree roots is a frequent occurrence. Under these conditions, it is necessary to select trees which have a root system not likely to cause trouble.

Trees which have compact, fibrous roots are least likely to create interference. They can be used on most streets, regardless of the nature and depth of underground services. If the root system is more widespread, yet not deep-rooted, the trees can be used safely over deep sewers, but not the horizontally spreading roots which may interfere with nearby drains. Tap rooted trees should not be planted directly over sewer lines.

Classification of street trees in relation to underground services, therefore, is directly related to the type of structure of their root systems.

Building Heights

The selection of trees in relation to building heights has been partially discussed under "Types of Streets." However, too little emphasis has been placed on the rows of trees as a specific design element of the street (36, p.10). A more detailed classification is necessary.

The recent trend in West Coast architecture is changing the appearance of the residential street. Houses are more widespread, often all on one floor, with a flat or slightly sloping roof. This is in marked contrast to the taller houses with high-pitched roofs which formerly predominated. Two-story houses tend to be equally horizontal in effect, but are more massive. Trees for the newer subdivisions should be planned in relation to these forms.

In relation to the modern architectural forms, planting should play a subordinate role (74, pp.176-178). Avenues of trees, selected for their functional use in the design, can provide a powerful influence by bringing together and adding harmony to the diversified design components of the street.

The city residential area may differ from the suburban in that more crowded conditions prevail (26, p.195).

Streets may be narrower and houses closer together. There may be greater variety in the architecture of the city street, because it has been settled for some time with buildings which are typical of the decade in which they were constructed. Street planting, if there is adequate room for it, must be planned to bring some order to this varied architectural scene, without seeming to make the street appear more crowded. Neat, small trees for one-story homes, or tall, columnar forms for the larger houses, are most suitable for this purpose. Many of the older streets of the Northwest cities were planted with large forest specimens. Such trees should be replaced with more suitable types.

Trees in city residential locations may be subjected to the same smoke and gas conditions and reduced light of the industrial area. Species which are tolerant of these limitations must be chosen. This difficulty usually is not encountered in the suburban area.

The type of tree selected for use in relation to the height of multiple-storied buildings depends upon the massiveness of the structures, their proximity to the street and other factors, such as width of planting strip, previously discussed. Small trees may be out of proportion to them. Therefore, if any trees are to be used, they should be tall and narrow for the restricted space or more widespread and high if there is plenty of room for them.

CHAPTER V

MORPHOLOGICAL CONSIDERATIONS IN RELATION TO TREE SELECTION

Introduction

Each type of tree is known to possess a set of characteristics, many of which are important in relation to the possible use of that tree on the city street. A few of these characteristics are determined by the morphology of the tree - its branching habit, its ultimate size and its root structure. The morphological approach of Ward (99, pp.1-90) has formed the basis of this discussion.

Primary shoots and often certain lateral shoots of trees are negatively geotropic, so that buds are carried upwards. There is, however, considerable diversity of branching which is largely responsible for the peculiar habit of individuals, of species and of varieties.

Environment has a marked effect on this branching pattern but, in general, the morphological characteristics that are peculiar to the individual determine the manner of growth, hence the shape.

Shape and habit of branching constitute the form of the tree. The form, then, becomes a component part of the design of the city street when the tree is planted and allowed to develop there. The choice of form depends upon the desired effect.

The ultimate size of a tree is important, too, in relation to the effect of its form on the design of the street. A more or less definite size, like shape and habit of branching, is characteristic of each species and variety (40, p.71). It may be modified by the effects of environment, a tree growing under adverse conditions remaining stunted or, under most favorable circumstances for growth, growing larger than expected. For this classification, however, the average mature size has been taken.

The extent of spread of the crown of a tree is dependent upon the nature of branching. It is not necessarily, therefore, in direct proportion to the height.

The resistance of a tree to breakage by wind, snow and ice depends upon its branching habit and its shape. Tall, open trees, with branches ascending at an acute angle to the principal stem, are more susceptible than horizontally branching types. A pyramidal or columnar tree is less subject to damage from the weight of snow and ice than a widespreading, globose or flat, oval tree would be. The branching pattern may be slightly modified by the constant weight of snow or the pressure of consistent winds. The shape, however, may be considerably altered by these effects.

Roots, too, adopt a form of branching peculiar to the genus, species or variety of tree. Environmental effects are often even more pronounced on them in determining the nature and extent of the system.

Shape of Trees

Many plants normally direct a maximum of growth energy into one principal stem from the start of its development. The result is a tree with a thick woody trunk or bole.

In the course of the natural development of the tree, it may bear branches above the trunk only. Such is the case with most species of *Quercus*. The principal stem may bear branches all along its course, as is the case with most species of *Ulmus*. The trunk may break into dividing branches, like species of *Acer* and *Fagus*. The tree may be large and tall, like species of *Fraxinus*; it may be small and low, like *Crataegus*. In general, the type of branching determines the natural characteristic shape and, to a certain extent, size of the tree.

Environment may alter or modify the shape and size of the tree. Man very often modifies the form to adapt it to a particular circumstance. Some shrubs can be readily forced into tree form by pruning and cultivation (91, p.152). Conversely, many trees may be forced into shrub form by a process of coppicing. A pollarded tree differs from a coppiced tree in the height at which the lopping of the stems and branches is performed. To make a pollard, the trunk is retained (32, pp.118-119). This is a practice much in evidence in Great Britain and has been brought to British Columbia by gardeners from the United Kingdom. It is seldom seen in the American portion of the Pacific Northwest.

The prevalent form of the ordinary trees generally approaches a single type: a trunk bearing a more or less rounded head of foliage. The actual shape or outline of the tree, however, is determined by the branching pattern. Quercus, Platanus and Juglans have heavy branches at right angles to the principal stem. The branches zigzag in a horizontal plane, owing to their phyllotaxy. Acer platanoides and Fagus produce heavy branches which ascend at more or less acute angles and break into twigs or spray at their upper ends. In both instances, the stem cannot be traced to the top. The few main branches, which form the basic structure of the crown, have developed into limbs of approximately equal value.

If the main stem or axis continues to grow indefinitely, with lateral branches coming off at acute angles, the shape of the tree may be pyramidal, rhomboidal or tall oval. Examples of such trees are species of Sorbus and _Tilia_. A columnar tree is usually formed by a series of branches along the main stem which come off from it and ascend parallel to it. The main axis may or may not lose its individuality. It is lost in _Populus nigra italica_, but not in _Carpinus betulus fastigiata_, although in the latter secondary axes are of equal importance to it.

Some trees assume a weeping aspect, most of the smaller branches and twigs becoming long and pendulous (52, pp.110-113). The foliage, too, may be light and drooping. This is a characteristic of _Salix babylonica_ and certain varieties of _Fraxinus_, _Betula_, and _Ulmus_.

Some species of trees, devoid of a central leader, are tall and open in form. This has been the result of the weight of foliage bending down the branches into a more or less curved form. This shape is typical of _Ulmus glabra_ and species of _Tilia_.

The ordinary branch essentially repeats the structure of the stem, ending in a bud and with lateral outgrowths. These may be either alternate or opposite. The terminal bud may be killed by frost or may naturally die each year, for example, in _Ulmus_, _Tilia_, _Betula_ and _Castanea_. All species of _Acer_ have true terminal buds, with a determinate amount of growth each year; _Betula_ species possess pseudo-terminal buds, with an indeterminate growth.

The typical shoot system begins life with a remarkable regularity of structure, but some branches grow into shoots of unlimited growth; others form dwarf-shoots; others flowering branches; some terminal buds are arrested. Spur shoots, with short internodes limiting their growth, are frequently formed. These are the flower and fruit-bearing shoots of Prunus, Malus and Pyrus. Many trees develop branches where expected, only to cast them off later by a process of abscission, similar to leaf shedding. Thus, the branching of the shoot loses symmetry as time progresses and the tree takes on a form or outline which is usually typical for that particular species or variety.

Branches are morphologically of like kind with the axis producing them. However, they undergo alterations in form, position and relations, depending on environmental factors and their function. The primary axis continues to grow in length and develops branches or secondary axes in normal succession, so that the youngest and shortest are nearest the growing point, giving a tapered or acropetal appearance. If nothing has happened to the parent axis and it continues to elongate, with the lateral axes in acropetal succession, a monopodium or pyramidal tree results, with a racemose or indefinite branching system. If the terminal bud dies normally, the lateral bud grows on, making a sympodium tree, with a cymose or definite branching pattern. Any monopodial branching system may be converted into an artificially sympodial one by the process of removing the terminal bud during the course of development of the tree. It is not an easy matter to make a monopodial tree from a sympodial one, although some trees, when deprived of their central leaders, tend to form new ones from the nearest secondary axis.

The primary purpose of branching is to expose the leaves or other organs more effectively to light and air. If a tree is suddenly exposed to light, suffers severe pruning or loses a limb by breakage, epicormic branching may occur. These branches are formed from adventitious buds. Some trees which sucker freely following injury are: *Ulmus*, *Aesculus*, *Prunus*, *Platanus*, *Malus*, some species of *Acer*, *Tilia* and *Betula*. Among the trees which rarely sucker are: *Quercus*, *Carpinus*, *Fagus*, *Acer platanoides*, *Acer pseudoplatanus* and *Fraxinus*.

Advantage is taken of this principle in pollarding trees. Frequent examples are: *Fagus*, *Carpinus*, *Ulmus*, *Quercus*, *Populus*, *Fraxinus*, *Robinia*, *Acer* and *Betula*.

Root suckers, from adventitious buds, frequently occur on *Populus*, *Cornus*, *Sorbus*, *Liriodendron*, *Ailanthus* *Ligustrum*, *Euonymus* and *Robinia*. These may be a serious nuisance.

In summary, the classification of trees according to shape has been accomplished by the establishment of eight classifications, based on crown characteristics. They are as follows: rounded-globose, crown not taller than broad, often spheroidal, depressed, broad-domed, spreading, tall oval, crown elongated and obviously longer than broad, oblong or ovoid, the stem usually traceable to the top, flat oval, crown sub-spheroidal, the stem soon lost in the branches, which come off and ramify at all angles, pyramidal, crown tapering to a point, owing to the prolongation of the stem through it as a leader, pyramidal pointed, pointed conical, ovoid-acute, spiriform or tapering, columnar, crown not tapering to a point but rounded at apex, cylindrical, long ellipsoid, narrow-oblong or broad columnar, weeping, crown expanded and depressed, forming an umbrella-like head on the elongated stem, most of the smaller branches and twigs long and pendulous, horizontal branching, crown formed with extensively spreading limbs and principal branches zigzag and tortuous and spray very irregular, no tendency to deliquescence, tall open, crown somewhat rounded, the stem soon lost in branches at acute angles, tendency to deliquescence.

Root Systems

Branching of the root system is much less varied than the shoot, since fewer functions are performed by the former (48, pp.262-266). The primary root develops secondary roots, which, in turn, develop tertiary roots and so on, indefinitely. Typical roots only bear lateral organs of like kind, as no appendages are developed. In some instances, however, as with Malus and Populus, buds may be formed which develop into leafy branches.

Roots may encounter obstacles in the soil, necessitating some change. Tree roots are perennial, the larger and older portions being much like stems in their development of bark, wood and seasonal growth.

There are two types of root systems resulting from the dominance, or lack of dominance, of the primary root. If it grows more rapidly than the branch roots, it forms a central axis which penetrates the ground vertically faster than the secondary roots grow outward. This tap root system is characteristic of Carya, Juglans, and some species of Quercus. If, on the other hand, the secondary roots spread out horizontally at such a rate as to obscure the axis of the primary root, a fibrous root system results. Typical fibrous roots are found in Fagus, Fraxinus and Phellodendron.

The size of the root system may depend to a great extent upon environmental factors, such as the character of the soil, length of growing season and moisture supply.

Shape and extent depend, too, upon the nature of the species.

Morphologic effects of reduced aeration in the soil may include the following: less complex branching system, fewer root hairs and shorter roots. Under conditions of drought, the size of roots is usually increased.

CHAPTER VI

OTHER CHARACTERISTICS OF TREES AFFECTING THEIR SELECTION

Introduction

Each species or variety of tree has certain characteristics, other than size, shape and structure of roots, which help to determine its usefulness for various situations. Some grow faster than others. They may differ in their span of usefulness, in their susceptibility or resistance to diseases and pests, in their tolerance of the artificial environment of the city. Some are noted for specific characteristics, such as their production of showy flowers or fruit, their interesting branching pattern or seasonal effects. Each tree has a more or less definite landscape value in terms of its mass and texture.

The classification of street trees according to these characteristics helps to make possible the most suitable selection for any particular location.

Rate of Growth

The terms "rapid growth" and "slow growth" are relative expressions. It is, therefore, difficult to establish a quantitative basis for classification of trees according to their rate of growth.

A tree which appears to develop rapidly into the shape and size of structure planned for a specific location would seem to be the most desirable. Very often this is not the case. Quick growing trees are often short lived, have soft wood and are easily broken by the wind. Trees of slower growth are, in general, more reliable.

Rate of growth may be expressed in various ways: rate of increase in diameter of the trunk, rate of increase in height, rate of increase in spread. The development of the spread of a tree growing naturally in the open is usually in direct relation to the increase in elevation. The proportion of spread to height, however, is dependent on the characteristic shape of the species or variety. The extent to which a tree ultimately spreads may determine spacing. Since the rate of spread is largely incidental to development of height, rate of growth is more frequently expressed in terms of vertical elongation (109, pp.90-91). Increase in diameter of the trunk is most important for a forestry classification. It is, however, not generally used for the purpose of comparison or classification of trees for landscape use.

Useful information can be ascertained by examination of annual tree rings, obtained by increment borings, on increase of growth over the years. Variations, indicating fluctuations in growth rate, are usually the result of environmental changes. Similarly, increment borings are used to determine the age of the tree, as indicated by the number of annual rings.

The rate of growth of a tree, expressed in terms of increase in height, is inversely proportional to its age. Fluctuations, as indicated above, are usually a result of alterations in seasonal climatic conditions. The amount of growth in the two or three years immediately preceding examination is distinguished by the characteristic rings of bud scale scars at the base of the season's growth. Condition of the buds usually is an indication of the suitability of the circumstances for growth during the previous season.

There is little correlation between rate of growth and whether or not a tree has an indeterminate or determinate type of growth. If indeterminate growth is characteristic, the shoot and branches elongate until arrested by the seasonal change to conditions unfavorable for growth. Tips of such branches are frequently killed and the net result in growth is seldom more than with species which have a determinate growth. In the latter instance, growth has ended earlier in the season with the formation of a terminal bud is ready for immediate development on resumption of favorable conditions for growth in the spring.

In consideration of all these factors, trees have been listed according to their average rate of annual growth, under reasonably favorable conditions, during the first ten years after being planted in their permanent location.

Longevity

The length of life of a tree depends upon many factors, most of which are associated with the environment in which the tree is grown (36, p.156). Many species, however, have the ability to continue their growth for a great many years, almost regardless of the conditions of environment. Others, growing under apparently ideal conditions, will last but a few decades. A more or less definite limit of age is therefore associated with each species or variety. Most *Quercus* are termed long-lived; all deciduous species of *Prunus* are relatively short-lived.

There is often a distinct difference between normal life expectancy and span of usefulness. Under natural conditions, without the repair and protection afforded by man, the tree will live as long as it can withstand competition, the effects of climate and the ravages of disease and insect infestation. A tree which is resistant to such infestation and not subjected to fatal storm or other damage, may live for hundreds of years. The same tree on the city street, without damage, may be discarded in much less time because it has exceeded its span of usefulness, having surpassed its optimum proportions or lost the natural grace and beauty associated with a less mature specimen.

The limitations of soil, atmospheric conditions of the city and minimum maintenance usually tend to make a city tree shorter-lived than the same tree growing in the forest.

Associated with the limitations of the city environment is the degree of care provided for trees. Span of usefulness may be prolonged by the employment of proper cultural methods, particularly prompt repair, following damage from natural or other causes.

Specimens of the common Laburnum, over 300 years of age, are in existence in England, yet Laburnum is listed as a short-lived tree in the Pacific Northwest. Extensive tree surgery and extreme care have prolonged the life of a few individual specimens, yet, under reasonable conditions of care, the tree can be expected to outlive its usefulness in a relatively short period of time.

The degree of longevity as affected by susceptibility to disease is of great significance (61, pp.91-96). Declining vigor, associated with disease, paves the way for secondary infections, which, often more readily than does the primary infection, hasten decay and eventual death. In making the selection of trees for the various longevity groups, susceptibility to disease has been an important consideration, although length of usefulness of many susceptible species may be substantially increased by protection against disease.

Longevity is very often correlated with the rate of growth, since many of the fast growing trees are the least permanent. They are often less desirable than trees of slower growth. The characteristics which make them less desirable are soft or weak wood which breaks easily in storms, poorer shape and early maturity, necessitating more frequent removal and replacements. Cost of maintenance is higher.

In spite of these features, rapid growing trees are often selected for street use, because residents are often impatient of results, demanding fast growing material for quick effect. The use of short-lived, fast-growing trees represents poor economy.

Eventual or optimum size, associated with a particular tree species, sometimes indicates longevity. Many small trees are short-lived. That this is not necessarily true is evidenced by the fact that some small trees are slow growing, disease-resistant types, which may have a comparatively long life span, such as certain small species of *Acer*. Conversely, *Acer saccharinum* is a large tree, but rapid growing and short-lived. Most other large species of *Acer* are useful for a much greater length of time.

The shorter span of usefulness of many smaller trees may be offset by the decreased cost of maintenance and replacement.

Environmental factors have a significant effect upon survival. Natural factors of environment have been discussed under ecological considerations. The nature of the soil, exposure, injury from cold or storms, all affect longevity. The artificial environment, encountered under conditions of the city, has a marked effect on the life of many species, yet some are exceedingly tolerant of these conditions.

All these factors have had to be taken into consideration in classifying trees according to longevity, since length of life, although somewhat determinable by species or variety, is affected by all of them. This same complexity makes a quantitative evaluation difficult, in fact, almost impossible. However, from the literature of the field and casual personal observation, average or typical examples have been drawn for each of the four classifications. Detailed observation, accurate determination of age of existing specimens and consistent records would make the classification of this important characteristic of trees for city streets more valuable.

Diseases and Pests

Few species of trees are immune from insect and disease attack (88, pp.296-305) and (110, pp.259-262). There is, however, great variation in their degree of susceptibility and apparent immunity to infestation. Too, moderate control measures may be sufficient to keep disease and pests under control for many species. The tree species which are relatively immune to attack constitute the most important group, as control measures may be costly or impractical under city conditions.

The common types of parasitic diseases of special interest are leaf diseases, wilts, cankers, wood rots and root rots (60, pp.1-53). Of these, wilts and rots are most likely to prove disfiguring or fatal. Leaf diseases may be considered as nuisance disorders that attack occasionally without doing much damage, other than marring the appearance of the trees affected. Most of them are caused by fungi and they are readily controlled by fungicidal sprays or dusts.

Wilts are usually caused by fungi, which are able to invade the xylem, slowing down the movement of liquids and possibly having a toxic effect on the tree. Dutch elm disease is a typical wilt. Verticillium wilt on *Ulmus*, *Acer* and *Quercus* (8, pp. 851-855) is also important.

Verticillium wilt on *Acer macrophyllum* is of considerable importance in the Northwest. The disease is confined, however, to mature specimens, or those which are in a state of decline. Young, vigorous trees are relatively immune to this disease. This species of tree is not well adapted to use on the street, unless planted for replacement before maturity. For this reason, the disease is of little consequence.

The plum and apricot types of *Prunus* are somewhat susceptible to black knot disease. Outbreaks have been serious in portions of the region. Control measures must be adopted where the disease is prevalent in nearby fruit plantings. Another disease which may be serious in *Prunus* is witch's broom, common on the wild cherry in the Pacific Northwest. It has been known to spread to some of the Japanese flowering cherries.

Phloem necrosis is a serious virus disease, affecting *Ulmus americana* in the southeastern United States. It has not spread to other portions of the country.

Brooming of Robinia Pseudoacacia is attributable to virus infection. There are no serious virus diseases of the broadleaved trees in the Northwest.

Cankers may be caused by fungi or bacteria. They may appear on trunks, branches and twigs, producing dead areas and slowing the normal healing of wounds. Typical cankers of fungus origin are associated with Betula species, Platanus occidentalis and Cercis canadensis.

Wood rots are fungal in origin. They contribute largely to the loss of longevity of many trees. Prompt treatment of wounds is the most effective means of control. Important examples are: trunk rot of Betula, brown wood rot and butt rot of Ulmus and wood rot of Quercus.

Two common diseases of Cornus Nuttallii are a root rot and root crown rot, both of fungus origin. These attack older trees which may have been disturbed or exposed by forest clearing in their natural setting. Well-grown nursery specimens are less susceptible.

Few other root rots are important on deciduous trees. Some are associated with bacterial crown gall.

Bacterial infection is less common than fungal. Fire-blight, once an important disease of fruit trees, may affect Crataegus and sometimes Sorbus. Although fire-blight has been important in the Northwest, there is no indication of outbreak in these genera. Slime flux of *Ulmus* may be serious, but the disease is unknown on the West Coast.

Species and varieties of trees differ in the degree to which they may be affected by any particular disease. For example, not all species of *Ulmus* are equally susceptible to Dutch elm disease, *Ulmus parvifolia* being relatively resistant. The degree to which they are resistant to one disease is not necessarily related to their resistance to others.

The known susceptibility of a tree species to a disease may not be an important consideration in an area where the disease is unknown, but later introduction of the disease may prove to be costly. *Ulmus americana*, suffering from the ravages of Dutch elm disease in the eastern United States and Canada, is completely free from that disease in the Pacific Northwest. Many fine specimens of *Castanea dentata* are standing in this area, yet chestnut blight has killed out almost all eastern representatives of that species. Extensive plantings of such trees would have to be undertaken at the risk of possible subsequent infection and loss.

Few of the other important diseases of the eastern states have reached the West Coast. Consequently, there is a strong tendency to use species in the Northwest which are no longer practical in the East. The wisdom of the practice is questionable, although careful inter-state and international control has been effective to date.

Other relatively unimportant diseases may appear on the street trees of the Northwest. With moderate control measures, these can be kept under control. For most city situations only the serious diseases, likely to disfigure or cause mortality, need to be considered.

All important diseases of broadleaved trees in the Northwest can be said to be related to unsatisfactory conditions of their environment (110, pp.259-262). The comparatively isolated condition of well-spaced street trees affords a great deal of protection from infection and spread of disease. Trees which display lack of vigor, from deficiencies in the soil or poor management practices, are more likely to suffer from infection than vigorous specimens. Most serious adverse effect of environment is winter injury. Winter-killed twigs provide a suitable seat for infection which might spread to other parts of the tree. Improper pruning practices and insufficient care following injury may lead to disease troubles.

The selection of disease-resistant species and the replacement of those seriously affected with disease by those more resistant, is the logical disease control program.

The same rule - keeping the tree in a healthy vigorous condition for prevention of disease - holds true for many insect troubles. Some insects only attack decaying wood, or trees which are in a state of decline. The best controlling influence for insects is in proper tree spacing and better care. Sprays are usually necessary only for prevention or control of local insect problems.

A number of leaf insects may create problems. Most important of these are aphids. These insects are prevalent throughout the Northwest on a variety of trees. Most susceptible are Quercus, Acer platanoides, Acer Pseudoplatanus and Tilia. In districts where aphids are prevalent, consistent control measures are necessary. This is by far the most serious insect of the cities of the Pacific Northwest.

Other leaf insects attacking broad-leaved trees are leaf beetles on Ulmus and Tilia, mealy bug on Catalpa and various caterpillars. Leaf feeding insects are not a serious problem in the region, although local outbreaks of tent caterpillars may defoliate a variety of trees. These pests are cyclic and should be watched for during years when they might be prevalent.

Leaf insects, in general, have only nuisance value, rarely causing anything more serious than a temporary unsightly appearance.

The red spider mite may be found on some deciduous trees, but it is not considered a serious pest in the Northwest.

Borers seldom attack vigorous trees and few of the borers of economic importance in the eastern states are to be found in the Northwest. The bark beetle, which transmits the Dutch elm disease, is unknown in the region. Betula has not been subjected to injury from the birch borer. By keeping the street trees in a healthy, vigorous, uninjured condition, little trouble can be expected.

Scale infestations may occur on various tree species. This, too, is a local problem demanding local control measures when an outbreak occurs. A heavy load of scale is usually an indication of a poor pruning practice.

Climatic factors are important in relation to the check of various insect pests; cool wet summers are ideal for aphids, accounting for their prevalence throughout the Northwest during the summer of 1954. Moderate winters fail to destroy certain pests and an above-average build-up may occur in the subsequent season. This was noticeable in the summer of 1953, following the exceptionally mild winter of 1952-53.

Selection of tree species and varieties which are immune to insect troubles is the most logical solution to the problem. If, however, insects can be controlled by good management and moderate chemical control measures, they do not represent an important limiting factor to the choice of trees for the Pacific Northwest. In certain years, however, aphids will continue to be serious in spite of moderate control measures. Species which are not affected might be substituted for susceptible species, if the nuisance is considered to be sufficiently serious to be a limiting factor.

Tolerance

The artificial environment of the city imposes a great hardship upon many species of trees, which may not be sufficiently tolerant of its conditions (75, pp.43-48). In some instances, these conditions may be limiting, making survival impossible or use impractical. Some trees cannot withstand impurities in the atmosphere; they may suffer from reduced light intensities from smog; they may not be able to accommodate themselves to the confines of the soil of the city street, nor be able to withstand the shock of the move when planted; the obstructions of the street may withhold too much of the natural moisture supply.

Extremes of the natural environment frequently restrict the growth of certain trees. It is evident that species and varieties which may be able to withstand the extreme limits of drought and soil reaction are often those most readily adapted to the unnatural conditions of the city. These natural factors, although not necessarily a part of the city environment which may be, at least partially, controlled, are considered under "tolerance," because of this possible relationship.

The complex nature of the city environment makes it difficult to place the responsibility for failure or poor performance on any one factor (63, pp.220-222). The most useful list is, therefore, that of trees which are tolerant of city conditions.

Industrial smoke and gas is known to be responsible for the failure of many trees in eastern North American cities. Most liable to injury are: Fagus species, Acer saccharum and Acer rubrum, Carya species, Ulmus americana and species of Tilia. These same trees are satisfactory for use in city residential or suburban areas. First indication of smoke and gas injury is non-parasitic discoloration of foliage. This is accompanied by a general decline in vigor, usually ending in death. Gases enter the foliage through stomata, going into solution in the water contained in the hydrated walls of the parenchyma cells, finally diffusing into the protoplasts. Death or injury of leaf tissue may result. Tolerant species include Ailanthus altissima, Betula pendula, Platanus species and Crataegus.

Solid particles suspended in the air have the effect of screening some of the light from the sun. When the air is still, industrial areas may suffer a 90 per cent screening effect of the light from smoke (31, p.227). Aside from the possible toxic effect of smoke and gas, the decrease in light intensity may be serious. Most conifers suffer from the effects of smoke in both respects. Broadleaved deciduous trees are generally more tolerant, however, since the conditions of smoke and gas (smog) hanging low in the atmosphere are usually associated with that period of the year when the trees are naturally defoliated.

Few trees, suitable for street use, are tolerant of a permanent condition of deep shade. As indicated under "Light" partial shade is required for good performance of certain species. Amelanchier, Cercis, Cornus, Acer rubrum and Acer circinatum are tolerant of partial shade. Some of these, however, make better specimen trees when grown in full sun, notably Acer circinatum (87, p.309). Degree of tolerance for survival, in this instance, is not a sufficient guide to its selection, without the due regard for other characteristics.

Trees differ in their reaction towards disturbance. Specimens for street planting are never established in their permanent location in the small seedling or newly propagated state. Consequently, they must be started and grown elsewhere and moved into position when they have reached a suitable size. Transplanting acts as a "shock" to the tree; the more mature the tree, the greater the disturbance. Severity of shock depends upon the concentration of roots; the more compact the ball or mat of roots, the less the loss of roots. A concentration of roots into a comparatively small area is characteristic of certain species, such as Liriodendron Tulipifera, Betula pendula and Acer saccharum. These trees are readily transplanted at any age. A fibrous root system can often be retained on normally deep-rooting species, during their stay in the nursery, by frequent root pruning or moving. In this way, many trees which are normally difficult to transplant can be moved successfully. A few species will not tolerate even the nursery root disturbance and must be established in their permanent location at a very early age; for example, Arbutus Menziesii and Umbellularia californica. This prohibits the normal use of these two species for street planting.

The list of trees which are difficult to transplant at a useful size includes the various trees, most of which are deep-rooted, which must be properly prepared in the nursery. Extra care of their roots must be taken when being moved into their permanent location. Attempts have been made to establish these trees when much smaller than normal for planting out. The extra work involved to protect them from vandalism and breakage may be prohibitive. Authorities agree that larger specimens are more desirable. The difficult-to-transplant trees should not be overlooked, if they can be given proper preparation and subsequent care.

Improvements in equipment and techniques for moving large trees, in recent years, have helped to make more useful these trees which 'resent' disturbance.

There are many trees which are apparently tolerant of salt spray, hence, can be grown on the streets of seaside towns and cities. Susceptible species should be avoided.

The Pacific Northwest includes areas with high alkaline soils. Since the modification of pH is not practical, to any great extent, for the full extent of the root system of a tree and for a long period of time, it is of value to note the trees which are tolerant of conditions of high alkalinity. These include many useful trees, such as: Franklinia alatamaha, Gleditsia triacanthos inermis and Ailanthus altissima. While the coastal region and western inland valleys have a characteristically acid soil, extreme conditions of acidity are found only in poorly drained areas with clay, peat or muck soils. Some modification of the extreme is possible with improvement of drainage conditions and the addition of lime, otherwise the only trees suitable for planting are those which are tolerant of poor soil aeration as well as acidity. Few trees are feasible under this combination of factors.

Drought may be a limiting factor for tree growth. Some species are susceptible to drought injury; others are quite tolerant. Aside from the natural conditions of drought, which are associated with the low annual rainfall of certain portions of the Northwest and the characteristically dry summer climate, there are certain limiting effects created by the city environment. Paved road ways, sidewalks, drains and sewers have the combined effect of preventing much of the available atmospheric moisture from reaching tree roots. Where practical, additional moisture may be effectively applied by overhead sprinklers. Unless local residents are prepared to undertake this operation, few municipalities can afford to. It is most important, then, to select trees which are tolerant of drought, if it is apparent that natural moisture is likely to be insufficient. This factor may be dependent upon the nature of the soil and the height of watertable, as well as rainfall. The nature of the root system, hence the ability to survive on soil moisture, is another important consideration.

Trees which are tolerant of drought include Cladrastis lutea, Phellodendron amurense, Ulmus pumila, Ailanthus altissima and Prunus Mume.

Flowering Habits

There has been a marked increase in plantings of the flowering trees on Northwest city streets (100, pp.196-201). City planners, parks supervisors and residents have been searching for smaller trees, more in scale with the surroundings of the modern city residential subdivision than were the large broadleaved trees of a generation ago. Many of the smaller trees chosen for this purpose were flowering species, such as the Japanese varieties of Prunus (47, pp.22-23). This has led to a much greater interest in trees of all sizes which can provide the special seasonal effects of bloom.

The range of flowering trees for city streets is very great, including practically every size and shape that might be required. Among the largest are Aesculus carnea Briotii and Davidia involucrata, both excellent trees of good form and habit. Most Prunus and Malus are intermediate in size, with shape depending on varietal characteristics. Among the smallest of flowering trees is Magnolia stellata. Special shape requirements can be met by the use of fastigiate Prunus serrulata 'Amanogawa', weeping Crataegus monogyna pendula, horizontal branching Cornus florida, pyramidal Stewartia koreana or rounded Fraxinus Ornus.

The variation in season of bloom of the various flowering species makes it possible to choose trees for special seasonal effects, from late winter until autumn. Earliest to bloom are Corylus Colurna and Crataegus monogyna. These are followed by Cornus Nuttallii and the various Prunus, which extend through April and May, by which time Malus species and varieties are effective. The summer months are represented by Albizzia julibrissin and Koelreuteria paniculata, then in the fall, Prunus subhirtella autumnalis and Franklinia alatamaha are available to round out the season of bloom.

The season of bloom, generally speaking a definite characteristic of each species and variety of flowering tree, varies a great deal, depending on location and annual weather fluctuations. Earliness of bloom of most early flowering trees in the Northwest varies indirectly with the increase in latitude and directly with the distance from the seacoast. Late spring, summer and fall blooming species do not exhibit this variation, nor are they likely to be affected by a late spring. Spring flowering trees may have their bloom retarded as much as a month if the spring season is particularly cool. The length of the period of bloom is unpredictable, but may be increased by the effects of a cooler than average season and the absence of rain or high wind in the flowering season.

The early blooming species produce flowers before the foliage appears and are therefore often more important as flowering trees. They have the added effect of increasing the length of effectiveness of the tree. A common example of this is Prunus cerasifera atropurpurea. The significance of the bloom of other trees, appearing after the foliage has developed, depends upon the color, arrangement of flowers or the size of the individual blooms. Flowers of Halesia caroliniana are partially hidden by the foliage; Syringa amurensis japonica produces its flowers in an upright panicle, rising above the foliage. Flowers of Magnolia species are solitary, yet large and showy; many varieties of Prunus have either single or double flowers which depend upon their cluster formation for effectiveness.

A range of flower color is available from the variety of trees for each season, including white, various shades of pink, red, yellow and purple. No blue flowered trees are represented in the list of possibilities for the city street.

The selection of certain flowering trees for city streets may add to the maintenance costs. *Prunus*, *Malus*, *Crataegus* and others need protection against insects and disease. Some flowering species, though, are comparatively disease and pest free, for example, *Sophora japonica* and *Cercis*. Certain flowers, such as *Magnolia*, create a nuisance when they fall on streets and sidewalks. These factors, however, are seldom important enough to prohibit their use, although trees that do not give trouble might be selected from the list of flowering trees to replace the offending types.

Many lesser-known flowering trees have been selected as possibilities for street use (29, pp.65-69) and (39, pp.73-78). These trees all have certain desirable characteristics, not the least of which are their significant blooms. *Stewartia koreana*, *Koelreuteria paniculata* and *Syringa amurensis japonica* should make beautiful effects, where small trees are required. Larger trees, such as *Kalopanax pictus*, *Sophora japonica* and *Davidia involucrata* are excellent, whether in bloom or not. They should be better known and more frequently used in the various cities of the Pacific Northwest.

Fruiting Habits

The production of fruit is the normal result of the reproductive process of trees. Consideration of fruiting, under this heading, is limited to those species which have significant or showy fruits. These fruits may be of temporary value or their effect may be lasting; they may be desirable or a nuisance. They appear in a variety of colors, depending upon species characteristics.

Trees with undesirable fruit should be avoided on the street. Principal objection to the fruits of certain trees is that they create a nuisance to vehicular or foot traffic. Few species of Malus are satisfactory for use for this reason. The fruits of Aesculus are particularly hard, with a thick outer coating, which can make the street slippery in wet weather. Children frequently gather the chestnuts before they fall by climbing the trees. This is a dangerous practice, since a fall may cause injury to the children or they might land in the path of oncoming traffic. Aesculus may also suffer damage by breakage from children.

Trees with unattractive fruits should not be chosen, unless their good features outweigh this disadvantage. The long pods of Catalpa and Gleditsia detract from the appearance of these trees.

Some trees produce fruits with an objectionable odor, such as Ginkgo biloba. Female specimens of this tree should not be planted.

Trees with good fruiting habits may have the advantage of a prolonged season of effectiveness (51, pp.59-62). This is particularly true of the persistent varieties. Long after the foliage has dropped, the red or orange clusters of *Sorbus* are effective, as are *Cornus* and *Crataegus*. Some of the less persistent fruits, if they do not create a nuisance, are attractive, adding extra color to the city street during the summer months and before the foliage colors of autumn. The list of these desirable fruiting trees includes many of the small fruited species and varieties of *Malus*, most species of *Amelanchier* and and *Chionanthus virginicus*.

A few of the trees which have interesting or valuable fruits are dioecious, making it necessary to select a high proportion of females for the desired effect. As with *Ginkgo*, above, and with *Gleditsia*, it is possible to restrict the selection of specimens to males to avoid objectionable fruits.

The age of the tree, at which fruit is normally produced, may be important if an early fruiting effect is desired. Some trees do not bear fruit until well established. This may be a disadvantage with dioecious trees, if the sex has not been determined. Established female *Ginkgo* trees have not been objectionable until the first fruits appeared about 20 years after planting.

Of the entire selection of trees for street planting, only a few combine the desirable characteristics of a street tree with good fruiting habits. It becomes more important, then, to avoid the few which are objectionable because of their fruit.

Specific Effects

The streets of Pacific Northwest cities can be made more attractive by the selection of trees which have specific permanent or seasonal effects. Long avenues of trees, selected for suitable height and form, may be monotonous. Although the use of several different species may provide sufficient variety, greater interest can be assured if the trees selected have special features, such as interesting bark, different foliage colors, or if they produce special seasonal effects, other than flowers and fruit previously discussed.

A good bark pattern is especially valuable for winter effect when foliage, flowers and fruit are not present. *Acer griseum* is a small tree with reddish, shredding bark. It should be more widely used. *Stewartia* species have flaking, varicolored bark. *Betula* and *Platanus* species are well known for their interesting bark. *Phellodendron* has a corky bark, adding to its year around value. Many other trees might be selected for added interest by consideration of the special effects provided by unusual bark characteristics (50, pp.14,30-32).

Branching pattern, a particular characteristic of the species or variety, may be the special point of interest. This, too, is most important in the winter months (95, pp.44-45). As pointed out above, the shape of the tree is determined by its characteristic branching pattern. More emphasis should be placed on this important feature when selection of trees for any given location is being made, particularly because deciduous trees are devoid of a foliage cover for approximately half of the year.

Foliage colors are an important consideration of tree selection. While many trees appear to have normal green foliage, they may possess special seasonal color features, making them more interesting. Other trees have foliage throughout the season which is not green but yellow, yellow-green, grey-green, bluish, purple or copper colored. These trees are seldom satisfactory by themselves, being much more effective when used as specimens, or in groups, to relieve the monotony of long rows of the more standard types. Some streets of Vancouver, B. C., planted exclusively with Prunus cerasifera atropurpurea, present a somber appearance when in leaf. The trees are not in harmony with their surroundings. Where this variety has been alternated with trees possessing a green foliage, for example, Crataegus oxyacantha, the effect has been much more pleasing. *Liriodendron Tulipifera*, having light green foliage, does not appear to be out of harmony on the city street, while the different foliage color is interesting. Variegated trees do not belong on the city street, since their use would have a tiring effect.

Very beautiful seasonal effects are possible with many trees (104, pp.48-49). In the spring, those species which leaf out early present a welcome sight in the Northwest where cloudy weather prevails through the winter months. Some trees open out with foliage of a different color, changing to a normal green as the season progresses. *Prunus serrulata* '*Kwanzan*' and *Acer platanoides Schwedleri* have reddish or copper colored foliage in the early spring, turning green with the advance of spring.

Most striking of seasonal foliage effects occurs with autumn coloration. Most species of *Acer* and *Quercus* have long been valued for their fall color on the city street. Many of the lesser known trees, too, may be selected for this same effect. *Chionanthus virginicus*, *Halesia monticola* and *Cercidiphyllum japonicum* produce striking yellow effects; *Franklinia alatamaha*, *Oxydendrum arboreum* and *Euonymus europaea* have brilliant red foliage in the fall.

<u>Mass and Texture</u>

Associated with the form or outline of every tree is the impression of mass and texture which is made upon the observer (74, p.7). Mass, however, implies quantity, while texture, in its usage as pertaining to plant material, is relative. The quantity of branches and foliage, which together make up the crown of the tree, gives one the impression of degree of massiveness. Texture is very much dependent upon the branching pattern and the size and arrangement of the leaves. Mass and texture are not necessarily closely related. Many massive trees are fine-textured, the great quantity and compact arrangement of the small leaves creating a heavy mass effect. Some coarse-textured trees may also be trees of heavy mass because the large leaves make a solid canopy.

The mass of a tree should be taken into consideration in relation to the effect that it is expected to create on the city street (58, pp.145-146). Trees with heavy mass are more positive components of the landscape than are lighter ones. The effect of form, shape or outline is greater. They must be chosen with greater care. Massive trees create a denser shade and are, therefore, more likely to be chosen if shade is desired. They may be chosen to form a contrast with light colored or lightly constructed buildings. They are more likely to be chosen on the street to provide a tie with solid, massive buildings, linking them together, giving a sense of unity to the street. Lighter materials might be chosen to add grace to the residential street, giving a more subtle sense of elevation, providing less contrast to the contemporary building form, casting less shade.

Texture, too is important in relation to the design effect. A fine texture is usually associated with a fine branching pattern and comparatively small leaves. It is particularly compatible with the forms, structures and building materials of the modern West Coast home, where the coarse materials, such as brick and stone, are seldom used. Fine-textured trees attract less attention, hence, are more likely to become a part of the street. They are useful for framing or accentuating views, without obstructing them or competing with them for attention.

Coarse textured trees, like massive ones, may be employed for more significant effects, for contrast or for special interest. Extra seasonal interest may be obtained by the choice of trees which have a coarse branching pattern. This may be of special value when the foliage is absent.

Most of the trees which have been selected for possible street use have been classified according to mass and texture. Typical trees with heavy mass are _Acer platanoides_, _Quercus borealis_ and _Prunus cerasifera atropurpurea_. Trees with medium mass include _Cercidiphyllum japonicum_, _Cornus Nuttallii_ and _Quercus palustris_. Light mass trees are _Betula_ species, _Ailanthus altissima_ and _Robinia Pseudoacacia_. Typical coarse textured trees are _Aesculus_ species, _Catalpa speciosa_ and _Davidia involucrata_. Trees with medium texture include _Cladrastis lutea_, _Laburnum Watereri_ and _Sorbus_ species. Examples of fine textured trees are _Albizzia julibrissin_, _Cercis_ species and _Styrax japonica_.

CHAPTER VII

SUMMARY

The punched card system of classification has been used to assemble the results of an analysis of the street tree problem for the Pacific Northwest. Two hundred and forty five species and varieties of trees were selected for possible street use and classified according to a code, which was prepared for operation of the card system. The basis of classification followed the three lines of approach to the problem: ecological considerations, an analysis of the controlled conditions of the city environment, and a classification of the various tree characteristics which might affect their selection. The system has been designed to be a useful guide to city planners, arborists and landscape architects for street tree selection, so that suitable trees might be chosen to fit into the design of the street.

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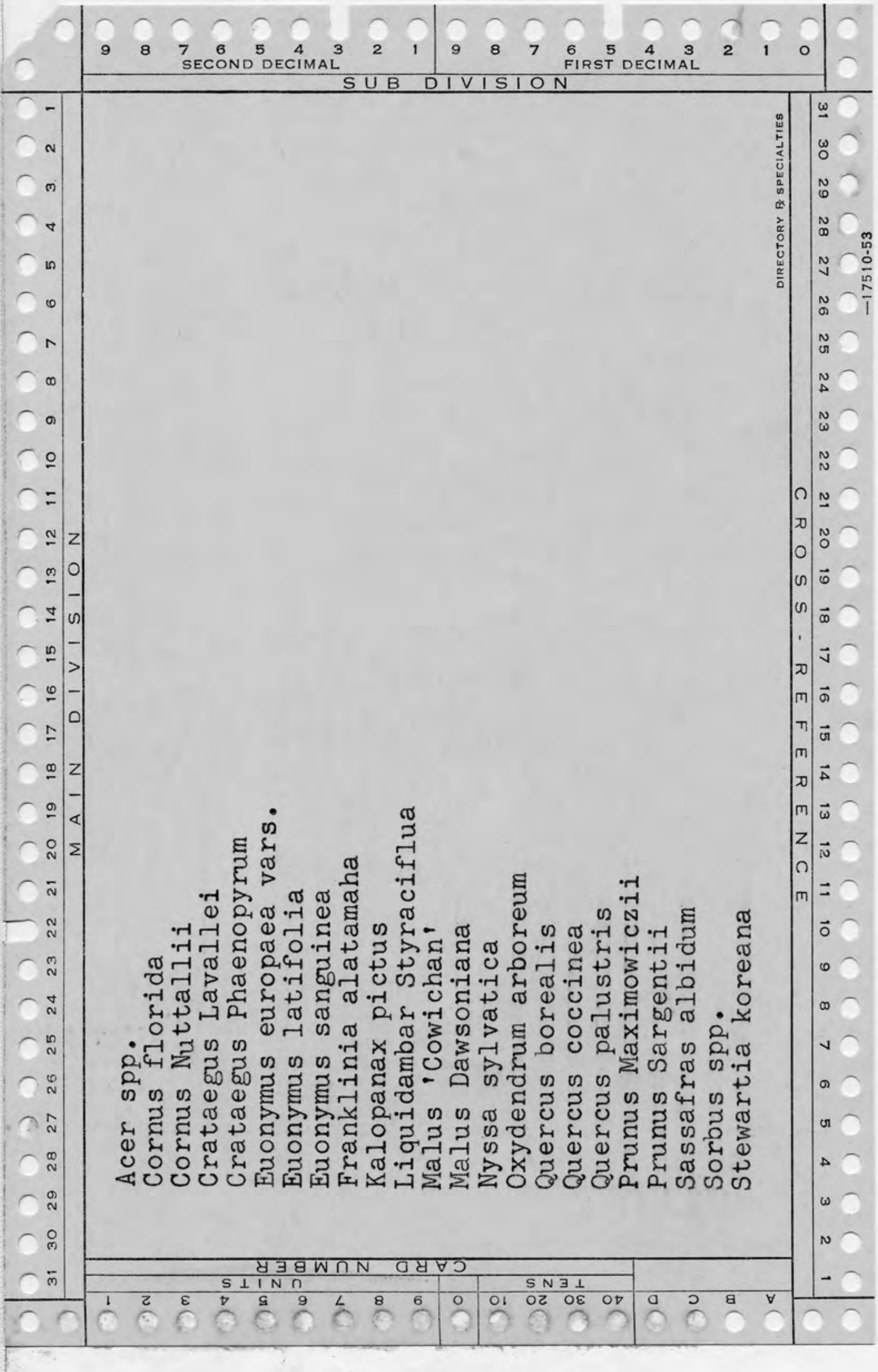
APPENDIX

APPENDIX A



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