SPECIES EVALUATION OF STREET TREE ADAPTABILITY IN AN URBAN ENVIRONMENT

by 7214

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INTRODUCTION

The spread of Dutch elm disease and the memory of Chestnut blight, have confronted urban citizens of America with the problem of preserving existing street trees. The stark reality of barren streets and desolate landscapes from the ravages of Dutch elm disease and elm phloem necrosis, as evidenced in many eastern cities, should concern public officials. The Dutch elm disease has caused many public officials to acknowledge their street tree situation and relatively recently has forced the burden of street tree establishment and maintenance to a much higher position in administrative priorities.

The increased urbanization of the American populace has intensified the problem of street tree installation and maintenance. Residents of stereotyped subdivisions demand relief from the monotony of an unimproved landscape. The current emphasis on environmental awareness has likewise placed pressure on responsible agencies to upgrade and beautify the city landscape.

Most city officials have been unprepared to accept the sudden imposition of magnified street tree responsibility conferred upon them by the mistakes of their predecessors. If the same problems are not to be perpetuated, corrective measures and long range planning must be inaugurated.

To assure a successful street tree program, municipal administrators must take aggressive and positive action to provide that the program, once initiated, will be maintained.

Though administrative and personnel changes may occur, the continuity of the program must be guaranteed.

Many officials of Kansas municipalities have the desire to instigate street tree programs but lack the technical information to get started. Some advisory assistance is available from other cities with similar street tree problems. Knowledgable advice and sound planning procedures are prerequisites which historical perspective may provide.

Kansas communities which lack the administrative depth and qualified indigenous personnel to perform the ground work necessary to establish a sound street tree program are requesting assistance. Such a request prompted the survey which provided the basis for this study.

It is hypothesized that the street tree problems of many mid-western communities similar to Hutchinson, Kansas, are largely the result of poor species selection and planting arrangement.

The specific objectives of the study were:

1. To survey the street trees in Hutchinson with regard to species identification, distribution, size, condition, and adaptability.

2. To search available literature to determine what other tree species might be suitable for use as street trees in Hutchinson.

3. To analyze the present status of the street tree plantings in Hutchinson in light of past planting procedures and to determine what alternatives are available for future planting patterns.

It is anticipated that data contained in this thesis will aid city officials and planners interested in establishing a street tree program in the mid-west.

REVIEW OF LITERATURE

Importance of Street Trees

General

The value of street trees to a city has both quantitative and qualitative implications. The quantitative value of street trees can be determined by establishment and maintenance costs or by the indemnity value (replacement cost). The qualitative value is more abstract, being a function of intangible values, but is vitally important when seeking public support for a municipal tree program. It is necessary to bring the importance and value of street trees to the attention of the taxpaying populace to gain support for adequate financing of a proposed program (30,40,65,72). The ultimate value of street trees has both functional and aesthetic aspects which are by no means mutually exclusive (54).

Aesthetic

Nelson and Porter (45, p. 13) reflect the popular assessment of street tree value by their statement:

> ". . . street trees contribute to the character and identity of the community and to the mental well-being, physical comfort, and the civic pride of the communities' citizens."

Sealy (71, p. 4) likewise expresses this subjective valuation:

> "A city well planted with shade trees is a City Beautiful. The final test of a city's beauty is the quality of the trees which grace its streets and roadsides."

Trees are of value as models for naturalistic artists. The beauty of a tree becomes somewhat tangible when interpreted on canvas by the artist's brush (43).

Practical Aspects

Conversely, Van Riper (85) stresses the practical and realistic aspects of street trees. He advocates the consideration of street trees as building materials to be used as needed to realize the best return on the investment. Scanlon (66) also regards the planting and management of city trees as a business proposition, a program of civic improvement. Increased real estate values, the attraction of superior businesses and a better class of citizens, stimulation of tourist business, and encouraging the construction of homes, apartments, and hotels are cited as potential benefits of well designed and maintained street tree plantings.

Purcell (50) emphasizes the realty value of trees and cites the increased sales and higher purchase prices of real estate property on which trees have been retained or selectively planted.

Street trees may provide a unifying effect in an area of architectural diversity or may relieve the monotony of architectural homogeneity (45).

Trees can also be effectively used to conceal objectionable views, to frame and emphasize desirable views, or to delineate street curvature (7).

Street trees have served a valuable function as camoflaging elements against enemy air strikes by reducing the visibility and vulnerability of strategic objectives (1,66).

Safety features derived from the judicious use of street trees include: providing a guide on the outside of the road, providing a barrier or deceleration cushion for motor vehicles that swerve off the road, and relieving the hypnotic effect of roadside monotony (15).

Roadside plantings may be used to channel traffic and regulate vehicular speed (6,33). To a motorist, his apparent speed in reference to static roadside objects will be of high velocity if these objects are densely articulated. Frequency and proximity of vegetative or fabricated roadside features reinforce the sense of speed. According to Appleyard, Lynch, and Myer (6, p. 8):

> "Objects might therefore be placed along the road simply to reassure the driver about his real motion, or even to accentuate his real motion if it is desirable that he slow down."

The basic role of plants in the moderation of the local climate is expressed by Robinette (57, p. 47):

> "The moderation of adverse microclimates through solar radiation, wind, precipitation and temperature control is one of the most important plant functions."

Glare and Reflection Control

The highly reflective surfaces which are built into the urban environment multiply the discomfort of incident and reflected light unless the light is diffracted or filtered in some manner. Though man-made features can be used for this purpose, these features may only amplify the artificialities of the urban complex. Plant materials can be used to reduce glare from either solar or synthetic sources. Headlight glare from approaching vehicles can be reduced by selective planting of median strips. The obnoxious and persistent glare from street lights, advertising signs, and flood lights can likewise be controlled by selective planting. The acres of pavement and smooth angular surfaces characteristic of urban areas promote daytime glare which can be softened by vegetative planting (60).

Wind Control

Tree plantings can be used to deflect, guide, slow, accelerate, or completely stop wind movement. The impedance of wind movement by plant materials serves to insulate the protected area against dramatic temperature fluctuations. Plant materials can also be used to channel wind movement and provide ventilation to stagnant areas (58).

Precipitation Control

The efficiency of precipitation in replacing soil moisture content may be increased by an overstory tree planting. The interception of moisture-laden air from below and the reduction of wind movement may materially inhibit the escape of moisture-laden air from transpiration in understory plantings (shrubs and turf) and may reduce evaporation from soil surfaces (57). Roadside tree plantings may be used as living snow fences to prevent the accumulation of snow on road pavements or to direct snowfall to desired locations (57,23).

Temperature Control

By the absorption, reflection, and transmission of solar radiation, summer temperatures may be significantly reduced beneath a canopy of trees. In winter, an evergreen planting may be used to insulate a cold spot. Temperature control by plant materials is a function of radiation control, wind control, and precipitation control (58).

Air Purification

Trees are natural "air conditioners" capable of purifying the air. This function is effected primarily by the removal of carbon dioxide from the air and the release of by-product oxygen during the photosynthetic process. The oxygen given off then serves as a dilution factor to improve the quality of the ambient air. Particulate matter in the air may be trapped by pubescent leaf surfaces or by condensed moisture droplets on the leaves and bark. By the reduction of wind movement in and around trees, larger particulates may be settled out. Another means by which air quality may be temporarily improved is the masking of obnoxious odors by more pleasant plant odors (56).

Noise Abatement

Plant materials can be effectively used to reduce sound pollution in the environment. By diffracting and breaking up sound waves or by changing their direction, the intensity of undesirable sounds can be reduced. The inherent plant sounds of rustling leaves and moving branches will mask objectionable sounds.

The noise produced by birds and animals attracted to trees by their flowers and fruit also perform a masking function and add another natural dimension to the urban setting (59).

Erosion Control

Even in the city, street trees contribute to the reduction of soil erosion. By intercepting falling raindrops, impact erosion is reduced. Fibrous rooted trees stabilize the soil and improve its structural quality reducing runoff and increasing water absorption capacity. The reduction of wind, as discussed previously, also reduces erosion by this means (61).

Quantitative Evaluation

The quantitative value of shade trees can be calculated by means of the shade tree evaluation formula. This formula was derived by the International Shade Tree Conference and has been upheld in court for damage claims to shade trees. This formula is based on the unit cross-sectional area of the trunk at breast height (4.5 feet above ground). Each tree is worth a base value of nine dollars per square inch of cross-sectional area. This base figure is then adjusted depending upon the kind of tree and the condition of the particular specimen. Percentage reductions in value for species and condition differences have been standardized by the International Shade Tree Conference. Additional reductions in value may be included at the discretion of the assessor for other pertinent factors such as land value or presence of many other trees to compensate for the loss of one. This formula is designed for use in evaluating solitary specimen trees which are an integral part of a landscape design (30,40).

The City Environment and Street Tree Growth

Although city trees may modify undesirable environmental conditions in an urban setting, a reciprocal relationship exists whereby city climatic conditions may affect the adaptability of tree species.

The performance of a plant species in a localized habitat is somewhat predictable when based on the particular ecological regime characteristic of that habitat. One or more of the endemic environmental conditions may limit species adaptation to a particular area. For most successful growth, the life cycle of the plant must be compatible with the local climate (44). Tree recommendations should be made only after the various limiting site factors have been carefully studied and analyzed (2).

The principal environmental elements which influence the selection and use of trees are edaphic, climatic, and physiographic (44). Five factors are recognized as important determinants of the success and growth of trees. These are (19,44):

1. The Atmospheric Factor
2. The Water Factor
3. The Soil Factor
4. The Light Factor
5. The Temperature Factor

The biotic factor, particularly insects and diseases, may also limit the adaptability of a tree species to an area (47). The activities of man and their influence on plant growth are also important components of the biotic factor.

The Atmospheric Factor

Aspects of the atmospheric effect on the growth of street trees are 1) quality of the air, and 2) force or potential force of wind (19,44).

The atmosphere must provide trees with ample carbon dioxide and oxygen to meet metabolic demands. Adequate quantities of these compounds are usually present in city air but may be contaminated with other atmospheric pollutants capable of irritating or damaging plant tissue. These pollutants occur in the gaseous, liquid, or solid state, or in a combination of these ("smog") (19). The effect of atmospheric phytotoxicants on plant materials may be diagnosed on the basis of acute visual symptoms (foliar lesions, necrosis, and chlorosis) (82).

Physiological damage may occur when solid particles settle on tree leaves. By obstructing the stomatal apertures the normal gaseous exchange between the leaf and the external atmosphere may be significantly retarded (19).

The toxicants most generally involved in widespread damage to plants from air pollutants are: sulfur dioxide, fluorides, ozone, peroxyacyl nitrates, ethylene, chlorine, and hydrogen sulfide (19,82).

Ozone and the peroxyacyl nitrates are very toxic products of a photochemical reaction between pollutants commonly found in congested metropolitan areas (82). The component reactants are air, sunlight, nitrogen dioxide, and hydrocarbons. The latter two materials are common constituents of internal combustion exhaust. Nitrogen dioxide accumulates in the atmosphere and absorbs ultraviolet light which provides the energy to drive the chemical conversion.

Sulfur dioxide is prevalent in areas where sulfur-containing fuels are burned. The toxicity of SO_2 is due to its reducing properties. A wide range of plant species are sensitive to SO_2 but the plants usually recover even from severe damage (82).

Primary pollutants in the peroxyacyl nitrate group are 1) peroxyacetyl nitrate (PAN), 2) peroxybuteryl nitrate (PBN), and 3) peroxypropionyl nitrate (PPN). These materials produce glazing and bronzing of the lower leaf surface and induce premature leaf drop. The order of toxicity is PAN $<$ PPN $<$ PBN (67).

The symptoms of air pollution damage may be similar to those caused by drought or excessive salts. However, damage may occur without the development of any visible symptoms (82).

Air movement is the most important atmospheric factor limiting the use and adaptability of trees. Trees are more susceptible to the dessicating effects of dry winds than are lower forms of life. Death of leaves and twigs often occur where dry winds are common. Mechanical breakage from wind often accompanies ice or snow accumulation. Uprooting (lodging) of shallowly rooted species may occur if winds are strong, especially if foliage is present (44).

The Water Factor

As the solvent which contains the mineral nutrient elements from the soil and mediates most aspects of plant growth and development, water is obviously essential to trees (44,52). The predominance of paved areas and bare unshaded surfaces in the urban environment leads to high soil temperatures and retards water infiltration. These conditions limit the effectiveness of precipitation in replenishing soil moisture. In addition, much of the unpaved area of the city is planted in sod forming grasses. By intercepting and retaining incident precipitation, these turf areas are efficiently competitive with trees for moisture (19).

The seasonal distribution of precipitation is extremely important to plant growth. Adequate soil moisture must be present during the annual period of most rapid plant growth (44). In a city situation, potential drought during this critical period may be alleviated by supplemental irrigation. If the ground water table is sufficiently high, seasonal drought may be inconsequential. A low water table, however, may necessitate the addition of supplemental water through a restricted soil surface area and to a reduced portion of the root system (19).

The Soil Factor

As the universal growing medium, the soil provides support, water, nutrients, and air to the trees which it sustains (44,19). Soil type may also affect vigor, date of flowering, amount of inflorescence, viability of seeds, susceptibility to drought and cold injury, and susceptibility to insects and disease (44).

In an urban situation, edaphic conditions are often less than adequate due to the heavy vehicular and pedestrain traffic around trees. Such traffic leads to severe soil compaction, which, in turn, reduces 1) the aeration of the soil and 2) the infiltration of water. Adequate soil aeration is vital to the uptake of mineral elements by tree roots. This uptake is dependent on aerobic respiration, an oxygen requiring process (19).

The soil reaction (pH) may also affect the uptake of nutrients from the soil. In areas where recent soil disturbance has exposed the subsoil (such as grading operations), the soil reaction may limit tree adaptability (19).

The Light Factor

The effect of light on plant growth depends upon 1) the kind of plant, 2) the life cycle stage, and 3) the function of the plant or particular plant part. In the urban environment, light efficiency may be reduced by moisture and particulate matter in the atmosphere. Low light intensity may favor vegetative growth at the expense of reproductive development (44).

Daylength (photoperiod) is important in the selection of tree species which are valued for their display of flower or fruit (44). Daylength may also affect the abscission of leaves and the dormancy relationships in some deciduous species. A delay of dormancy in the autumn or a premature interruption of dormancy in late winter may lead to cold temperature damage. The modification of daylength by street lamps, flood lights, or even porch lights may affect the growth of plants by altering the dormancy pattern (19,44).

The Temperature Factor

The hardiness of the various tree species is based on their ability to withstand exposure to minimum cold temperatures. Most tree species have been classified according to hardiness zone designations based on this low temperature adaptability. Trees which are marginal in a particular hardiness zone may be restricted by the interaction of other environmental conditions with low temperature in affecting plant adaptation (44).

There are several authoritative hardiness zone classification systems. Though differences exist between these systems, they are all valuable in the prediction of plant cold hardiness especially when compared and superimposed.

One of the most frequently quoted hardiness classifications is that of the United States Department of Agriculture. There are ten hardiness zones recognized by the USDA at 10°F intervals. This system was compiled on the basis of average minimum winter temperature isotherms recorded over a 39 year period (1899-1938). The zone map was updated in 1952 and has been revised on a local basis to better conform to smaller areas where more climatic data was available (4).

Perhaps one of the earliest hardiness classifications was that of Rehder (51), who recognized seven hardiness zones separated by either 5°F, 10°F, or 15°F intervals. This classification is similar to that of the USDA although the corresponding zones are one integer lower in Rehder's system.

The classification of Wyman (86) is again similar to the

USDA system. Ten zones are designated at 5°F, 10°F, or 15°F intervals. Wyman's map has recently (1967) been revised by the Arnold Arboretum (5).

One of the more unorthodox hardiness zone classifications is offered by Taylor (83), who recognized nine zones separated by 5°F or 10°F intervals. Though not analogous to the preceding systems, this zonation is valuable for comparative as well as original information.

The classification systems of Rehder (1940), Wyman, and the Arnold Arboretum (1967), are related, being improved modifications of an original map prepared by Rehder at the Arnold Arboretum (1927). Because of this relationship, zone numbers applied to specific plants can be transposed among these zone maps (5).

The source of plant materials may determine the relative hardiness of these plants in a particular region. The use of local seed or locally propagated plants which have, through natural selection or selective breeding, been tailored to the local environment is to be encouraged. Provenance testing has shown that trees from northern seed, planted farther south, may survive initial transplantation but later degenerate and succumb to drought and heat. Trees from southern seed, when planted north of their native habitat may adapt very poorly due to submarginal cold hardiness. The movement of plants from east to west (to generally drier climates) is usually less precarious than latitudinal movements but may be restrictive (80).

Increased cold hardiness may be derived by selecting plants or plant propagules from colder climates. Work by Funk (28) indicates that frost damage to Yellow Poplar (*Liriodendron tulipifera*) was greater in trees grown from seed collected in warmer habitats than to seedlings from seed collected in colder environments. Work by Jones and Wells (36) indicates that seed source may affect durability as reflected in susceptibility to ice breakage. Their work with Loblolly Pine (*Pinus taeda*) following a severe ice storm in 1963, indicates a high correlation between ice damage and mean minimum January temperatures at various seed sources. Ice damage was greater in trees from warmer seed sources.

High temperatures can kill plant tissues when the temperature exceeds the thermal death point which may be only slightly above the species' optimum for growth. High temperatures may affect the balance between respiration and photosynthesis. Dessication may result when high temperatures occur during a period of moisture deficiency (44).

Not all organs of a plant are equally resistant to temperature fluctuations. Reproductive processes will be the first to suffer from temperature extremes. If the foliar effect is a tree's value to the landscape, temperature extremes and fluctuations may not be critical (44).

The relationship of trees with their environment is summarized by Neill (44, p. 18):

> "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."

Likewise, Carter (19, p. 18) states:

> ". . . the old law of limiting factors applies to the growth of all plants. All factors needed for growth must be available at the same time."

Requistite Characteristics of Suitable Street Tree Species

Based on performances of undesirable street tree species, certain criteria have been developed for evaluating tree species for street tree use (67,68).

Stevenson (79) suggests three standards of value as a guide to intelligent street tree selection:

1. Suitability - This criterion refers to the ability of the tree species to survive the local climate and the restrictions imposed upon them by the city environment.

2. Simplicity - Uniformity and ease of maintenance are the result of simplicity in design. The use of a single species on successive blocks or sequence of blocks simplifies the planting and maintenance operations and provides harmony in design.

3. Proportion or Scale - Because there is variability in the size of city streets, in the space available for tree planting, and in the size of adjacent architecture, only those species should be selected which conform to the size of these features.

Hadland (31, p. 274) offers the following as considerations in determining the performance of street tree species:

"1. Adaptability to soil and exposure.

2. Ornamental in either form, structure, foliage or flowers; usually a combination of these.

3. Not excessively demanding in maintenance and cultural requirements of pruning, spraying and fertilizing.

4. Seldom high in any objectionable qualities like short life, invasive roots, pests, brittleness or litter."

Bannwart (8) includes hardiness, straightness and symmetry, immunity from insect and disease, abundance of shade, cleanliness, and longevity as factors of consideration in street tree selection.

The desirable decorative qualities of street trees are other criteria considered by Scott (70). These include growth habit (form), texture, foliage color (summer and autumn), bark, flowers, and fruit.

Piester (47) considers the cultural and physical factors of street tree selection:

1. Ease of transplantation and establishment (preferably by bare roots).

2. Should develop branches well out of the way of pedestrian and vehicular traffic without distorting the natural form of the tree.

3. Should not have large or invasive root systems that disturb walks, curbs, driveways, or underground utilities.

The limited availability of otherwise acceptable tree species may preempt their incorporation into the planting (23,35).

Nelson and Porter (45) suggest that, ideally, street trees should have a reasonably fast growth rate. Longevity and durability should not be sacrificed for a faster growing species.

The Master Plan

A planned street tree program can be established in one of the following three ways (45, p. 15):

"1. The community may assume all responsibility for planting and maintenance of street trees.

2. Specific regulations prohibiting planting of certain kinds of trees may be passed by the community government.

3. The local government and civic groups and garden clubs may develop a master plan for street tree planting and encourage voluntary cooperation by citizens in carrying out the plan."

The best alternative is the first, as expressed by William Solotaroff (76, p. 233):

> "It is only when planting and care of street trees is vested in a special department that all the principles essential to secure the most stately and impressive effect of highway planting can be applied...."

Likewise, Charles Lathrop Pack (46, p. 223) stated:

> "To make street care successful and satisfactory there must be one central head charged with full responsibility and armed with authority to establish and enforce suitable regulations."

Scanlon (69) agrees that it is much more satisfactory to have the municipal government in charge of the entire street tree program. Only by this means can continuity of the program be insured. Though a time-consuming and expensive task, the development of a long range, low maintenance, reduced conflict program is dependent upon the planning and implementation of a comprehensive street tree program.

If the community lacks the resources to commit itself to such an involved program, it should reserve the authority to govern the species selection for all plantings in public areas (69). This regulation should include all planting and removal operations involved in the establishment of new subdivisions. All development proposals should be reviewed and sanctioned by the municipal arborist before approval is granted (22). The Federal Housing Administration requires one tree per lot in FHA financed home building, but no restrictions or recommendations as to species selection are included in FHA specifications (73).

In those cities where a comprehensive master shade tree program is feasible, Bruns (18) suggests that a municipal tree census is the first step. An adequate census should include: 1) kind of tree, 2) exact location, 3) height, 4) diameter at breast height (DBH), 5) grading the trees as to condition (A, B, C, etc.), 6) marking for pruning, spraying, for insects and diseases, or removal.

Baxter (14) also advocates an inventory and evaluation of existing street trees, but only after, 1) acquiring a qualified arborist, 2) establishing a shade tree commission, and 3) enacting the necessary legislation to give these entities the necessary authority to carry out the program. The survey must be complete and must be kept up to date by recording all subsequent removals and plantings. Baxter would include the spacing between trees in addition to those criteria cited by Bruns.

The legislation used to provide authority for a street tree program is usually in the form of an ordinance which establishes the responsibility for street tree installation and maintenance. This ordinance should include (66, p. 208):

"a. Definitions
b. Authority of City and Duties of Administration
c. Acts Prohibited
d. Acts Permitted and Regulations
e. Penalties for Violation
f. Repeal of Conflicting Ordinances; and Severance Clause."

Kansas statutes (38) grant to any Kansas municipality the authority to enact and enforce such an ordinance and may serve as a guide for composing a valid document with adequate coverage of all anticipated ramifications.

A model ordinance is available from the International Shade Tree Conference as are ordinances from other Kansas cities (72). It is important to study the local situation in depth and formulate the ordinance to conform to the requirements of the local objective (84).

The enforcement of the local ordinance will be practicable only if (11, p. 209):

> "1. The ordinance has the overwhelming support of the citizens of the community.
>
> 2. The ordinance was enacted as the result of an expressed desire of a majority of the citizens of the jurisdiction for a well-ordered and maintained street tree program.
>
> 3. The ordinance provides some flexibility as to type of street trees to be planted.
>
> 4. The ordinance grants authority to the enforcement officer equal to the responsibility placed on him to carry out the ordinance.
>
> 5. The ordinance protects the constitutional rights of all the citizens of the jurisdiction."

For the ordinance to be effective, it is necessary to convert its contents into a set of operational policies and procedures (72).

Scanlon (66, p. 357) summarizes the elements of an integrated street tree organization as:

> ". . . an ordinance, a Master Street Tree Plan, good equipment, trained men, experienced leadership, adoption of modern methods, research projects and publicity."

The Planting Design

The traditional design of street tree plantings has been premised on a rigid formula of stereotyped trees mathematically spaced in rectilinear alignment. This system was originated in seventeenth century France to satisfy the self-assumed piety and egotism of King Louis XIV and his desire to dominate both man and nature. Even contemporary reasons for such highly structured manipulation of plant materials are not ample justification for the perpetuation of spatial monotony. Such a dull and unimaginative use of trees ignores their functional use in defining and modifying the spaces along the city streets of twentieth century America (37).

Proper utilization of street trees and their treatment as third dimensional elements, rather than simple bi-dimensional forms, enables the designer to develop the comprehensible space which is essential to any landscape composition. Discreet imposition of a vegetative canopy or appropriate screening elements provides a finite and perceptible condition of space with which the observer can identify (37,42).

Modern landscape theory teaches that "form follows function". The design of any landscape composition should be dictated by the functional use of the component plant materials and the purpose of the integrated planting (54).

Trees possess the same physical properties as do inanimate structures, but, unlike these structures, plant materials grow, change with the seasons, adapt to the environment, and increase in value with time (42).

All landscape elements, especially in an urban situation, are observed against a particular background. Trees should be selected which will complement the background and implement the desired intent of the plan. If the background is architectural or engineered, the planting should not compound any potential monotony of these features (37,42). Martel (42, p. 169) summarizes the alternative ways in which plant materials may be utilized in order to complement or supplement the background:

"1. Appear in the strongest possible contrast with the background.

2. Appear in the least possible contrast with the background.

3. Appear as a combination of these."

The trees selected to achieve the appropriate option should not be in strong contrast with one another, but only in reference to the background. The trees should have dominant structural characteristics in common (42).

Initial consideration of the plant materials to be used in achieving a desirable street tree design should be in terms of their abstract characteristics. The requisite form, texture, growth habit, color, and size should be determined before species selections are made to conform to these characteristics (70).

The most basic principle in the placement of trees along city streets is that of "trees to fit the space" (21,68). The final mass of the mature trees must be adjusted to the space available (35). Harmony and balance in the design dictates that the trees must be in scale with the width and length of the street and in proportion to other "street factors" (abutting or adjacent structures) (79).

There is some apparent disagreement among experts about the degree of species diversity which should be used in a street tree planting design. Justice (37) advocates the use of different species, with different forms, planted at different and varying intervals (groups of smaller trees and larger specimens where appropriate). He suggests that by this means the component trees will not only be interesting in themselves, but will also provide spatial variation as the street is traversed. Piester (47, p. 36) concurs, and states:

> "....plant more street trees and diversify them even as trees are diversified in nature."

Conversely, Scanlon (66) and Stevenson (79) advocate the use of a single species (an official tree) on the street or sequence of streets which comprises a visual entity. The object of this arrangement would be simplification of the selection, acquisition, and maintenance of the street trees. These authors, however, agree that many different species should be used in the city as a whole.

Scott (70) admonishes the extremes of either design and points out that the exclusive use of only a few tree species may create a monotonous situation, but that excessive variety may result in a bizarre vegetative kaleidoscope. The use of too many exotic species may present a particular problem in this respect. Species selection is always a matter for the exercise of restraint and good judgement.

Cornell (21) believes that the planting of highways should be a selective process rather than a rule of thumb procedure.

He recognizes the inherent potential for the exercise of original design to personalize the planting and manifest the unique qualities of the highway.

In some cases no organized street tree planting is feasible. These cases should be recognized and no forced planting should be attempted (21,44).

A second controversy exists concerning the planting of trees 1) inside the sidewalk (a) on public property if possible (b) on private property if necessary, or 2) in the conventional manner with a tree lawn or planting strip explicitly for this purpose. Because the space allotted for street tree planting and the jurisdiction of public and private entities is subject to legislative definition, there may be little opportunity for off-street planting without the forfeiture of maintenance and regulatory authority. Hopefully, future street design will alleviate this problem and allow a greater degree of freedom in the placing of trees away from the street proper (3,10,33,79).

Because many of the better street tree species require wide spacing intervals, Scanlon (66) advocates the use of faster growing but shorter lived ornamental species as interplantings between the longer lived, slower growing species. By this means a much more imaginative initial design could be achieved. These interplanted trees would presumably be removed when their utility became marginal.

These interplantings would be temporary and degenerate, would be costly to maintain, and the imminent removal cost must be considered. It is much better to plant fewer of the permanent street trees at proper distances and maintain them adequately than to complicate the design by crowding in trees to make a show while they are young (86).

The implementation of a planting design may include the following two prerequisites:

1. In either a renovation or original street tree program, the conservation of existing trees should precede any proposed planting operations (8).

2. Selective thinning may be necessary to allow the better trees to develop. This will result in a maximum of shade and beauty at a minimum of maintenance (85).

In the design of street tree plantings, appearance competes with efficiency and utility. For this reason the location of street trees should be determined concurrently with the location of other street elements (sewers, gas and water mains, fire plugs, power and phone lines, and street lights (15,85). That roadside planting is an integral part of the design and construction of such roads must be recognized (23).

Modern street and highway landscape designs should possess some degree of flexibility in order that future developments may be accommodated without a decimation of the planting (24).

A critical point to consider during the entire planning and design process is the ultimate goal of city-wide embellishment. Each component street must be designed as a unit of the city street system. Each individual property should be considered a part of the street system and should have a view, not necessarily a tree (37,66).

Patented Trees

In recent years many new functional and ornamental trees have been placed on the market. Exceptional forms have been granted patent rights by the United States Patent Office because of their desirable characteristics. Many of these patented forms are vegetatively propagated clones of superior mutants. Others are the result of objective breeding programs (29).

Before patent rights can be granted, the plant must markedly differ from the species type in at least one obvious characteristic, such as, form, fruit, flower, or foliage. In addition, a patented plant must be the first specimen recognized and registered as a valuable deviant (29).

Because patented trees are by definition consistent in their patented characteristic, and their performance is predictable, the objectionable qualities and defects of non-patented seedlings can be alleviated.

The current demand for trees with definitely specifiable sizes and shapes to conform to the restricted spaces and design requirements in contemporary settings reflects the value and utility of these patented forms (29).

MATERIALS AND METHODS

Information for this study was derived from a street tree survey conducted in the city of Hutchinson, Kansas during the summer of 1968. The survey provided an inventory of the existing street trees.

The survey was restricted to public street trees (those planted in the public easement) and the survey area was selected on the basis of street tree concentration. Within the survey area, eleven sections were designated comprising a total of 445 square blocks (Plate I). The blocks to be surveyed within these sections were randomly selected. Within this total, 223 square blocks were surveyed for all criteria (Plate II). Street trees on the remaining 222 square blocks were surveyed to determine only Dutch elm disease infection and/or susceptibility to such infection.

All street trees on the blocks surveyed were individually judged on the following criteria (Plate III):

1. Spacing - Approximate spacings (distance between trees) were determined to provide a measure of density, competition, and Dutch elm disease susceptibility.

2. Tree Number - The trees on each block were numbered consecutively within each block from the north end of all north-south blocks and from the west end of all east-west blocks.

3. Species - The street trees were identified and recorded by common names which were later converted to scientific (Latin) nomenclature.

4. DBH - This refers to the diameter at breast height (4.5 feet above the ground). Measurements were recorded to the nearest two inches.

5. Condition Class

   a. #1 - 10% or less pruning necessary in tree crown, no apparent butt rot or hollow heart.

   b. #2 - 11-30% pruning necessary in tree crown, no apparent butt rot or hollow heart.

   c. #3 - 31-50% pruning necessary in tree crown, slight butt rot or hollow heart.

   d. #4 - 51% or more pruning necessary in tree crown, considerable butt rot or hollow heart.

   e. #5 - Dead

   (Vigor and general state of health were also considered as arbitrary criteria.)

6. Pruning - All trees requiring pruning were designated by a check mark. Amount of required pruning was reflected in the condition classification.

7. Remove - Dead or in very poor condition. Removal recommended for sanitation purposes.

8. Insect - Indicated insect symptoms were present, usually identified under "Comments".

9. Disease - Indicated disease symptoms were present, usually identified under "Comments".

10. DED - This category was applicable only to elms and refers to the presence of, or susceptibility to Dutch elm disease infection. Three classes were designated:

    a. #1 - No symptoms of Dutch elm disease or dead wood present in which beetles could breed.

    b. #2 - No visible symptoms of Dutch elm disease but dead wood present providing a prime bark beetle breeding site.

    c. #3 - Visible symptoms of Dutch elm disease, sample taken.

11. Site - This was a general category and was broadly interpreted. Included in this category was evidence of excavation, excessive competition or wear, and poor drainage (puddling, etc.).

12. Comments - Used primarily to identify disorders occurring and marked in preceding categories.

EXPLANATION OF PLATE I

The eleven sections selected to compose the survey area.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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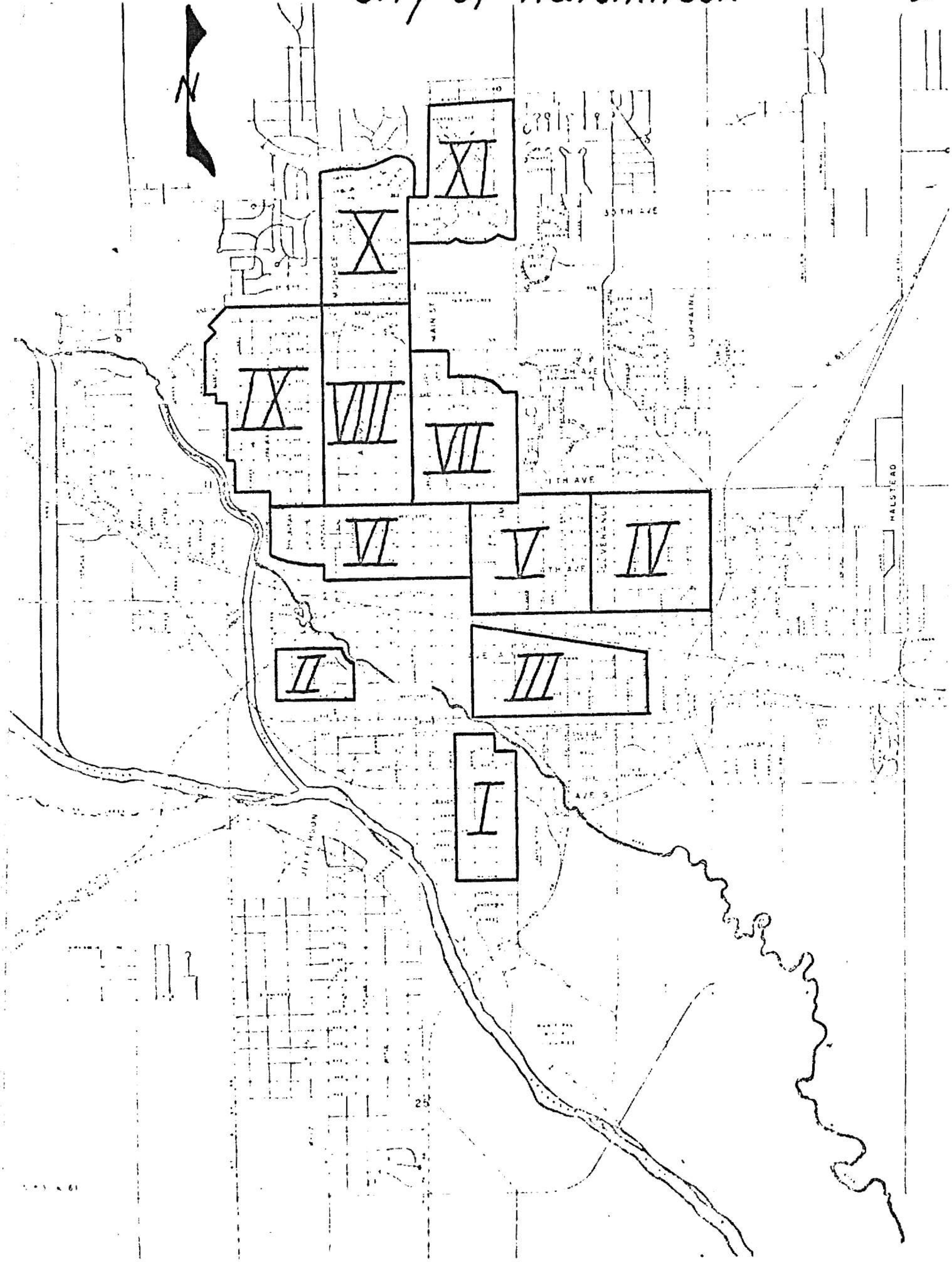
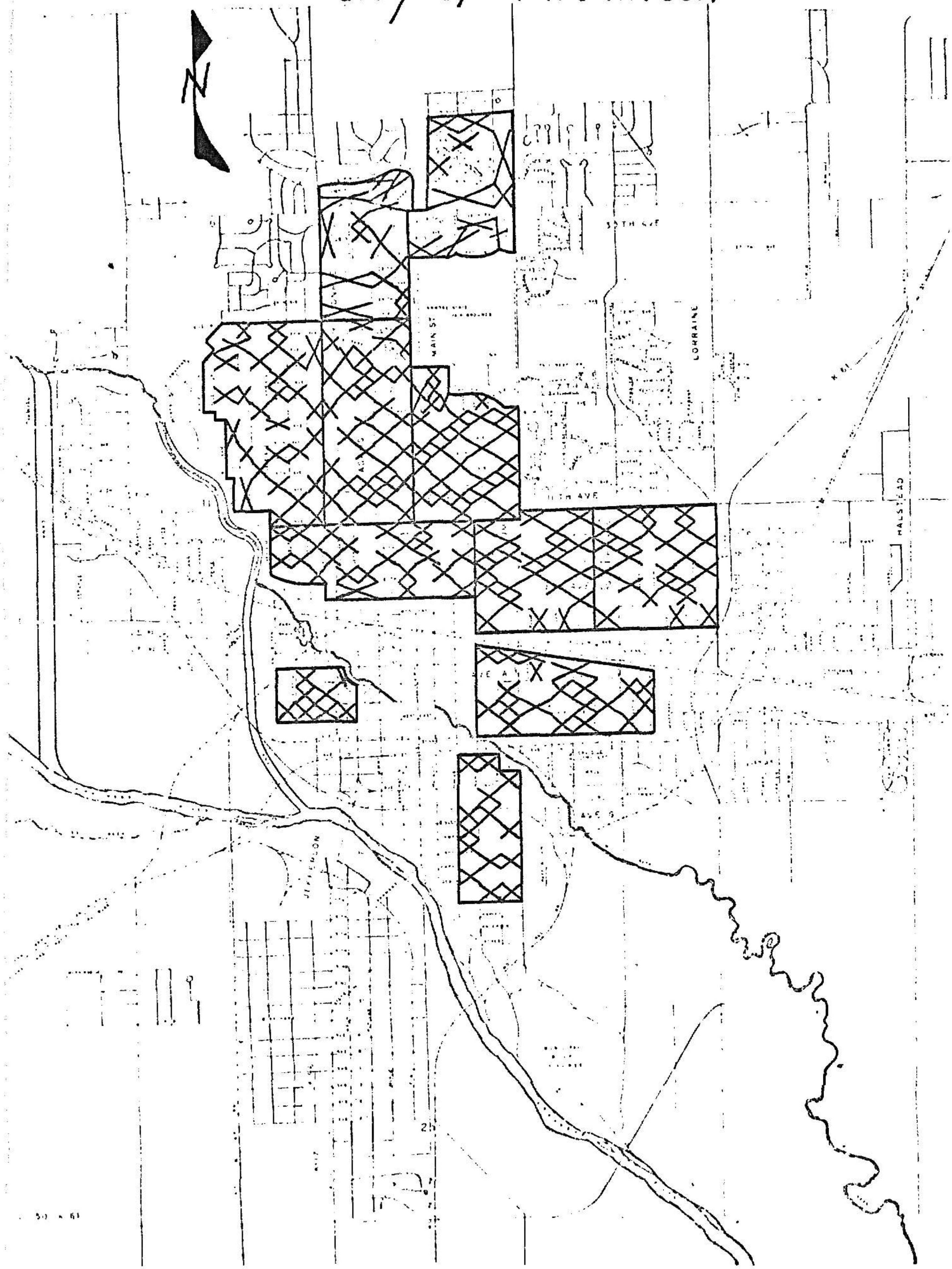
City of Hutchinson



EXPLANATION OF PLATE II

The individual blocks which were surveyed for the specific criteria as discussed in the text.

City of Hutchinson



EXPLANATION OF PLATE III

A sample data sheet used for recording data during the survey.

STREET ADDRESS ______________

SHADE TREE SURVEY
CITY OF HUTCHINSON

Code No. ______________

Date ______________

Spacing	Tree No.	Species	DBH	Cond. Class	Pruning	Remove	Insect	Disease	DED	Site	Comments

The second portion of the study consisted of an academic evaluation of 147 deciduous tree species for possible use as street trees in Hutchinson. All of these species were evaluated according to the following criteria:

1. Environmental adaptability
2. Size and Form
3. Susceptibility to insects and disease
4. Longevity
5. Transplantability
6. Durability
7. Tendency to produce litter
8. Tendency to sucker
9. Tolerance to pruning

Dioecious species of which one sex is preferred were also noted.

The original 147 species (Table 5) were included on the basis of their predicted cold hardiness in the Hutchinson area. This cold hardiness was determined by reference to several hardiness zone classifications (Wyman, Rehder, USDA). Coniferous species were eliminated from consideration because of their inappropriate form (low and horizontal branching pattern).

Tables were compiled for each of the criteria considered indicating those species which possess the desirable or undesirable feature in question.

The final section of the study involved 1) the renovative planting design of older areas that were initially planted improperly, and 2) the incorporation of sound planting design in new residential areas. The renovation phase of the study was based on the street tree survey from which one representative area of the city was selected for further analysis. This area was developed graphically showing the original design and a possible solution to the problems encountered. This selected area was of additional concern because of the threat of Dutch elm disease. The illustrations depict the stepwise process of selective thinning and replanting which is necessary in a renovative process of this nature.

In addition to this area, an undeveloped subdivision (Kisiwa Creek) was considered and graphically illustrated to show a sound design and species selection program. Three alternative designs were developed showing different approaches to the problem of street tree planting design.

RESULTS AND DISCUSSION

Hutchinson, Kansas, a city of 40,000 population, is located in south central Kansas on the flood plain of the Little Arkansas river. The city encompasses an area of approximately 16 square miles and has approximately 25,000-30,000 street trees along 170 miles of streets.

The climate of Hutchinson is subhumid continental, characterized by abundant sunshine, frequent day-to-day weather changes, large seasonal temperature fluctuations, moderately strong surface winds, and relatively low humidities (17).

The critical climatic data concerning the adaptability of street tree species in Hutchinson are summarized below:

HUTCHINSON, KANSAS - CLIMATIC EXTREMES

Latitude - 38°
Longitude - 97° 54'
Elevation - 1535 ft.

Highest temperature recorded - +116°F
(July 31, 1934)

Lowest temperature recorded - -27°F
(February 13, 1905)

Highest mean maximum temperature for one month - +103.2°F
(July, 1934)
- 18 consecutive days over 100°F
- 25 of 31 days over 100°F
- Highest temperature during the month - +116°F
- Lowest temperature during the month - +82°F

Lowest mean minimum temperature for one month - -4.5°F
(January, 1940)
- Every day of month below 32°F
- 12 of 31 days 0°F or below

- Lowest temperature during the month	-	-12°F
- Highest temperature during the month	-	+24°F
Normal Annual Precipitation (through 1955)	-	28.53"
Highest Annual Precipitation (1944)	-	46.97"
Lowest Annual Precipitation (1952)	-	15.40"
Latest 32°F Freeze in Spring	-	May 27, 1907
Earliest 32°F Freeze in Fall	-	Sept. 20, 1918

Hutchinson is located near the boundary between zone 5 and zone 6 according to the USDA's classification and has a similar border location in other cold hardiness classifications (Plate IV).

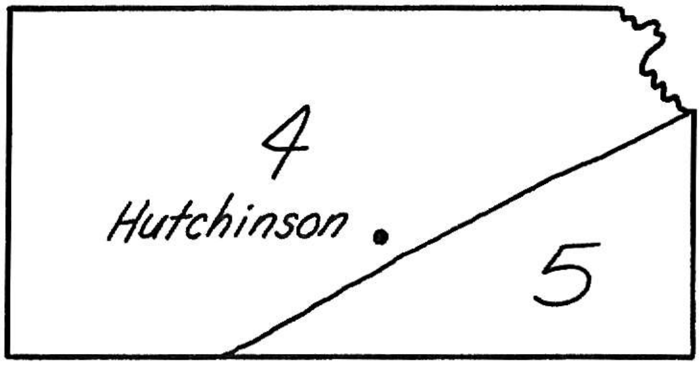
The rainfall pattern in the Hutchinson area is irregular with periods of excessive rainfall being followed by precipitation deficiency (12).

Fortunately, approximately 70% of the annual precipitation falls as rain during the growing season (from April to September) (Plates V and VI) (12).

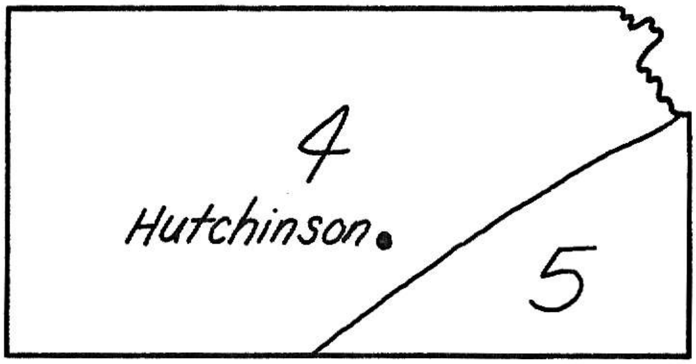
The proximity of the Little Arkansas river produces a relatively high water table beneath the city of Hutchinson which could conceivably provide supplemental water to tree species during otherwise droughty periods. The water table is in no cases deeper than 20 ft. under the city and in most cases is considerably shallower (5-10 ft. deep) (12,63). This ground water reservoir has a potential of producing in excess of 1000 gal./min./ well of water which is perhaps indicative of its potential in sustaining tree growth (13).

EXPLANATION OF PLATE IV

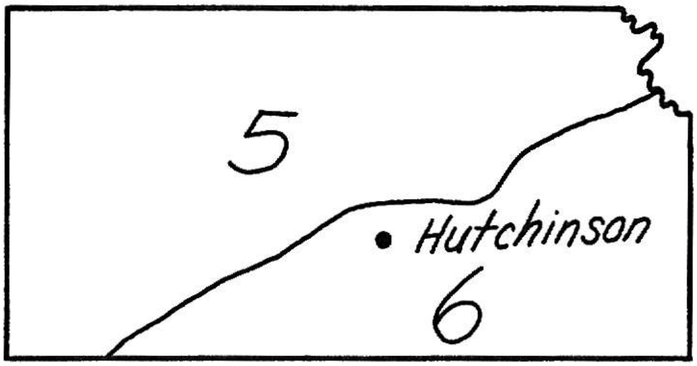
Location of Hutchinson, Kansas, as related to various hardiness zone classification systems.



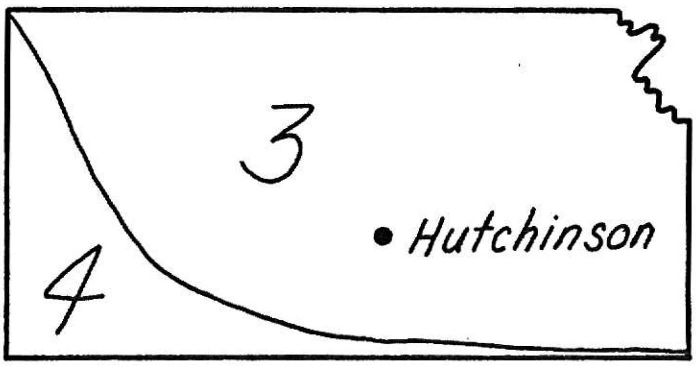
Wyman -1965



Rehder -1940



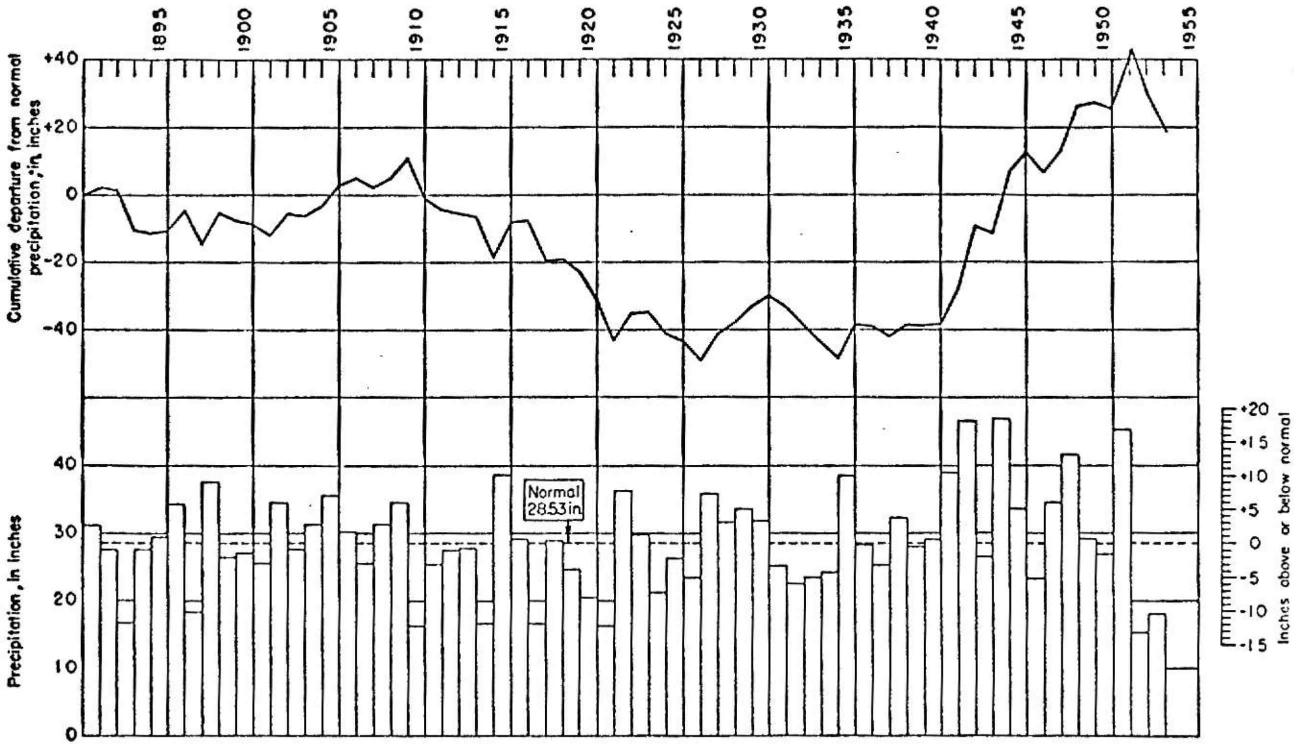
USDA



Taylor

EXPLANATION OF PLATE V

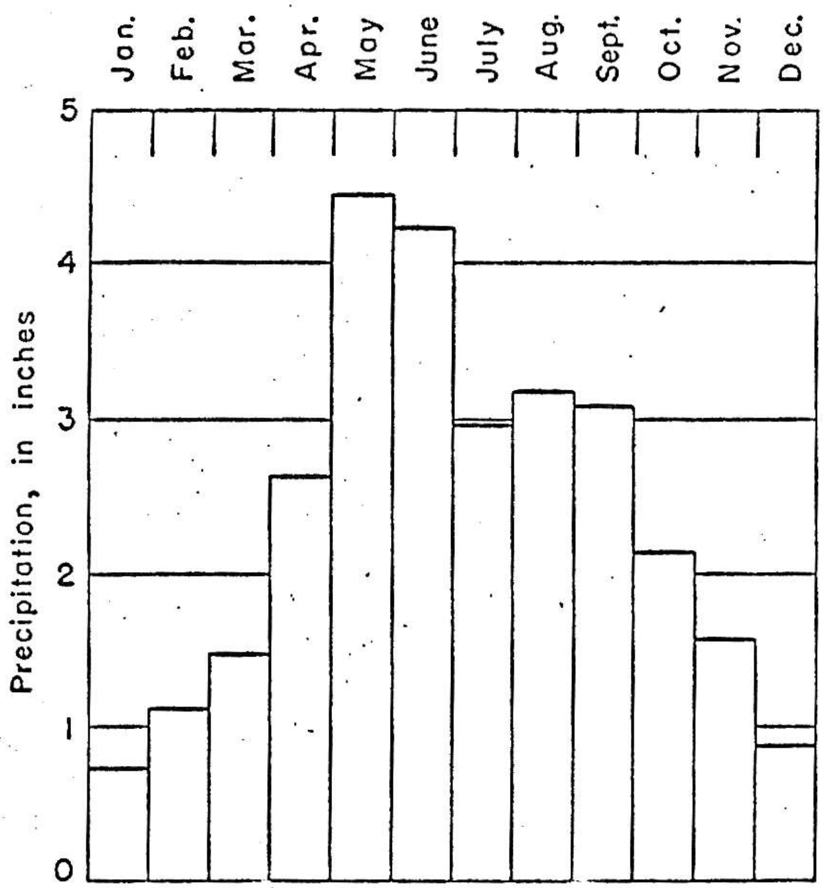
Annual precipitation data for Hutchinson, Kansas (12, p. 13).



—Annual precipitation and cumulative departure from normal precipitation at Hutchinson.

EXPLANATION OF PLATE VI

Monthly distribution of precipitation for Hutchinson, Kansas, (through 1955) (12, p. 15).



—Monthly distribution of precipitation at Hutchinson.

The topography of the city of Hutchinson is, for the most part, flat. The soils are relatively deep, naturally fertile, and well drained. The surface horizon is primarily fine sandy loam or silt loam with a slightly acid soil reaction. This surface layer is subtended by a heavier sandy clay or clay loam substratum at a depth of 10-30 inches. The subsoil contains scattered calcareous deposits with the potential of affecting plants which prefer an acid soil or are sensitive to an alkaline medium. These soils are composed of glacial outwash, alluvium deposits, or wind blown loess, the specific soil types being dependent on a predominance of one or more of these morphological activities. The predominate soil types in Hutchinson and their series designations are (63):

1. Va - Vanoss silt loam
2. Na - Naron fine sandy loam
3. Fs - Farnum - Slickspot complex
4. Cf - Carwile - Farnum fine sandy loam
5. Da - Dale clay loam
6. Ca - Canadian fine sandy loam

Many of the initial street tree plantings in Hutchinson were installed between 1875 and 1885 shortly after the city's incorporation in 1872. A second comprehensive planting was installed between 1905 and 1911 with another intensive planting effort between 1916 and 1920. These early plantings were primarily composed of Siberian elm (Ulmus pumila), hardy catalpa (Catalpa speciosa), treeofheaven (Ailanthus altissima), American elm (Ulmus americana), and silver maple (Acer saccharinum). The remnants of these plantings are now quite problematical possessing the inherent weaknesses of the species involved and the imminent difficulties of poor planting design. More recent plantings were not as isolated or as extensive as were the earlier plantings, but poor species selection and planting design has continued to plague even the most recently planted areas.

The streets in most of the city have been platted in the conventional grid pattern although the newer areas are of more contemporary design with curves, cul-de-sacs, etc. The streets are consequently straight, uniform, and flat with little or no topographic interest.

THE SURVEY RESULTS

The street tree survey revealed several important characteristics of the Hutchinson street tree plantings. The city is quite segregated as to species distribution, and this segregation is emphasized by a preponderance of a few species. Although 53 species were encountered, almost 97 percent of the survey sample was composed of only 16 different species. Even more significant was the frequency of elms; American elms comprised 40 percent and Siberian elms comprised 36 percent of the survey population (Table 1).

Because of the segregated street tree distribution in the city, several characteristic areas could be delineated.

Table 1. Survey results - Street tree species observed in the sample area (Plate I), the number of individual trees in each species grouping, and the percentage distribution of the relative species.

COMMON NAME	BOTANICAL NAME	NUMBER OF TREES	PERCENT
American Elm English Elm Others	Ulmus americana Ulmus procera Ulmus spp.	3336	39.78
Siberian Elm	Ulmus pumila	2993	35.69
Silver Maple	Acer saccharinum	430	5.13
American Planetree London Planetree	Platanus occidentalis Platanus acerifolia	269	3.21
Southern Catalpa Northern Catalpa Chinese Catalpa	Catalpa bignonioides Catalpa speciosa Catalpa ovata	178	2.12
Green Ash Red Ash	Fraxinus pennsylvanica lanceolata Fraxinus pennsylvanica	169	2.02
Honeylocust	Gleditzia triacanthos	134	1.60
Pin Oak	Quercus palustris	114	1.36
Hackberry	Celtis occidentalis	103	1.23
Treeofheaven	Ailanthus altissima	89	1.06
Eastern Redbud	Cercis canadensis	86	1.03
Eastern Redcedar	Juniperus virginiana	80	.95
Eastern Cottonwood	Populus deltoides missouriensis	72	.86
White Mulberry Red Mulberry	Morus alba Morus rubra	67	.80
Miscellaneous*		265	3.16
	TOTAL	8385	100.00

*See Table 2.

Table 2. Tree species included under "Miscellaneous" in Table 1.

	BOTANICAL NAME	COMMON NAME
1.	Acer negundo	Boxelder
2.	Acer saccharum	Sugar Maple
3.	Albizzia julibrissin	Silktree
4.	Betula alba (pendula)	European White Birch
5.	Broussonetia papyrifera	Papermulberry
6.	Carya glabra	Pignut Hickory
7.	Carya illinoensis	Pecan
8.	Diospyros virginiana	Common Persimmon
9.	Elaeagnus angustifolia	Russianolive
10.	Ginkgo biloba	Ginkgo
11.	Gymnocladus dioicus	Kentucky Coffeetree
12.	Juglans nigra	Eastern Black Walnut
13.	Koelreuteria paniculata	Panicled Goldraintree
14.	Liquidambar styraciflua	American Sweetgum
15.	Maclura pomifera	Osageorange
16.	Malus spp.	Flowering Crabapples
17.	Picea pungens	Colorado Spruce
18.	Pinus nigra	Austrian Pine
19.	Pinus ponderosa	Ponderosa Pine
20.	Pinus resinosa	Red Pine
21.	Pinus strobus	White Pine
22.	Pinus sylvestris	Scotch Pine
23.	Populus alba	White Poplar
24.	Populus alba pyramidalis	Bolleana Poplar
25.	Populus nigra italica	Lombardy Poplar
26.	Prunus spp.	Cherry, Peach, Plum
27.	Pyrus spp.	Pear
28.	Quercus borealis	Northern Red Oak
29.	Quercus macrocarpa	Bur Oak
30.	Robinia pseudoacacia	Black Locust
31.	Salix babylonica	Babylon Weeping Willow
32.	Sapindus drummondi	Western Soapberry
33.	Sophora japonica	Japanese Pagodatree
34.	Tamarix spp.	Tamarisk
35.	Taxodium distichium	Common Baldcypress
36.	Thuja occidentalis	Eastern Arborvitae
37.	Tilia cordata	Littleleaf Linden

Characteristic Areas

1. Early Planted Area

The older part of town, represented by section I of Plate I, was referred to in the discussion of early street tree plantings. The predominance of elms, treeofheaven, and catalpa reflect these early plantings. The trees appear to have been neglected. Growing conditions have been less than adequate as the parking of cars and playing of children has led to soil compaction and mechanical damage. Overplanted areas and underplanted areas were both observed, which indicates the absence of a rational planting plan. Quick improvement and immediate satisfaction could be achieved by an intensified renovation program in this area.

2. West of Junior College

The plantings immediately west of the junior college, represented by section VII and portions of section VIII of Plate I, have the potential of becoming the most troublesome area in the city. This area was selected for discussion because it exhibited a problem common to many Kansas communities. Uninterrupted rows of American elms were planted when the district was developed. The trees were apparently planted on twenty foot centers in the original planting, and, although many have been lost, the restrictive spacing still presents problems. The individual trees are in surprisingly good condition despite the crowded conditions. The extreme planting density of American elms in this area has complicated the threat of Dutch elm disease in the city. Isolated infections of the disease were found in this and adjacent sections. The incidence of Dutch elm disease may be expected to increase in this section.

3. The Countryside Area

The "Countryside" subdivision, represented by that portion of section X, north of 30th avenue in Plate I, is a relatively new subdivision. The plantings consisted of the repetitous use of honeylocust, pin oak, and sycamore (American planetree). The houses are primarily low, spreading, ranch-type structures which will be completely out of scale with the pin oaks and planetrees when the trees approach ultimate size. There was a certain amount of revelation observed in the design of the subdivision, as broad curving streets replaced the typical grid pattern, and sidewalks were not included. The soil in this area is alkaline to the extent that pin oaks are chlorotic.

4. The Downtown Area

At the time of this survey, the downtown area of Hutchinson was virtually devoid of landscaping and was considered a characteristic area on this basis. During the interim between the survey and this writing, however, an enlightened renovation of the business district has been conducted. Mall type areas have been incorporated utilizing tubbed tree specimens. The species used included:

<u>Liquidambar styraciflua</u> - American Sweetgum
<u>Prunus blireiana</u> 'Newport' - 'Newport' Purpleleaf Plum
<u>Malus</u> 'Hopa' - 'Hopa' Crabapple
<u>Cercis canadensis</u> - Eastern Redbud
<u>Fraxinus pennsylvanica lanceolata</u> 'Marshall's Seedless' - Marshall's Seedless Ash

5. The Outlying Areas

The outlying areas of the city were quite diversified and defy inclusion into a true characteristic area. A couple of generalizations can be drawn which encompass these areas. In these areas the problem was not one of crowded spacing or even poor species selection but was the lack of any significant planting at all. These areas, along with the new subdivisions, provide the opportunity for pilot plantings based on sound procedures and practices.

Condition Classification and Pests

As indicated in Table 3, the large proportion of the street trees were in good to excellent condition at the time of the street tree survey despite crowded and sub-optimal growing conditions. The condition of these street trees encourages the adoption of conservation practices but also makes the process of selective thinning (removal of competitive trees) more difficult.

Of the trees requiring pruning (Table 4), 54% were Siberian elms and 38% were American elms. The pruning requirements of elm species is critical due to the imminent threat of Dutch elm disease and the preference of its vectors, the elm bark beetles, for dead or dying elm wood for breeding purposes.

The important insect and disease problems observed during the course of the survey were species specific being observed in large quantities on a few species. The principal disease problem was slime flux (wetwood) of the elms. Because of the omnipresence of this disease, notation of individual cases was

Table 3. Number and percentage of trees surveyed which were included in each of the five condition classes as described in the Materials and Methods.

CONDITION CLASS		NUMBER OF TREES	PERCENTAGE
# 1		6280	74.90
# 2		1163	13.90
# 3		739	8.80
# 4		160	1.90
# 5		43	.50
	TOTAL	8385	100.00

Table 4. Number and percentage of trees surveyed which exhibited the problem indicated.

PROBLEM AREA	NUMBER OF TREES	PERCENTAGE
Required Pruning		
- Total	1577	18.80
- Siberian Elm	796	9.50
- American Elm	604	7.30
- Others	177	2.00
Insect Problems		
- Total	3135	37.40
- Siberian Elm	1749	21.00
- American Elm	934	12.00
- Planetree	234	2.90
- Others	118	1.50
Disease Problems*		
- Total	378	4.50
- Planetree	251	3.00
- Pin Oak	49	.60
- Others	78	.90

*Slime flux (Wetwood) of the elms was observed on 95%+ of the elms surveyed. Because of the omnipresence of this disease, the minimal amount of direct damage it causes, and the futility of control measures, individual cases were not recorded.

Dutch elm disease was present but not in large enough quantities to warrant inclusion into this table.

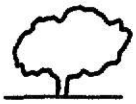
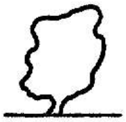
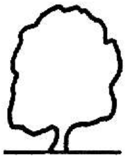
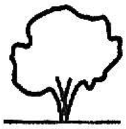
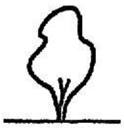
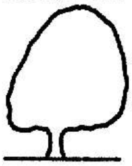
abandonded early in the survey. Sycamore (American planetree) anthracnose was also of epiphytotic proportions during the summer of 1968. The trees eventually recovered from the infection. Iron chlorosis is a perpetual problem in pin oaks in some parts of the city, particularly where alkaline soil conditions exist. Dutch elm disease was first positively isolated in Hutchinson as a result of this survey. Seventeen individual cases of the disease were discovered and confirmed during the investigation.

Elm leaf beetles were the most severe insect pests and were responsible for the virtual defoliation of many Siberian elms throughout the city. Leaf beetles were not as prevalent on American elms although they were frequently observed. Lace bugs were prevalent on the American planetrees but caused little severe damage. Aphids were also present but were not strictly monitored. Other insects observed included: elm scales, elm calligrapha beetles, Mimosa webworm on honeylocust, borers (particularly on ash species), and elm bark beetles (insect vector of Dutch elm disease).

THE SPECIES EVALUATION

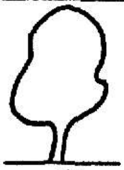
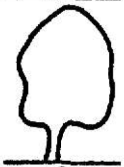
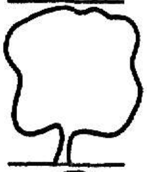
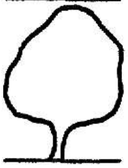
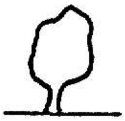
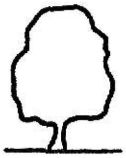
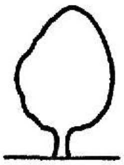
The 147 species which were evaluated for street tree use are categorized in the following tables (5-17). These tables are self-explanatory and are offered as such in this section. The tables were compiled by reference to the following sources: 16,20,25,26,27,32,34,39,41,46,48,49,51,53,62,64,75,76,77,81,83, 86,87.

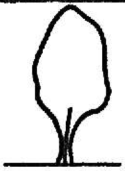
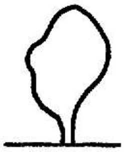
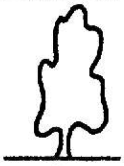
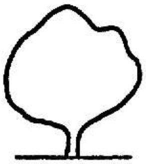
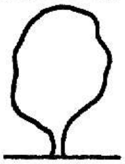
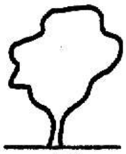
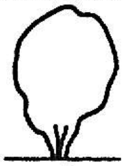
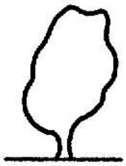
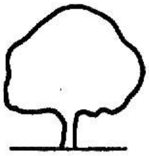
Table 5. Growth characteristics of the tree species which were evaluated for possible street tree use in Hutchinson.

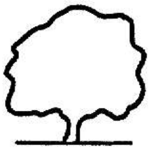
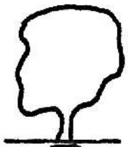
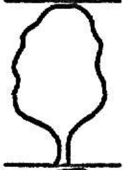
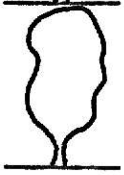
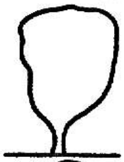
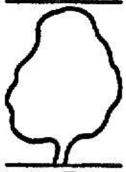
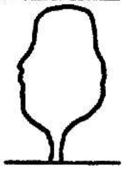
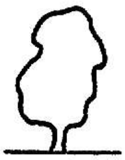
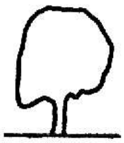
BOTANICAL NAME	FORM	SILHOUETTE*	ULTIMATE SIZE**	
			height	breadth
Acer campestre	shrubby, compact broadly elliptical low branching densely twiggy		20-30	20-30
Acer ginnala	upright, rounded dense, low-headed irregular		20-30	20-30
Acer japonicum	round topped open, irregular		20-30	20-30
Acer negundo	broad, open irregular		40-60	30-40
Acer nigrum	broadly rounded ovate, dense symmetrical		60-80	50-60
Acer palmatum	open, irregular round topped shrubby, dense		20-30	20-30
Acer pensylvanicum	oval, irregular open, shrubby		20-30	20-30
Acer platanoides	broad, rounded dense, regular dome-shaped		50-70	40-50

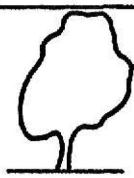
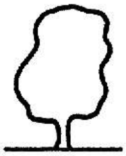
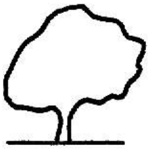
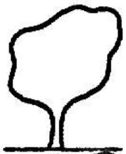
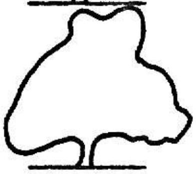
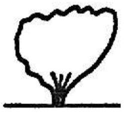
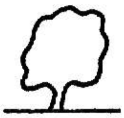
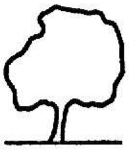
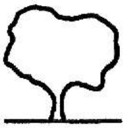
*No attempt was made to draw these silhouettes to scale. The relative sizes of these species are as reflected in the size category.

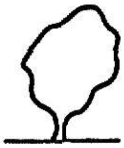
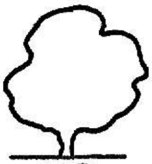
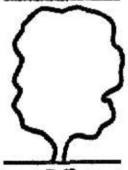
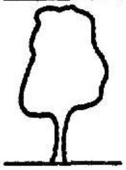
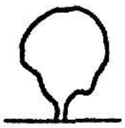
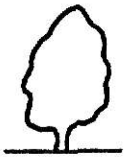
**These generalized dimensions were modified to account for expected size reductions due to the absence of optimum growing conditions in the city environment and the Hutchinson climate.

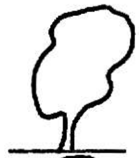
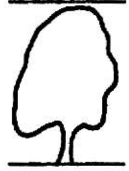
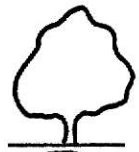
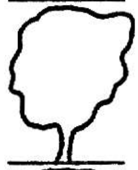
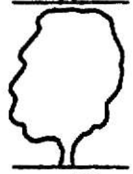
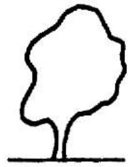
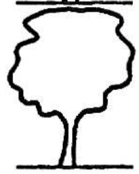
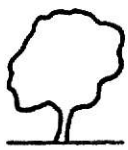
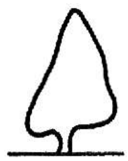
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Acer pseudoplatanus	upright, broad rounded		60-80	40-60
Acer rubrum	symmetrical ovate to narrow ascending branches		60-90	40-60
Acer saccharinum	open, irregular wide-spreading massive		80-100	60-70
Acer saccharum	dense, widely oval round topped		70-90	50-60
Acer spicatum	shrubby, rounded		20-30	20-30
Acer tataricum	upright elliptical		20-30	20-30
Aesculus glabra	irregular broadly rounded		40-50	30-40
Aesculus hippocastanum	dense broadly ovate low branching		40-60	30-40
Ailanthus altissima	round topped open, spreading upright, exotic		50-60	30-40
Albizzia julibrissin	flat topped wide-spreading horizontal branching		20-30	20-30

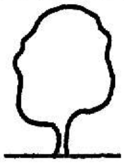
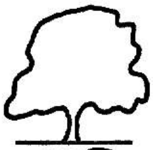
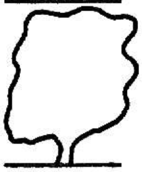
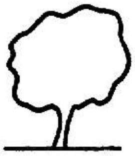
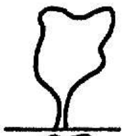
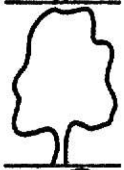
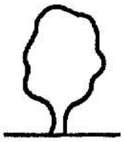
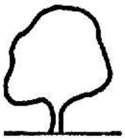
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Amelanchier canadensis	narrow, rounded open, shrubby upright		20-30	10-20
Asimina triloba	open, irregular		20-30	20-30
Betula alba (pendula)	narrow, pyramidal somewhat pendulous graceful		30-40	20-30
Betula lenta	symmetrical ovoid		50-60	30-40
Betula lutea	broad, rounded		50-70	30-40
Betula nigra	irregular open, broad vase-shaped		60-80	40-50
Betula papyrifera	narrow, compact graceful		60-80	30-40
Betula populifolia	irregular, open narrow, loose		30-40	20-30
Broussonetia papyrifera	broad, rounded		40-50	30-40
Bumelia lanuginosa	horizontal, tortuous branching, picturesque		20-30	10-20

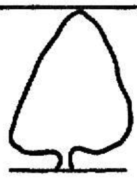
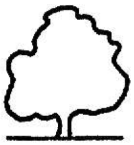
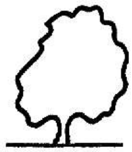
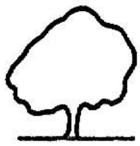
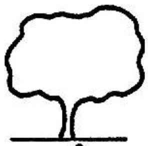
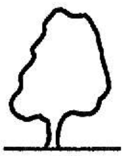
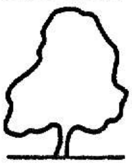
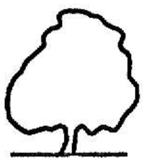
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Carpinus betulus	round topped narrow, bushy low branching spreading		40-50	20-30
Carpinus caroliniana	dense, compact globose		20-30	10-20
Carya cordiformis	narrow irregular		50-70	20-40
Carya glabra	open, oval uniform, narrow		50-70	20-40
Carya illinoensis	broadly oval uniform		90-120	50-60
Carya laciniosa	narrow, oblong		60-80	30-40
Carya ovata	narrow, oblong open, irregular upright		70-90	30-40
Carya tomentosa	upright, rounded symmetrical, open		40-60	20-40
Castanea mollissima	dense, rounded broad spreading low headed		20-30	20-30
Catalpa bignonioides	loose, rounded open, irregular		30-40	20-30

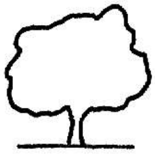
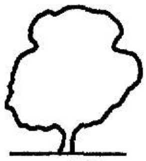
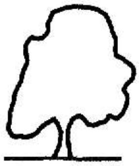
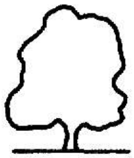
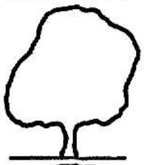
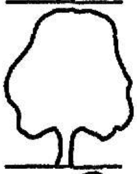
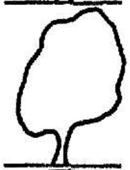
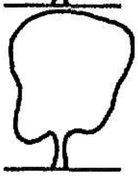
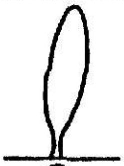
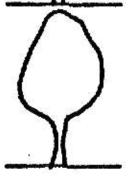
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Catalpa ovata	symmetrical upright, spreading		40-60	30-40
Catalpa speciosa	erect, oblong, loose open, symmetrical		40-60	30-40
Celtis laevigata	spreading round headed		70-90	40-50
Celtis occidentalis	open, uniform vase-shaped		80-100	50-60
Cercidiphyllum japonicum	dense, broadly ovate low branching wide spreading irregular		40-70	40-50
Cercis canadensis	broad, upright slightly rounded		20-40	20-30
Cercis chinensis	shrublike spreading		10-20	10-20
Chionanthus virginicus	shrublike, stiff somewhat rounded		10-30	10-20
Cladrastus lutea	dense broadly ovate round topped low branching		40-50	30-40
Cornus florida	flat topped spreading horizontal branching pattern		20-30	20-30

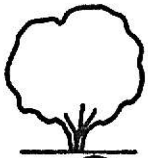
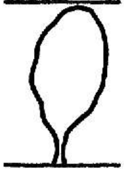
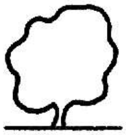
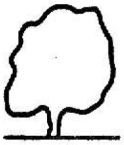
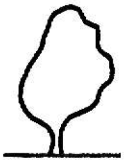
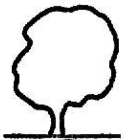
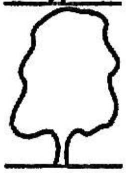
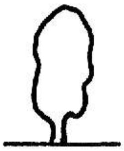
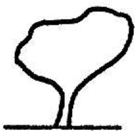
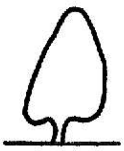
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Cotinus coggygria	broadly rounded stiffly upright shrubby		10-20	10-20
Crataegus crusgalli	low, dense, broad flat topped stratified branching		20-30	20-30
Crataegus mollis	rounded, dense		20-30	20-30
Crataegus oxyacantha	shrubby, dense round topped low branching		10-20	10-20
Crataegus phaenopyrum	upright broadly ovate densely compact		20-30	10-20
Diospyros virginiana	upright round headed open, irregular		40-50	20-30
Elaeagnus angustifolia	broad, rounded open, irregular		20-30	20-30
Euonymus bungeana	arching, pendulous branching pattern		10-20	5-15
Evodia danielli	open shrublike		20-30	10-20
Fagus grandifolia	upright densely pyramidal low branching		50-70	20-40

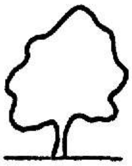
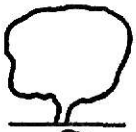
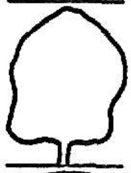
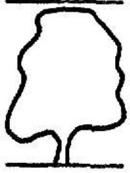
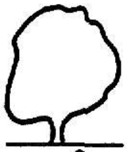
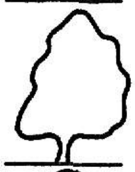
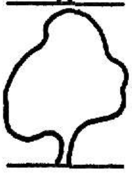
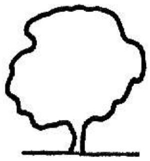
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Franklinia alatamaha	loose, open upright, pyramidal		20-30	10-20
Fraxinus americana	upright broad, rounded		70-90	50-60
Fraxinus ornus	dense round headed		40-60	30-50
Fraxinus pennsylvanica	irregular, open ascending branching habit		40-60	30-40
Fraxinus pennsylvanica lanceolata	broad, compact upright, irregular		50-70	30-50
Fraxinus quadrangulata	upright open, rounded		50-70	40-50
Ginkgo biloba	open, erect pyramidal when young variable, exotic		70-90	40-50
Gleditzia triacanthos	vase-shaped broad, open round topped horizontal branching		80-100	50-60
Gymnocladus dioicus	regular, oval coarse ascending branches		60-80	40-50
Ilex opaca	upright compact, pyramidal densely branching		20-30	10-20

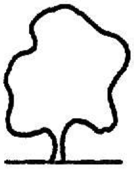
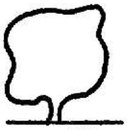
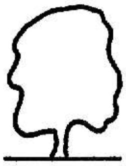
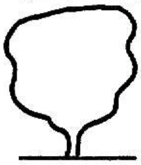
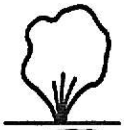
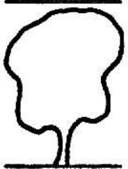
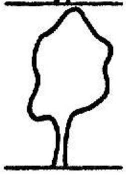
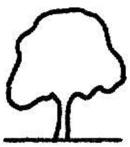
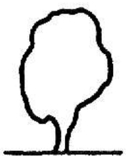
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	breadth
Juglans cinerea	open, round topped wide-spreading		60-80	40-50
Juglans nigra	open, rounded broad spreading low branching		90-120	50-70
Juglans regia	open, rounded spreading		40-60	40-50
Kalopanax pictus	open, globose wide-spreading ascending branches		50-60	30-40
Koelreuteria paniculata	upright flat topped dense, rounded		20-40	20-30
Laburnum anagyroides	flat topped, open stiff, upright irregular narrowly vase-shaped		20-30	10-20
Liquidambar styraciflua	upright pyramidal when young becomes rounded		70-100	40-60
Liriodendron tulipifera	oval, upright open, cylindrical high branching		90-120	50-60
Maackia amurensis	neat, upright		30-50	20-30
Maclura pomifera	rounded, dense		30-50	30-40

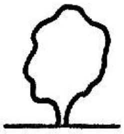
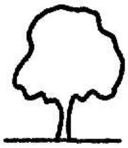
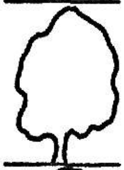
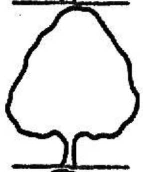
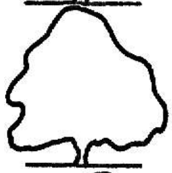
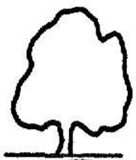
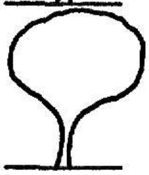
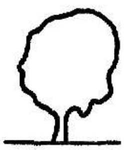
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE	
			height	breadth
Magnolia acuminata	pyramidal broad, massive		50-70	30-50
Magnolia soulangeana	shrubby, becomes broad and rounded laterally spreading branches		10-20	10-20
Magnolia stellata	shrublike densely branching wide-spreading		20-30	20-30
Malus spp.	Much variation within the genus		5-40	5-40
Morus alba	broad, dense round topped		30-50	30-40
Morus rubra	open, irregular broad, rounded fairly dense		50-60	30-40
Nyssa sylvatica	upright narrow, open irregularly pyramidal		60-80	30-40
Ostrya virginiana	broad, rounded gracefully pyramidal		30-40	20-30
Oxydendrum arboreum	erect, oval		40-60	20-40
Paulownia tomentosa	broad oval, open		30-50	20-40

BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Phellodendron amurense	open, rounded broad spreading low branching irregular		40-50	30-40
Pistacia chinensis	broad round headed		30-50	20-40
Platanus acerifolia	massive, irregular becomes rounded low branching		90-110	50-70
Platanus occidentalis	broad, open rounded, irregular low branching		100-120	60-80
Platanus orientalis	broad, massive open, rounded variable		60-80	50-60
Populus alba	open, upright irregularly pyramidal		70-90	40-50
Populus canadensis eugenei	wide-spreading		80-100	50-70
Populus deltoides missouriensis	wide-spreading open, irregular		80-110	50-80
Populus nigra italica	columnar		60-80	5-10
Populus tremuloides	loose, open round topped irregular		40-60	20-30

BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Prunus armeniaca	rounded loose, open		20-30	20-30
Prunus avium	erect, ovate rounded		40-70	20-30
Prunus cerasifera	rounded, upright		10-20	10-20
Prunus cerasus	broadly rounded		10-20	10-20
Prunus pensylvanica	slender, oblong round topped		20-30	10-20
Prunus persica	triangular crown low branching		20-30	20-30
Prunus serotina	oval, thin, open ascending branching pattern		60-80	30-50
Prunus virginiana	oval, rounded		20-30	10-20
Ptelea trifoliata	round headed loose, open irregular		10-20	5-10
Pyrus calleryana	upright, rigid columnar to pyramidal		20-30	10-20

BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
Quercus alba	broad, open, rounded horizontal branching pattern		50-70	40-60
Quercus bicolor	open, oblong		60-70	40-50
Quercus borealis	dense broad, uniform round topped		70-90	40-50
Quercus coccinea	open, oblong round topped		60-80	40-50
Quercus imbricaria	open, upright dense, oblong somewhat pyramidal		60-80	30-50
Quercus macrocarpa	broad, rounded rugged character		70-90	50-60
Quercus palustris	pyramidal when young becomes rounded irregular low hanging branches		60-80	40-50
Quercus phellos	conical when young becomes rounded		40-50	20-40
Quercus prinus	dense, compact rounded		40-50	20-40
Quercus robur	wide-spreading, open rounded, gnarly		70-90	60-70

BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
<u>Quercus stellata</u>	irregular, tortuous low, rounded crown picturesque		40-50	30-40
<u>Quercus velutina</u>	wide, rounded irregular		80-100	40-50
<u>Robinia pseudoacacia</u>	open, oblong irregular becomes ragged		50-60	30-40
<u>Salix alba</u>	broad, open round topped low branching		50-70	40-50
<u>Salix babylonica</u>	broad, rounded weeping habit		30-40	30-40
<u>Salix discolor</u>	irregularly upright spreading		10-20	10-20
<u>Sapindus drummondi</u>	irregular round headed high branching		30-40	20-30
<u>Sassafras albidum</u>	oval, loose open, irregular		40-50	20-30
<u>Sophora japonica</u>	broadly oval dense, exotic		50-70	30-40
<u>Sorbus aucuparia</u>	ovate, upright ascending branching pattern		30-50	20-30

BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE height	ULTIMATE SIZE breadth
<u>Staphylea trifoliata</u>	shrubby, loose open, round topped		10-20	10-20
<u>Syringa amurensis japonica</u>	pyramidal when young becomes rounded		20-30	20-30
<u>Tamarix spp.</u>	shrubby, loose open, irregular		10-20	10-20
<u>Tilia americana</u>	ovoid, upright round topped wide-spreading		80-100	40-60
<u>Tilia cordata</u>	upright, neat densely pyramidal round topped		60-80	30-50
<u>Tilia europea</u>	pyramidal in youth becomes broad and rounded		70-90	40-50
<u>Tilia platyphyllos</u>	pyramidal symmetrical		70-90	60-70
<u>Toona sinensis</u>	spreading, dense round topped exotic		40-50	30-40
<u>Ulmus americana</u>	vase-shaped wide-spreading variable		80-100	60-80
<u>Ulmus carpinifolia</u>	upright, dense rounded		50-70	30-40

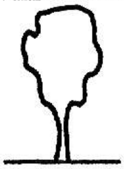
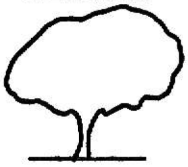
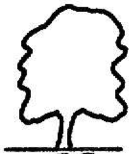
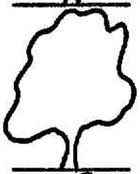
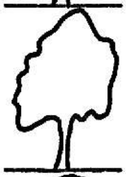
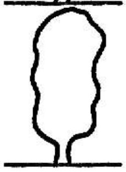
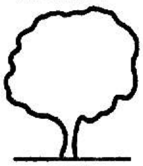
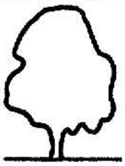
BOTANICAL NAME	FORM	SILHOUETTE	ULTIMATE SIZE	
			height	breadth
Ulmus fulva	open, high branching vase-shaped		40-60	30-50
Ulmus glabra	oblong wide-spreading large and massive		80-100	50-70
Ulmus parvifolia	round topped regular		30-40	20-30
Ulmus procera	upright broadly oval round topped		80-100	60-80
Ulmus pumila	loose, open oblong		40-60	20-30
Ulmus thomasii	oblong round topped		50-70	30-40
Xanthoceras sorbifolium	shrublike, upright stout branches		10-20	5-10
Zelkova serrata	upright round topped wide-spreading		70-90	60-70
Zizyphus jujuba	spiny, open		20-30	15-20

Table 6. Tree species which should be climatically adapted to the Hutchinson area according to information from references consulted.

	BOTANICAL NAME	COMMON NAME
1.	Acer campestre	Hedge Maple
2.	Acer ginnala	Amur Maple
3.	Acer negundo	Boxelder
4.	Acer platanoides	Norway Maple
5.	Acer saccharinum	Silver Maple
6.	Acer saccharum	Sugar Maple
7.	Acer tataricum	Tatarian Maple
8.	Ailanthus altissima	Treeofheaven Ailanthus
9.	Albizzia julibrissin	Silktree
10.	Betula nigra	River Birch
11.	Betula populifolia	Gray Birch
12.	Broussonetia papyrifera	Common Papermulberry
13.	Bumelia lanuginosa	Woollybucket Bumelia
14.	Carya illinoensis	Pecan
15.	Carya tomentosa	Mockernut Hickory
16.	Catalpa bignonioides	Southern Catalpa
17.	Catalpa ovata	Chinese Catalpa
18.	Catalpa speciosa	Northern Catalpa
19.	Celtis laevigata	Sugar Hackberry
20.	Celtis occidentalis	Common Hackberry
21.	Cercis canadensis	Eastern Redbud
22.	Chionanthus virginicus	White Fringetree
23.	Crataegus spp.	Hawthorns
24.	Diospyros virginiana	Common Persimmon
25.	Elaeagnus angustifolia	Russianolive
26.	Euonymus bungeana	Winterberry Euonymus
27.	Fraxinus americana	White Ash
28.	Fraxinus pennsylvanica	Red Ash
29.	Fraxinus pennsylvanica lanceolata	Green Ash
30.	Fraxinus quadrangulata	Blue Ash
31.	Ginkgo biloba	Ginkgo
32.	Gleditzia triacanthos	Common Honeylocust
33.	Gymnocladus dioicus	Kentucky Coffeetree
34.	Juglans nigra	Eastern Black Walnut
35.	Koelreuteria paniculata	Panicled Goldraintree
36.	Maclura pomifera	Osageorange
37.	Malus spp.	Flowering Crabapples
38.	Morus alba	White Mulberry
39.	Morus rubra	Red Mulberry
40.	Paulownia tomentosa	Royal Paulownia
41.	Pistacia chinensis	Chinese Pistache
42.	Platanus acerifolia	London Planetree
43.	Platanus occidentalis	American Planetree
44.	Populus alba	White Poplar
45.	Populus canadensis eugenei	Carolina Poplar
46.	Populus deltoides missouriensis	Southern Poplar

47.	Populus nigra	Black Poplar
48.	Prunus spp.	Cherry, Plum, Peach
49.	Ptelea trifoliata	Common Hoptree
50.	Pyrus spp.	Pears
51.	Quercus alba	White Oak
52.	Quercus borealis	Northern Red Oak
53.	Quercus macrocarpa	Bur Oak
54.	Quercus palustris	Pin Oak
55.	Quercus robur	English Oak
56.	Quercus stellata	Post Oak
57.	Quercus velutina	Black Oak
58.	Robinia pseudoacacia	Black Locust
59.	Salix spp.	Willows
60.	Sapindus drummondi	Western Soapberry
61.	Sophora japonica	Japanese Pagodatree
62.	Staphylea trifoliata	American Bladdernut
63.	Syringa amurensis japonica	Japanese Tree Lilac
64.	Tamarix spp.	Tamarisk
65.	Tilia americana	American Linden
66.	Tilia cordata	Littleleaf Linden
67.	Tilia europea	European Linden
68.	Tilia platyphyllos	Bigleaf Linden
69.	Ulmus americana	American Elm
70.	Ulmus carpinifolia	Smoothleaf Elm
71.	Ulmus glabra	Scotch Elm
72.	Ulmus parvifolia	Chinese Elm
73.	Ulmus procera	English Elm
74.	Ulmus pumila	Siberian Elm
75.	Ulmus thomasii	Rock Elm
76.	Xanthoceras sorbifolia	Shinyleaf Yellowhorn

Table 7. Tree species with marginal climatic survival potential in the Hutchinson area but whose culture should be attempted on an experimental basis in sheltered or favorable microclimates with hardy clones.

	BOTANICAL NAME	COMMON NAME	LIMITING FACTOR(S)
1.	Acer japonicum	Fullmoon Maple	Excessive heat may be limiting
2.	Acer nigrum	Black Maple	Requires moist soil Does not tolerate city conditions well
3.	Acer rubrum	Red Maple	Requires moist soil
4.	Aesculus glabra	Ohio Buckeye	Excessive heat and low humidity may be limiting
5.	Amelanchier canadensis	Shadblow Serviceberry	Prefers shade or partial shade but adapts to exposed locations
6.	Betula alba (pendula)	European White Birch	Prefers moist soil and cool conditions
7.	Carya cordiformis	Bitternut Hickory	Prefers moist site in partial shade Adapts to drier upland sites
8.	Carya glabra	Pignut Hickory	Excessive heat may be limiting
9.	Carya ovata	Shagbark Hickory	Requires protection and adequate moisture
10.	Castanea mollissima	Chinese Chestnut	Excessive heat and adequate moisture may be limiting
11.	Cercidiphyllum japonicum	Katsuratree	Prefers rich moist acid soil Cold hardiness may be limiting
12.	Cercis chinensis	Chinese Redbud	Cold hardiness may be limiting
13.	Cladrastus lutea	American Yellowwood	Subject to sunscald

14.	*Cotinus coggygria*	Common Smoketree	Cold hardiness may be limiting
15.	*Evodia danielli*	Korean Evodia	Excessive heat and wind may be limiting
16.	*Fraxinus ornus*	Flowering Ash	Cold hardiness may be limiting
17.	*Ilex opaca*	American Holly	Cold hardiness may be limiting
18.	*Juglans cinerea*	Butternut	Requires adequate moisture
19.	*Juglans regia*	English Walnut	Cold hardiness may be limiting
20.	*Kalopanax pictus*	Castoraralia	Requires adequate moisture and a cool soil
21.	*Liquidambar styraciflua*	American Sweetgum	Requires protection from wind and prefers an acid soil
22.	*Liriodendron tulipifera*	Tuliptree	Requires protection from wind when young Subject to sunscald
23.	*Maackia amurensis*	Amur Maackia	Excessive heat may be limiting
24.	*Magnolia soulangeana*	Saucer Magnolia	Requires protection from wind
25.	*Ostrya virginiana*	American Hophornbeam	Prefers partial shade and cool conditions Adapts to dry upland sites
26.	*Oxydendrum arboreum*	Sourwood	Prefers high humidity Requires acid soil
27.	*Phellodendron amurense*	Amur Corktree	Cold hardiness may be limiting
28.	*Platanus orientalis*	Oriental Planetree	Cold hardiness may be limiting Requires protection from wind
29.	*Populus tremuloides*	Quaking Aspen	Excessive heat and disease may be limiting

30.	<u>Prunus armeniaca</u>	Apricot	Cold hardiness may be limiting Requires protection
31.	<u>Quercus bicolor</u>	Swamp White Oak	Requires adequate moisture
32.	<u>Quercus coccinea</u>	Scarlet Oak	Must be sheltered
33.	<u>Quercus imbricaria</u>	Shingle Oak	Prefers moist soil Excessive heat and wind may be limiting
34.	<u>Quercus phellos</u>	Willow Oak	Requires a moist to swampy soil
35.	<u>Quercus prinus</u>	Swamp Chestnut Oak	Excessive heat and wind may be limiting
36.	<u>Sassafras albidum</u>	Common Sassafras	Prefers shade or partial shade Requires deep acid soil
37.	<u>Sorbus aucuparia</u>	European Mountainash	Requires protection from wind and sun Subject to sunscald
38.	<u>Toona sinensis</u>	Chinese Toon	Cold hardiness may be limiting
39.	<u>Ulmus fulva</u>	Slippery Elm	Excessive heat may be limiting
40.	<u>Zelkova serrata</u>	Japanese Zelkova	Requires a moist soil and protection
41.	<u>Zizyphus jujuba</u>	Common Jujube	Cold hardiness may be limiting

Table 8. Tree species with marginal climatic survival potential in Hutchinson whose culture as street trees in this area should probably not be attempted.

	BOTANICAL NAME	COMMON NAME	LIMITING FACTOR(S)
1.	*Acer palmatum*	Japanese Maple	Requires protection Prefers partial shade
2.	*Acer pensylvanicum*	Striped Maple	Requires shade Requires moist soil
3.	*Acer pseudoplatanus*	Planetree Maple	Cold hardiness is limiting
4.	*Acer spicatum*	Mountain Maple	Requires shade Requires moist soil
5.	*Aesculus hippocastanum*	Common Horsechestnut	Requires protection from hot winds Objects to reflected heat of pavement
6.	*Asimina triloba*	Common Pawpaw	Prefers cool soil Requires shade and protection
7.	*Betula lenta*	Sweet Birch	Requires a cool, moist site Particular of soil conditions Culture is difficult
8.	*Betula lutea*	Yellow Birch	Requires shelter from wind
9.	*Betula papyrifera*	Paper Birch	Requires cool, moist site
10.	*Carpinus betulus*	European Hornbeam	Requires cool conditions Cold hardiness is limiting
11.	*Carpinus caroliniana*	American Hornbeam	Prefers shade Requires cool conditions
12.	*Carya laciniosa*	Shellbark Hickory	Excessive heat is limiting Requires moist soil

13.	<u>Cornus florida</u>	Flowering Dogwood	Requires protection from hot winds Prefers high humidity Prefers acid soil
14.	<u>Fagus grandifolia</u>	American Beech	Excessive heat is limiting Requires moist soil Sunscalds
15.	<u>Franklinia alatamaha</u>	Franklinia	Requires protection and a moist, acid soil
16.	<u>Laburnum anagyroides</u>	Goldenchain Laburnum	May suffer from late or early frost Cold hardiness is marginal Must be protected
17.	<u>Magnolia acuminata</u>	Cucumbertree Magnolia	Requires a cool site and protection Intolerant of extremes of wet or dry
18.	<u>Magnolia stellata</u>	Star Magnolia	Cold hardiness is marginal
19.	<u>Nyssa sylvatica</u>	Black Tupelo	Requires moist, acid soil

Table 9. Tree species which are susceptible to insect and disease pests and whose culture as street trees should be limited unless preventative and control measures are available.

	BOTANICAL NAME	COMMON NAME	INSECT OR DISEASE
1.	Acer spp.	Maples	Cankers, borers, scales, aphids, Verticillium wilt, Ganoderma rot, Forest tent caterpillar
2.	Aesculus glabra	Ohio Buckeye	Mealy bugs, Tussock moth, scales
3.	Aesculus hippocastanum	Common Horsechestnut	Anthracnose, scales, cankers, borers, mealy bugs
4.	Albizzia julibrissin	Silktree	Nematodes, scales, Mimosa webworm, Fusarium wilt, cankers
5.	Amelanchier canadensis	Serviceberry	Scales, cankers, borers, bacterial fireblight, alternant host of a conifer rust
6.	Betula spp.	Birches	Fungal dieback, borers, cankers, aphids, leopard moth, birch leaf miner, gypsy moth
7.	Broussonetia papyrifera	Papermulberry	Root knot nematode root rot, scales, cankers
8.	Carya spp.	Hickories	Twig girdler, Fall webworm, Hickory bark beetle, cankers, borers, aphids, scales, gypsy moth
9.	Castanea mollissima	Chinese Chestnut	Resistant to Chestnut blight, cankers
10.	Celtis occidentalis	Common Hackberry	Witch's broom, nipple gall

11.	*Cercis spp.*	Redbuds	Cankers, scales, borers, leaf tyers
12.	*Cornus florida*	Flowering Dogwood	Botrytis blight, Twig blight, Club gall, cankers, scales, borers
13.	*Crataegus spp.*	Hawthorns	Cedar-hawthorn rust, fireblight, leaf miner, tent caterpillar, scales, borers, aphids
14.	*Elaeagnus angustifolia*	Russianolive	Cankers, scales, aphids
15.	*Euonymus bungeana*	Winterberry Euonymus	Scales, anthracnose, aphids
16.	*Fagus grandifolia*	American Beech	Scales, cankers, borers, gypsy moth, aphids, bark disease (scale-fungus symbiosis)
17.	*Fraxinus spp.*	Ashes	Borers, scales, cankers, flower gall, yellow sawfly, fall webworm, Sphinx moth, Tussock moth, anthracnose
18.	*Gleditzia triacanthos*	Common Honeylocust	Scales, cankers, borers, wood decaying fungi, twig girdler, Mimosa webworm, Tussock moth
19.	*Juglans spp.*	Walnuts, Butternut	Dieback and decay, cankers, scales, bacterial blight, Tussock moth, walnut Datana
20.	*Liquidambar styraciflua*	American Sweetgum	Bleeding necrosis, leader dieback, scales, fall webworm, forest tent caterpillar
21.	*Liriodendron tulipifera*	Tuliptree	Scales, cankers
22.	*Maackia amurensis*	Amur Maackia	Cankers, wilt, wood and heart rot

23.	Magnolia spp.	Magnolias	Cankers, dieback and decay, many scales
24.	Malus spp.	Flowering Crabapples	Fireblight, cedar-apple rust, aphids, scales, borers, cankers, gypsy moth, tent caterpillar, root worms
25.	Morus spp.	Mulberries	Cankers, heart rot, bacterial fireblight, scales
26.	Nyssa sylvatica	Black Tupelo	Sphinx moth, cankers, wilt, heart rot, scales
27.	Platanus acerifolia	London Planetree	Cankerstain, borers, cankers, lacebugs
28.	Platanus occidentalis	American Planetree	Anthracnose, scales, lacebugs
29.	Populus spp.	Poplars, Cottonwood and Aspens	Cankers, borers, scales, gypsy moth, twig girdler, tent caterpillar, large elm sawfly, cottonwood daggar moth, browntail moth, dieback
30.	Prunus spp.	Peach, Plum Apricot, Cherry	Borers, scales, shot hole bacterium, cankerworm, many other insects and diseases
31.	Pyrus spp.	Pears	Borers, scales, cankers
32.	Quercus spp.	Oaks	Oak wilt (red oak group) anthracnose, cankers, borers, scales, gall insects, shoestring root rot, twig pruner, twig blight
33.	Robinia pseudoacacia	Black Locust	Borers, locust leaf miner, wood decay, cankers, scales
34.	Salix spp.	Willows	Borers, cankers, scales, gypsy moth, anthracnose fall webworm, bacterial twig blight, willow shoot sawfly

35.	<u>Sassafras albidum</u>	Common Sassafras	Cankers, scales, Tussock moth
36.	<u>Sorbus aucuparia</u>	European Mountainash	Cankers, borers, scales aphids, crown gall bacterial fireblight
37.	<u>Syringa amurensis japonica</u>	Japanese Tree Lilac	Borers, scales, bacterial blight, powdery mildew, Phytopthora blight, Verticillium wilt
38.	<u>Tamarix spp.</u>	Tamarisk	Cankers, Scales
39.	<u>Tilia spp.</u>	Lindens	Cankers, scales, aphids, borers, sapwood decay, anthracnose, Tussock moth, twig girdler
40.	<u>Ulmus spp.</u> (including <u>Zelkova spp.</u>)	Elms	Dutch elm disease (Asian species are resistant) phloem necrosis, Verticillium wilt, elm leaf beetle, European elm scale, cankers, aphids, fall webworm, many other insects
41.	<u>Zizyphus jujuba</u>	Chinese Jujube	Scales, mites, mealy bugs

Table 10. Tree species which are rarely seriously affected by insects or diseases.

	BOTANICAL NAME	COMMON NAME
1.	Ailanthus altissima	Treeofheaven Ailanthus
2.	Asimina triloba	Common Pawpaw
3.	Bumelia lanuginosa	Woollybucket Bumelia
4.	Carpinus spp.	Hornbeams
5.	Catalpa spp.	Catalpas
6.	Celtis laevigata	Sugar Hackberry
7.	Cercidiphyllum japonicum	Katsuratree
8.	Chionanthus virginicus	White Fringetree
9.	Cladrastus lutea	American Yellowwood
10.	Cotinus coggygria	Common Smoketree
11.	Diospyros virginiana	Common Persimmon
12.	Evodia danielli	Korean Evodia
13.	Franklinia alatamaha	Franklinia
14.	Ginkgo biloba	Ginkgo
15.	Gymnocladus dioicus	Kentucky Coffeetree
16.	Ilex opaca	American Holly
17.	Kalopanax pictus	Castoraralia
18.	Koelreuteria paniculata	Panicled Goldraintree
19.	Laburnum anagyroides	Goldenchain Laburnum
20.	Maclura pomifera	Osageorange
21.	Ostrya virginiana	American Hophornbeam
22.	Oxydendrum arboreum	Sourwood
23.	Paulownia tomentosa	Royal Paulownia
24.	Phellodendron amurense	Amur Corktree
25.	Pistacia chinensis	Chinese Pistache
26.	Platanus orientalis	Oriental Planetree
27.	Ptelea trifoliata	Common Hoptree
28.	Sapindus drummondi	Western Soapberry
29.	Sophora japonica	Japanese Pagodatree
30.	Staphylea trifoliata	American Bladdernut
31.	Toona sinensis	Chinese Toon
32.	Xanthoceras sorbifolia	Shinyleaf Yellowhorn

Table 11. Tree species which are characteristically short-lived.

	BOTANICAL NAME	COMMON NAME
1.	Acer negundo	Boxelder
2.	Acer saccharinum	Silver Maple
3.	Ailanthus altissima	Treeofheaven Ailanthus
4.	Asimina triloba	Common Pawpaw
5.	Betula spp.	Birches
6.	Carya cordiformis	Bitternut Hickory
7.	Catalpa spp.	Catalpas
8.	Elaeagnus angustifolia	Russianolive
9.	Evodia danielli	Korean Evodia
10.	Gleditzia triacanthos	Common Honeylocust
11.	Juglans cinerea	Butternut
12.	Laburnum anagyroides	Goldenchain Laburnum
13.	Paulownia tomentosa	Royal Paulownia
14.	Populus spp.	Poplars, Cottonwood, aspens
15.	Prunus cerasus	Sour Cherry
16.	Prunus pensylvanica	Pin Cherry
17.	Prunus persica	Peach
18.	Robinia pseudoacacia	Black Locust
19.	Salix spp.	Willows
20.	Sorbus aucuparia	European Mountainash
21.	Ulmus pumila	Siberian Elm

Table 12. Tree species which are characteristically difficult to transplant.

	BOTANICAL NAME	COMMON NAME
1.	Acer japonicum	Fullmoon Maple
2.	Acer palmatum	Japanese Maple
3.	Acer pensylvanicum	Striped Maple
4.	Asimina triloba	Common Pawpaw
5.	Betula alba (pendula)	European White Birch
6.	Betula lenta	Sweet Birch
7.	Betula lutea	Yellow Birch
8.	Carpinus spp.	Hornbeams
9.	Carya spp.	Hickories, Pecan
10.	Castanea mollissima	Chinese Chestnut
11.	Cercidiphyllum japonicum	Katsuratree
12.	Cladrastus lutea	American Yellowwood
13.	Cornus florida	Flowering Dogwood
14.	Crataegus spp.	Hawthorns
15.	Diospyros virginiana	Common Persimmon
16.	Fagus grandifolia	American Beech
17.	Franklinia alatamaha	Franklinia
18.	Gleditzia triacanthos	Common Honeylocust
19.	Gymnocladus dioicus	Kentucky Coffeetree
20.	Juglans spp.	Walnuts, Butternut
21.	Kalopanax pictus	Castoraralia
22.	Liquidambar styraciflua	American Sweetgum
23.	Liriodendron tulipifera	Tuliptree
24.	Magnolia spp.	Magnolias
25.	Nyssa sylvatica	Black Tupelo
26.	Ostrya virginiana	American Hophornbeam
27.	Paulownia tomentosa	Royal Paulownia
28.	Prunus spp.	Cherry, Plum, Peach
29.	Pyrus spp.	Pears
30.	Quercus alba	White Oak
31.	Quercus bicolor	Swamp White Oak
32.	Quercus borealis	Northern Red Oak
33.	Quercus coccinea	Scarlet Oak
34.	Quercus imbricaria	Shingle Oak
35.	Quercus macrocarpa	Bur Oak
36.	Quercus prinus	Swamp Chestnut Oak
37.	Quercus robur	English Oak
38.	Quercus velutina	Black Oak
39.	Sassafras albidum	Common Sassafras
40.	Xanthoceras sorbifolia	Shinyleaf Yellowhorn
41.	Zizyphus jujuba	Chinese Jujube

Table 13. Tree species which are weak wooded or brittle and of limited durability.

	BOTANICAL NAME	COMMON NAME
1.	Acer negundo	Boxelder
2.	Acer saccharinum	Silver Maple
3.	Aesculus glabra	Ohio Buckeye
4.	Aesculus hippocastanum	Common Horsechestnut
5.	Ailanthus altissima	Treeofheaven Ailanthus
6.	Albizzia julibrissin	Silktree
7.	Asimina triloba	Common Pawpaw
8.	Betula spp.	Birches
9.	Bumelia lanuginosa	Woollybucket Bumelia
10.	Carya illinoensis	Pecan
11.	Catalpa spp.	Catalpas
12.	Celtis laevigata	Sugar Hackberry
13.	Celtis occidentalis	Common Hackberry
14.	Diospyros virginiana	Common Persimmon
15.	Elaeagnus angustifolia	Russianolive
16.	Evodia danielli	Korean Evodia
17.	Fraxinus spp.	Ashes
18.	Ginkgo biloba	Ginkgo
19.	Juglans cinerea	Butternut
20.	Liriodendron tulipifera	Tuliptree
21.	Morus alba	White Mulberry
22.	Morus rubra	Red Mulberry
23.	Populus spp.	Poplars, Cottonwood, Aspens
24.	Prunus cerasus	Sour Cherry
25.	Prunus persica	Peach
26.	Robinia pseudoacacia	Black Locust
27.	Salix spp.	Willows
28.	Sassafras albidum	Common Sassafras
29.	Tilia spp.	Lindens
30.	Ulmus procera	English Elm
31.	Ulmus pumila	Siberian Elm

Table 14. Tree species which tend to sucker and might be considered as undesirable for street tree use on this basis.

	BOTANICAL NAME	COMMON NAME
1.	*Acer negundo*	Boxelder
2.	*Ailanthus altissima*	Treeofheaven Ailanthus
3.	*Broussonetia papyrifera*	Common Papermulberry
4.	*Catalpa spp.*	Catalpas
5.	*Fagus grandifolia*	American Beech
6.	*Morus spp.*	Mulberries
7.	*Paulownia tomentosa*	Royal Paulownia
8.	*Populus spp.*	Poplars, Cottonwood, Aspens
9.	*Prunus cerasus*	Sour Cherry
10.	*Prunus virginiana*	Common Chokecherry
11.	*Robinia pseudoacacia*	Black Locust
12.	*Salix spp.*	Willows
13.	*Sassafras albidum*	Common Sassafras
14.	*Sorbus aucuparia*	European Mountainash
15.	*Syringa amurensis japonica*	Japanese Tree Lilac
16.	*Zizyphus jujuba*	Chinese Jujube

Table 15. Tree species which tend to produce litter and might be considered "dirty" in this respect.

	BOTANICAL NAME	COMMON NAME
1.	Acer negundo	Boxelder
2.	Aesculus hippocastanum	Common Horsechestnut
3.	Ailanthus altissima	Treeofheaven Ailanthus
4.	Catalpa spp.	Catalpas
5.	Diospyros virginiana (female)	Common Persimmon
6.	Gleditzia triacanthos (female)	Common Honeylocust
7.	Gymnocladus dioicus (female)	Kentucky Coffeetree
8.	Maclura pomifera (female)	Osageorange
9.	Morus spp. (female)	Mulberries
10.	Paulownia tomentosa	Royal Paulownia
11.	Phellodendron amurense	Amur Corktree
12.	Platanus occidentalis	American Planetree
13.	Populus deltoides missouriensis (female)	Southern Poplar

Table 16. Tree species which do not tolerate pruning well.

	BOTANICAL NAME	COMMON NAME
1.	Acer japonicum	Fullmoon Maple
2.	Acer palmatum	Japanese Maple
3.	Asimina triloba	Common Pawpaw
4.	Betula spp.	Birches
5.	Carya spp.	Hickories, Pecan
6.	Castanea mollissima	Chinese Chestnut
7.	Cercidiphyllum japonicum	Katsuratree
8.	Cladrastus lutea	American Yellowwood
9.	Diospyros virginana	Common Persimmon
10.	Franklinia alatamaha	Franklinia
11.	Gymnocladus dioicus	Kentucky Coffeetree
12.	Juglans cinerea	Butternut
13.	Juglans nigra	Eastern Black Walnut
14.	Koelreuteria paniculata	Panicled Goldraintree
15.	Liriodendron tulipifera	Tuliptree
16.	Magnolia spp.	Magnolias
17.	Nyssa sylvatica	Black Tupelo
18.	Paulownia tomentosa	Royal Paulownia
19.	Phellodendron amurense	Amur Corktree
20.	Populus spp.	Poplars, Cottonwood, Aspens
21.	Sassafras albidum	Common Sassafras

Table 17. Dioecious tree species of which one sex is preferred as a street tree.

	BOTANICAL NAME	COMMON NAME	PREFERRED SEX
1.	*Ailanthus altissima*	Treeofheaven Ailanthus	Use female only, male flowers have an objectionable odor
2.	*Broussonetia papyrifera*	Papermulberry	Use male to avoid objectionable, mulberry-like fruit
3.	*Diospyros virginiana*	Common Persimmon	Use male to avoid messy objectionable fruit
4.	*Fraxinus spp.*	Ashes	Use male to avoid the profuse seeds which may produce litter
5.	*Ginkgo biloba*	Ginkgo	Use male only, fruit has objectionable odor
6.	*Gleditzia triacanthos*	Common Honeylocust	Use selected males to avoid objectionable fruit pods
7.	*Gymnocladus dioicus*	Kentucky Coffeetree	Use male only, fruit pods produce litter
8.	*Ilex opaca*	American Holly	Use female for red berries - male branch must be grafted on for pollination purposes
9.	*Maclura pomifera*	Osageorange	Use males to avoid objectionable fruit ("hedge-apples")
10.	*Morus spp.*	Mulberries	Use male to avoid objectionable fruit
11.	*Populus deltoides missouriensis*	Southern Poplar (Cottonwood)	Use males to avoid the profuse, cotton-like seed

Street Tree Planting Design

The design of a street tree planting may at first appear to be a simple process of locating trees along the street in an orderly manner. While this is true in some cases, the design may be complicated by conflict with traffic, utilities, street lights, or other "street factors". The lack of jurisdiction by the municipality beyond the public easement may also influence the design by affecting maintenance after planting. Street tree planting design is further complicated by the responsibility which anyone who plants a tree must assume; the subsequent care and protection of the tree must be insured. This axiom should serve as an admonition to all who perform street tree planting design, to accept it for the scrupulous discipline that it is, and to become aware of the problems inherent in such a design.

Street tree planting design may be divided into two subcategories, 1) renovative design, and 2) original design.

Renovative design consists of remedial considerations of plantings that are becoming problematical due in part to poor species selection or planting arrangement. Renovative considerations are becoming more and more necessary as old plantings approach maturity. Particularly in areas threatened by the Dutch elm disease, overcrowded conditions must be alleviated.

The objective of original street tree planting design is to combine appearance and utility into an integrated plan.

Street tree planting design, as any landscape design, is contingent upon the particular site factors in the area and is limited only by these factors and the imagination of the designer.

In the following section, renovation and original designs will be presented in an attempt to elucidate some of the problems and principles which govern such designs.

The Renovative Design

The following Plates (VII-XIII) depict an orderly renovation plan for an area in Hutchinson. This area consists of 14th street between Poplar and Plum and the intersecting streets of Maple and Elm. The present design (Plate VII) is encumbered by an excessive American elm population, being further jeopardized by the presence of Dutch elm disease.

The sequence of plates is self-explanatory and reflects the process by which the design was approached:

1. The recommended removal of old, weak, and competitive trees in order to establish the proper spacing between trees. This was a selective thinning process and not an indiscriminate removal.

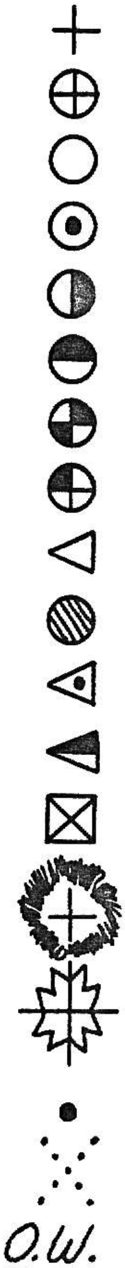
2. Where planting was too sparse, the recommended interplanting with suitable species was utilized to establish continuity of the design.

3. Where selective thinning established voids in the design, interplanting with complementary and suitable species was recommended to interrupt the dangerous repetition of elms in anticipation of future elm losses.

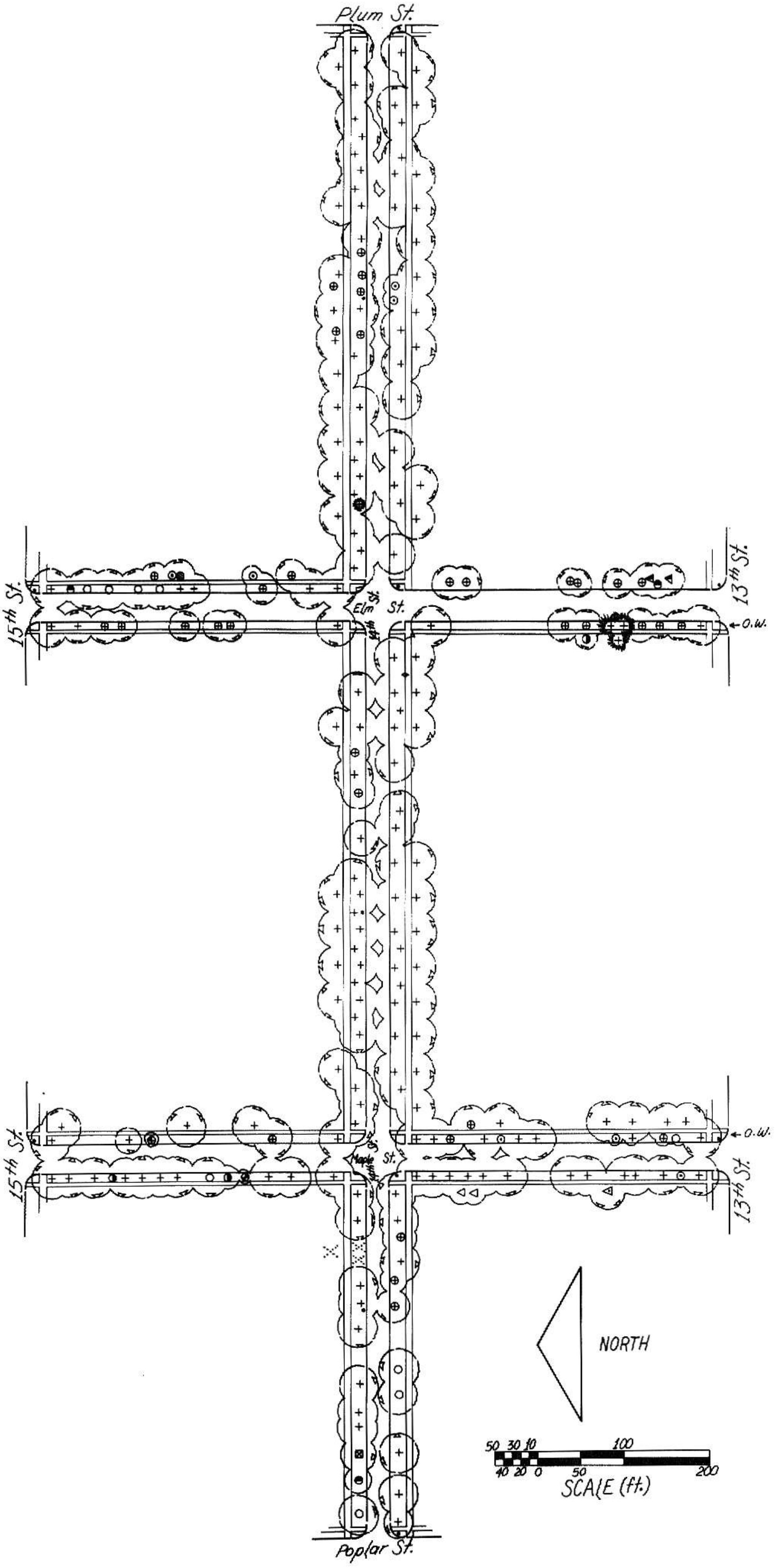
The selective thinning process resulted in approximately a 50% reduction in stand. While this may seem excessive, each recommended removal was justified (Plate IX) and was necessary to preserve the remainder of the trees. Even with this removal operation, many large elms remain on 40 foot spacings. These will have to be trenched and/or treated with a soil sterilant to break root grafts between the trees and prevent the spread of Dutch elm disease by this method. Much as with design, the recommended removal of a living tree is a moral decision and is irreversible. Ample justification for any recommended removal, and conviction that the planting will benefit from such a removal are two unavoidable considerations.

EXPLANATION OF PLATE VII

The existing street tree planting which was selected for renovative development. Tree species and other features are identified by spot symbols according to the following legend:

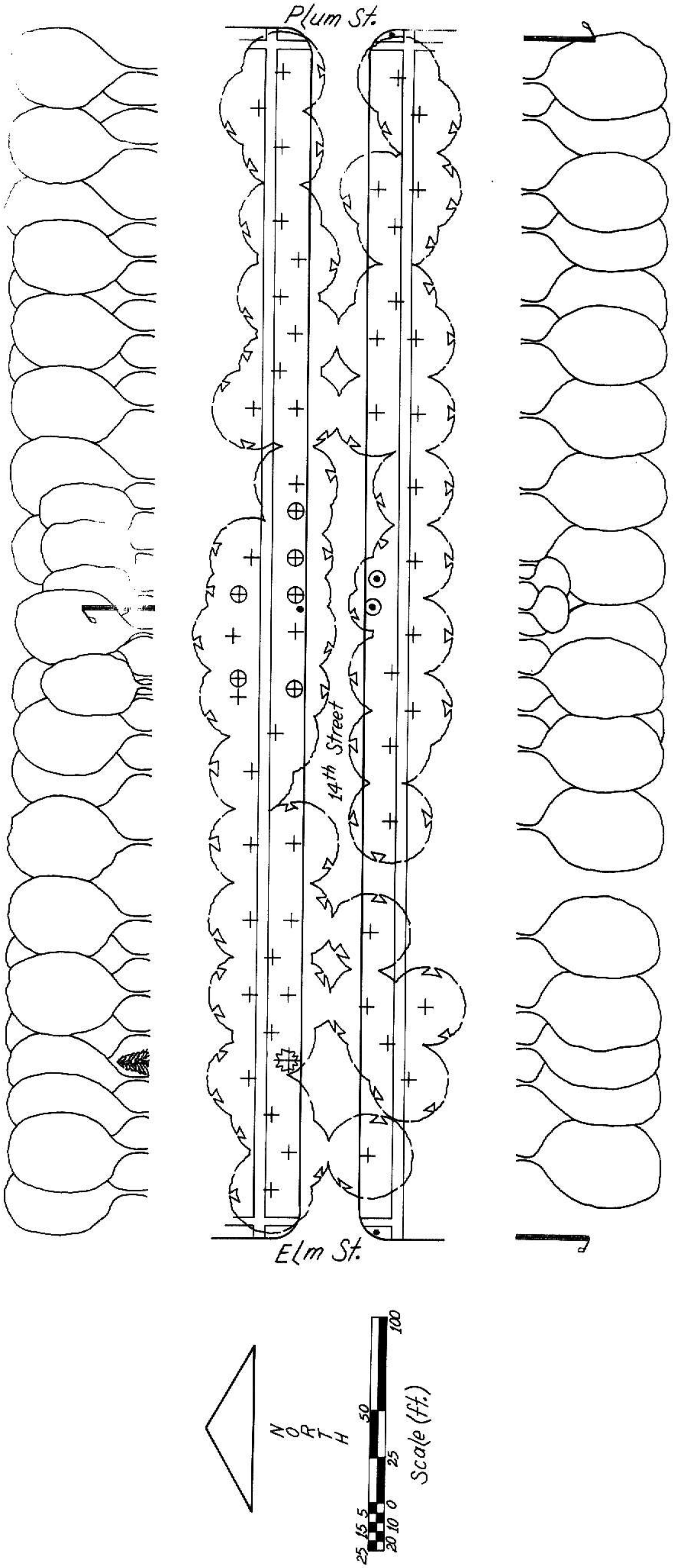


- American Elm
- Siberian Elm
- Silver Maple
- Eastern Redbud
- Silktree
- Green Ash
- Rose of Sharon
- Purpleleaf Plum
- Catalpa
- Bur Oak
- Honeylocust
- Southern Poplar (Cottonwood)
- American Planetree (Sycamore)
- Austrian Pine
- Scotch Pine
- Light Pole
- Dutch Elm Disease
- Overhead Wires


Plum St.
15th St.
Elm St.
14th St.
13th St.
O.W.
15th St.
Maple St.
14th St.
13th St.
O.W.
NORTH
50 30 10
100
40 20 0
50
200
SCALE (ft.)
Poplar St.

EXPLANATION OF PLATE VIII

The existing street tree planting of 14th Street between Elm and Plum, in plan and elevation, which was selected for renovative development. Species identification is as in Plate VII.


Plum St.
14th Street
Elm St.
NORTH
25 20 15 10 5 0 25 50 100
Scale (ft.)

EXPLANATION OF PLATE IX

The existing planting selected for renovative development. Those trees which have been recommended for removal in the selective thinning process are indicated, and justified, according to the following legend:

1. Remove to establish proper spacing.

2. Remove due to poor condition of the tree.

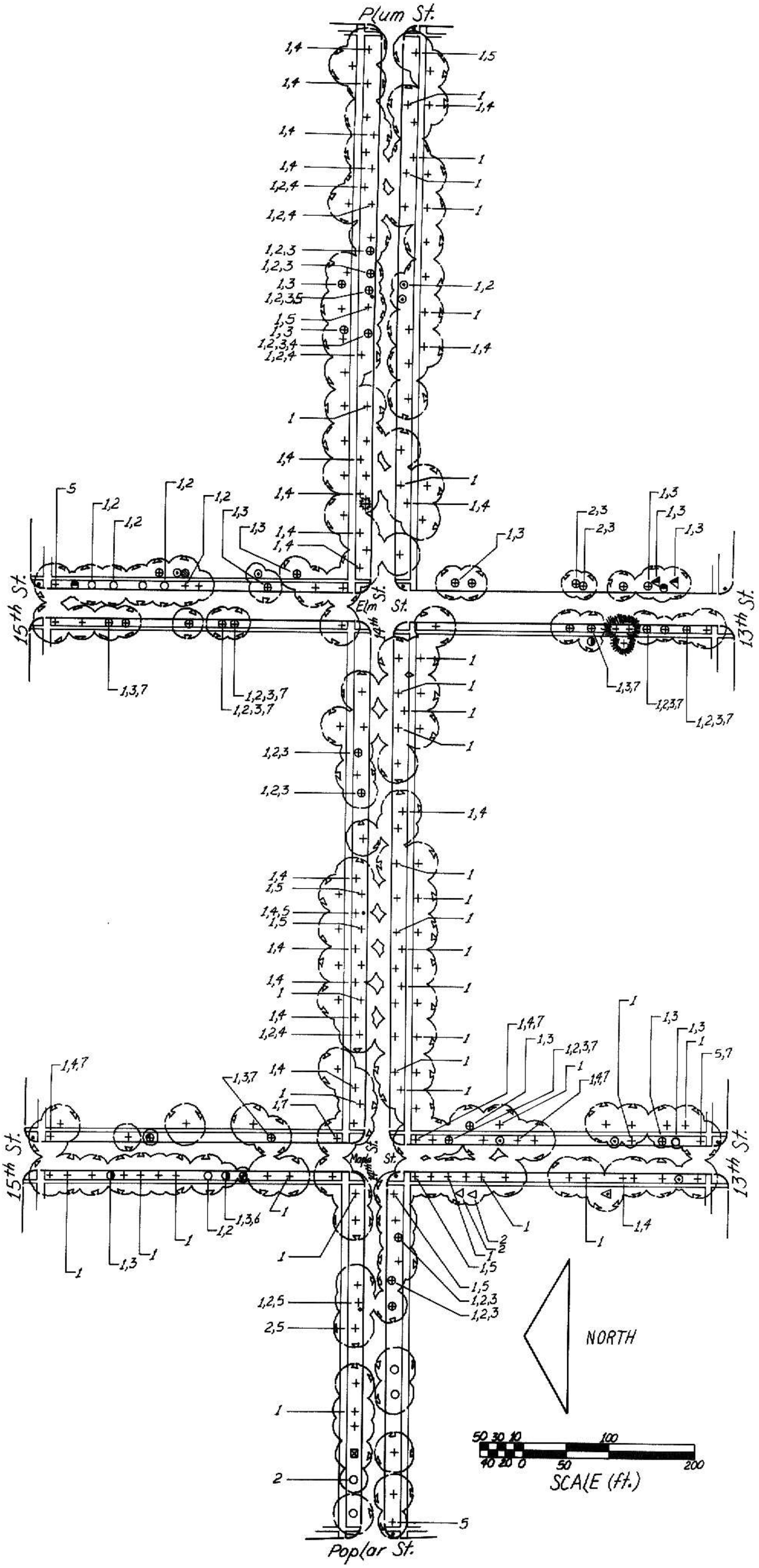
3. Poor species - Remove to allow the establishment and development of better species.

4. Remove to eliminate sidewalk and/or driveway interference.

5. Remove to eliminate interference with street lights.

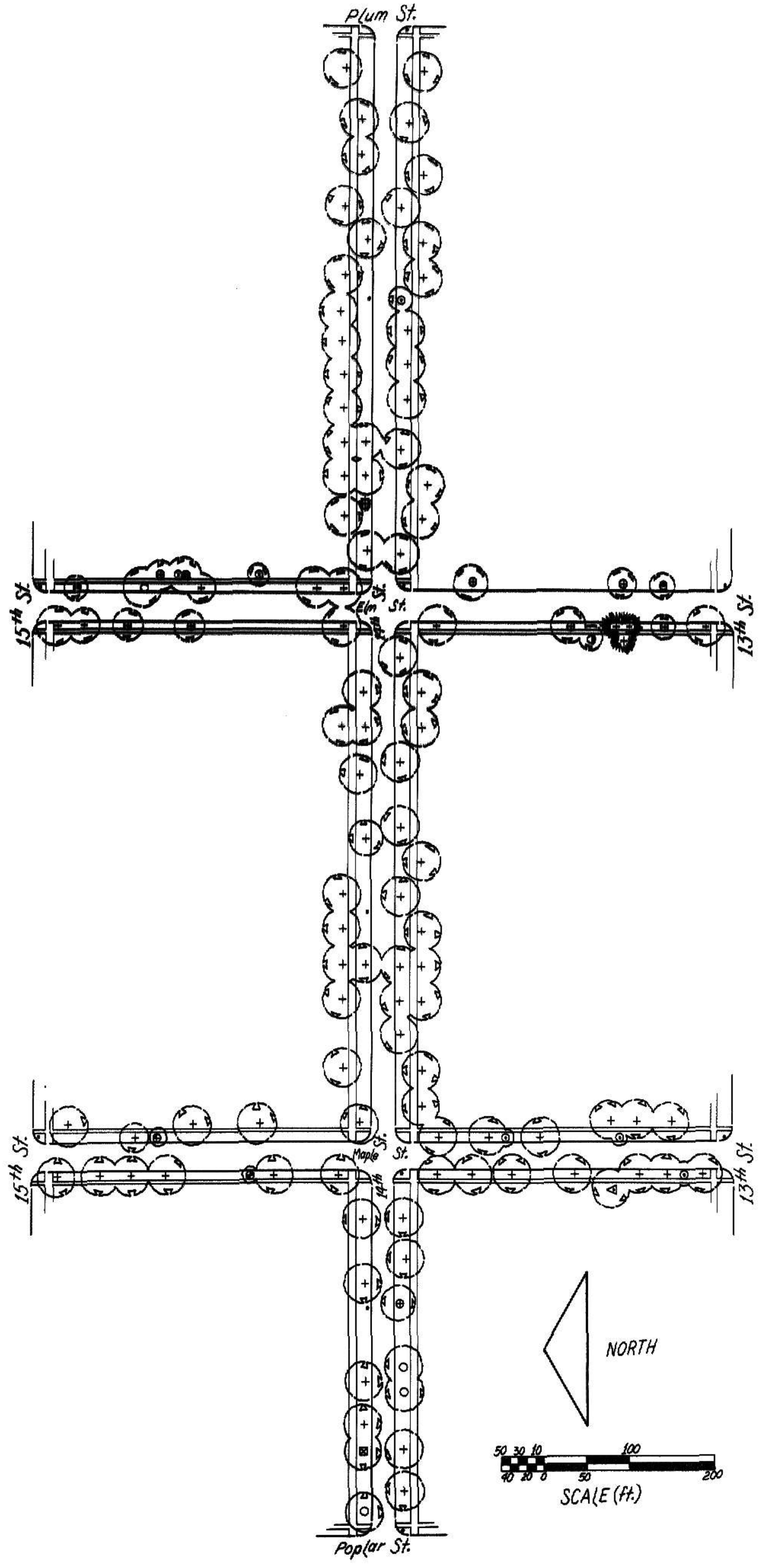
6. Remove to eliminate present or potential interference with pedestrian or vehicular traffic.

7. Remove to eliminate or avoid conflict with overhead utility wires.


Plum St.
Elm St.
14th St.
15th St.
13th St.
Maple St.
Poplar St.
NORTH
50 30 10
40 20 0
50
100
200
SCALE (ft.)

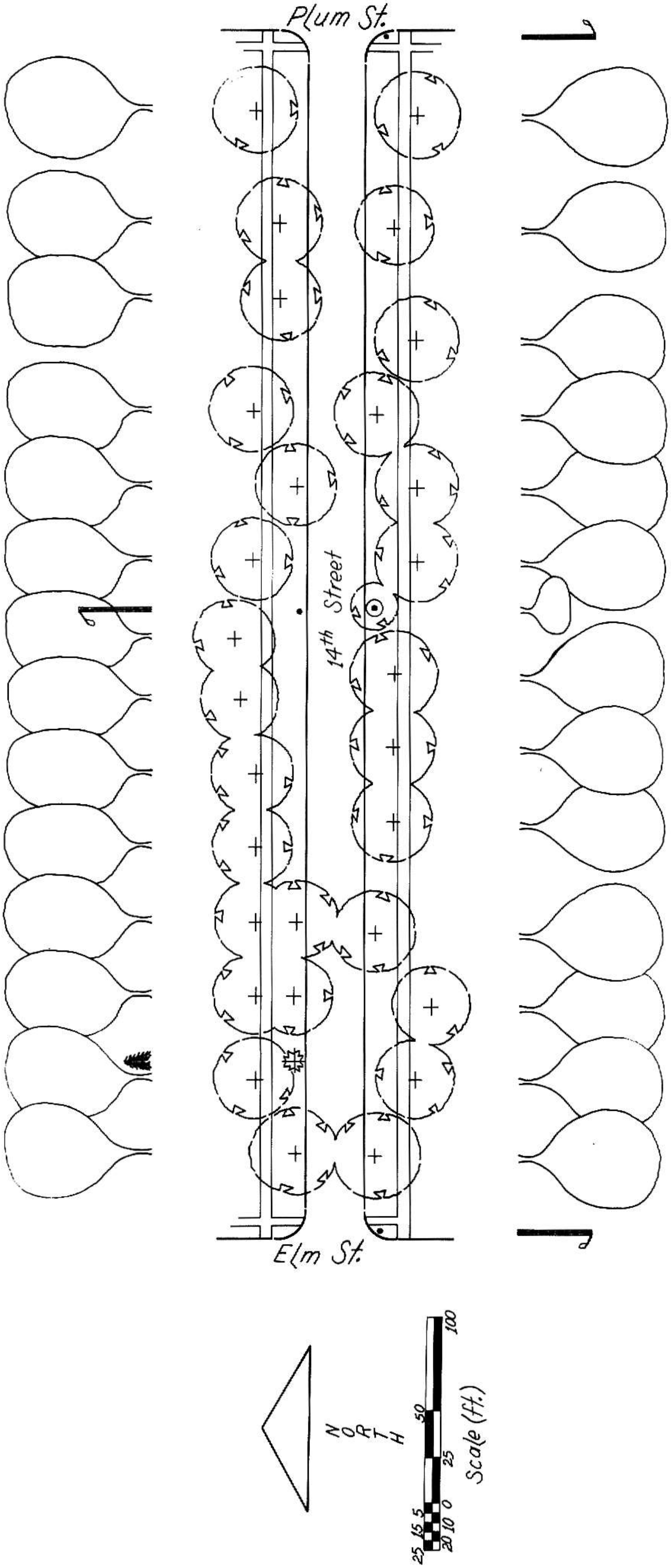
EXPLANATION OF PLATE X

The Renovation Section, in plan, following the recommended removal of those trees indicated in Plate IX.


Plum St.
15th St.
Elm St.
14th St.
13th St.
Maple St.
Poplar St.
NORTH
50 30 10
100
40 20 0
50
200
SCALE (ft.)

EXPLANATION OF PLATE XI

The renovative design of 14th street between Elm and Plum as it would appear in plan and elevation following the selective thinning operation.

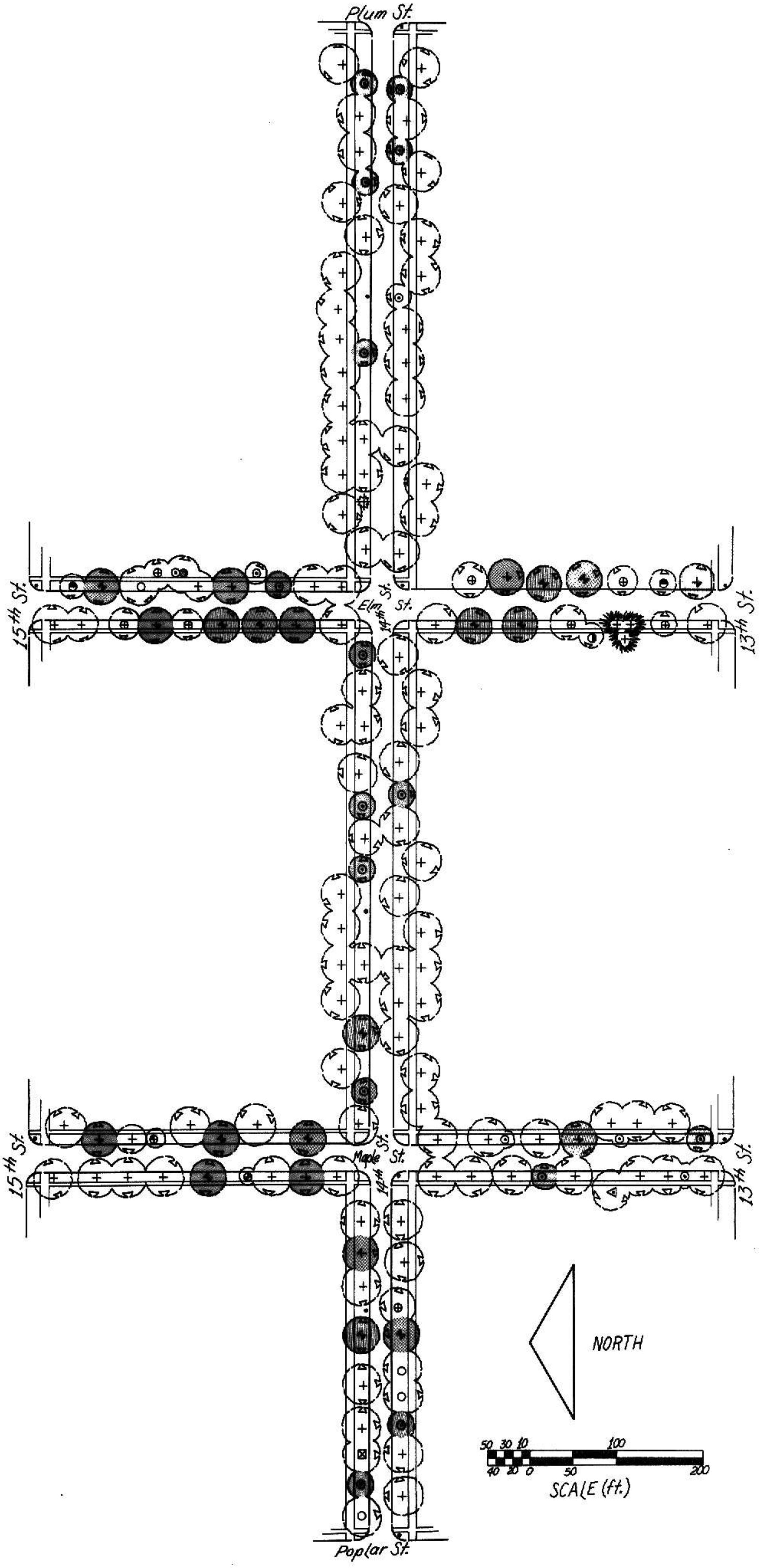

Plum St.
14th Street
Elm St.
NORTH
Scale (ft.)
25 15 5 0 25 50 100
20 10

EXPLANATION OF PLATE XII

The Renovation Section, in plan, following the recommended planting of new trees where voids previously existed or were created by the selective thinning process. Additional species and their symbols which were not included in Plate VII are:

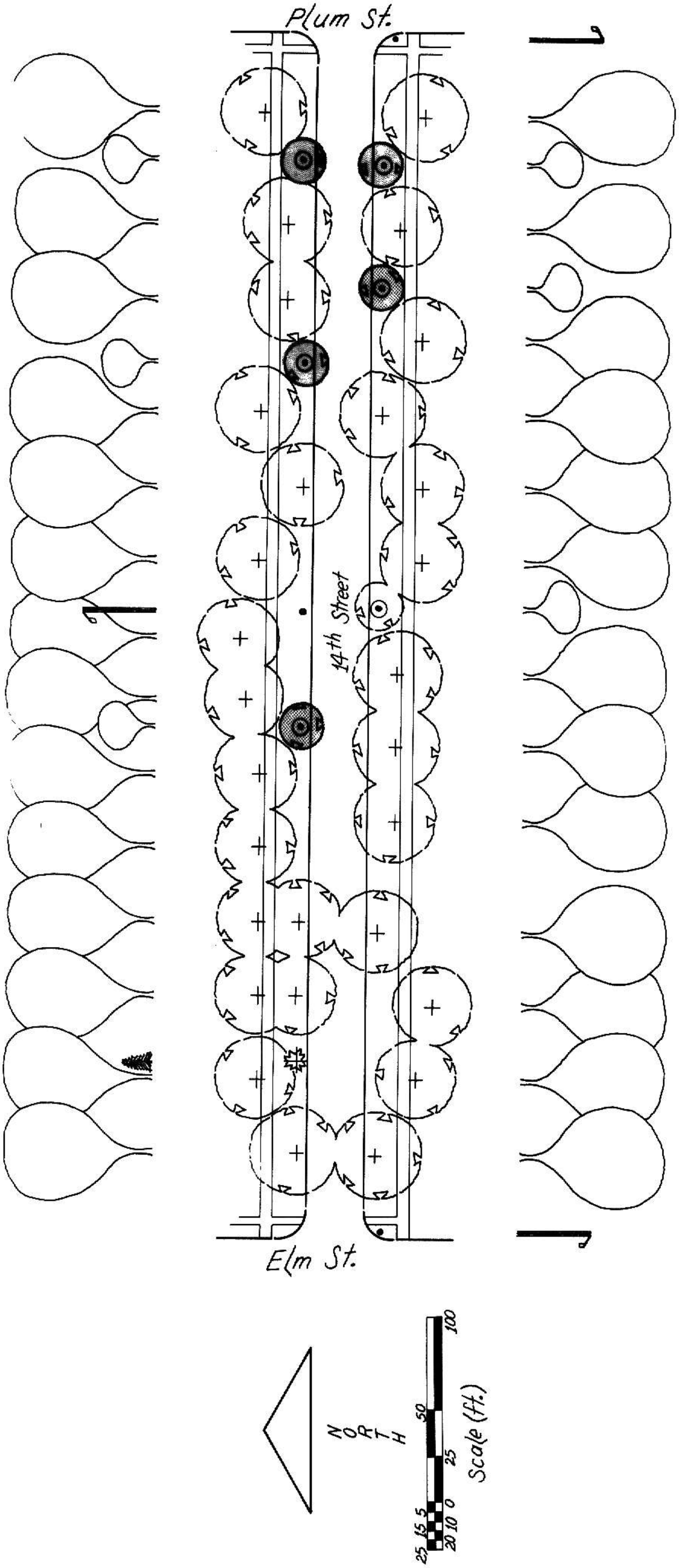
 - Chinese Pistache

 - Western Soapberry


Plum St.
Elm St.
15th St.
14th St.
13th St.
Maple St.
15th St.
14th St.
13th St.
Poplar St.
NORTH
50 30 10 100
40 20 0 50 200
SCALE (ft.)

EXPLANATION OF PLATE XIII

The Renovative design of 14th street between Elm and Plum as it would appear in plan and elevation following the planting of new trees where voids previously existed or were created by the selective thinning process.


Plum St.
14th Street
Elm St.
NORTH
Scale (ft.)
25 15 5
20 10 0
25
50
100

The Original Design

Many of the problems which dictate a need for expensive street tree planting renovation could be eliminated at the outset by careful consideration of the original design. The following plates (XV-XX) represent examples of three methods of street tree planting design: 1) the conventional (Utility) design, 2) the "Aesthetic" design, and 3) the "Compromise" design. The subdivision (Kisiwa Creek) which was selected to illustrate these designs is located on Plate XIV. This subdivision, though platted, is relatively undeveloped, with few houses or streets.

A very important consideration which must be reconciled before a design can be attempted involves the use of private property. Even with relatively large public easements, the design potential is limited if restricted to public property. The use of private property may present problems of jurisdiction concerning the subsequent maintenance of trees after planting. The individual upon whose property the tree is planted may retain sole control of the fate of the tree after initial planting. If such is the case, it might be well to avoid the use of private property even at the expense of the design.

The Conventional Design

The conventional design of street tree plantings (Plates XV and XVI) involving the methodical replication of a single species, is a contributing factor to the current problem of Dutch elm disease. The establishment of a street tree monoculture of any species creates conditions favorable for the spread of insects and disease. Also, when one tree is removed from a row of identical trees, its absence attracts attention, distracting from the remainder of the design. Despite its potential problems, this method of design has desirable features. The number of trees required for the design is minimal and negotiable depending upon the spacing of individual trees. In addition to the reduced cash outlay for plant materials, the cost of planting a limited number of trees and planting on regular intervals, reduces the expense of installation. The cost of maintenance, particularly spraying, would also be reduced because only one spray mixture would have to be formulated to sufficiently spray a large area.

The Aesthetic Design

The design represented by Plates XVII and XVIII is an attempt to achieve a truly aesthetic design without regard to expense of installation or maintenance, or to the infringement upon private property. This type of design presents definite problems but is offered as an example of the other extreme. A much more satisfying effect of embellishment can be achieved by the use of more species, the massing of trees, and the creation of spaces by the manipulation of plant spacing and arrangement. This design incorporates many more individual trees (higher initial capital outlay) and the cost of installation would be greater due to variable spacings. The expense of maintenance such as spraying would also be restrictive because several formulations would be necessary to protect the diversified species. The inaccessibility of trees planted off the street and surrounded by other trees would also increase costs.

The tree species represented in this design and the design to follow have been selected to provide year-around interest and beauty. They are adequately complementary in size, form, and texture to be integrated into a landscape design. These are:

1. Eastern Redbud - Cercis canadensis
2. Washington Hawthorn - Crataegus phaenopyrum
3. Japanese Tree Lilac - Syringa amurensis japonica
4. 'Chanticleer' Pear - Pyrus calleryana 'Chanticleer'
5. Chinese Pistache - Pistacia chinensis
6. Western Soapberry - Sapindus drummondi
7. Panicled Goldraintree - Koelreuteria paniculata
8. 'Radiant' Crabapple - x Malus 'Radiant'

This group of species provides an excellent succession of spring and summer bloom over an extended period of time:

- Eastern Redbud - Mid-April (magenta)
- 'Radiant' Crabapple - Late April (pink)
- Washington Hawthorn - Early May (white)
- Japanese Tree Lilac - Late May (cream white)
- Panicled Goldraintree - July (yellow)

They also provide excellent autumn color:

- Chinese Pistache - Red-orange foliage
- Washington Hawthorn - Scarlet to orange foliage
  - Bright red fruit
- 'Chanticleer' Pear - Red to scarlet foliage
- 'Radiant' Crabapple - Bright red fruit
  - Reddish-purple foliage
- Eastern Redbud - Yellowish foliage
- Western Soapberry - Yellowish foliage
- Panicled Goldraintree - Yellow-brown foliage
- Japanese Tree Lilac - Brown foliage

Good winter character is also achieved by the use of these species:

- Western Soapberry - Ornamental fruit clusters
- Eastern Redbud - Ornamental fruit (pods)
- 'Radiant' Crabapple - Ornamental fruit
- Panicled Goldraintree - Ornamental fruit clusters (pods)

The Compromise Design

The street tree planting design represented by Plates XIX-XX is presented as a compromise between the Conventional and the "Aesthetic" designs, with the desirable characteristics of each and few limitations of either. This design is relatively easy to design, install, and maintain. It consists of autonomous groups of trees, varying in size, but composed of only a single species. All trees are located in the public easement. This design provides diversity with enough replication to preserve the continuity of the design. The species groupings are relatively easy to maintain because one spray formulation could be used on many groups before requiring reformulation. Though little landscape interest is achieved by massing or the creation of spaces, it is not devoid of interest. Sources of interest are: 1) the decorative qualities of the component species (as described in the previous section), and 2) the variation in height and mass of the species groupings.

The species selection and planning involved in this design are summarized as follows:

1. No one species should comprise more than 15-20% of the total planting. (This refers only to the design entity itself. On a city-wide basis, no one species should comprise more than 3-4% of the planting.)

2. Tree spacing should reflect the ultimate size of the trees and should not be pre-determined by an arbitrary means.

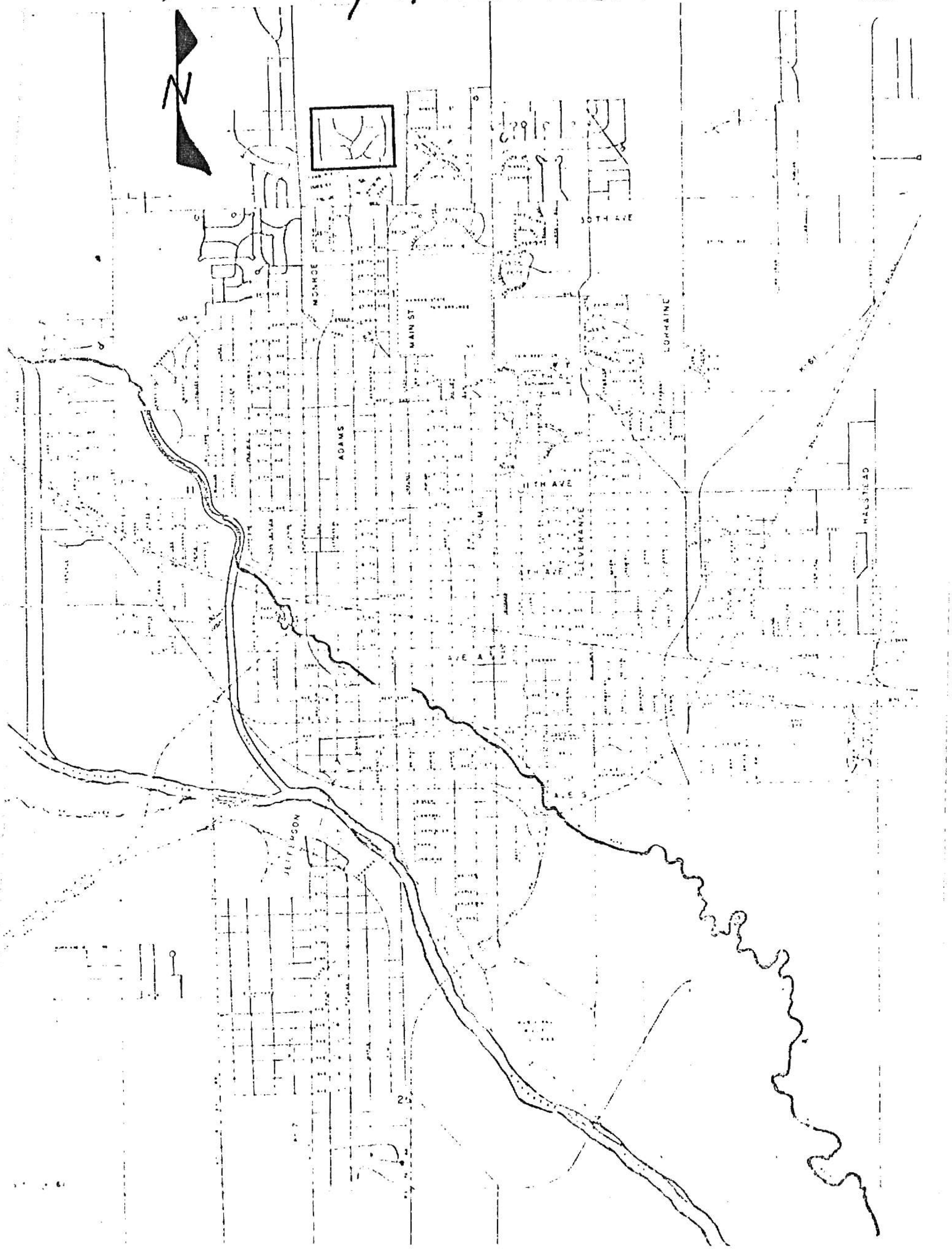
3. All proposed street trees should accomodate the space allotted and should conform to the scale of the adjacent buildings and the street proper.

4. All visible features of the trees should be inter-complementary and not in visual conflict with other street features.

EXPLANATION OF PLATE XIV

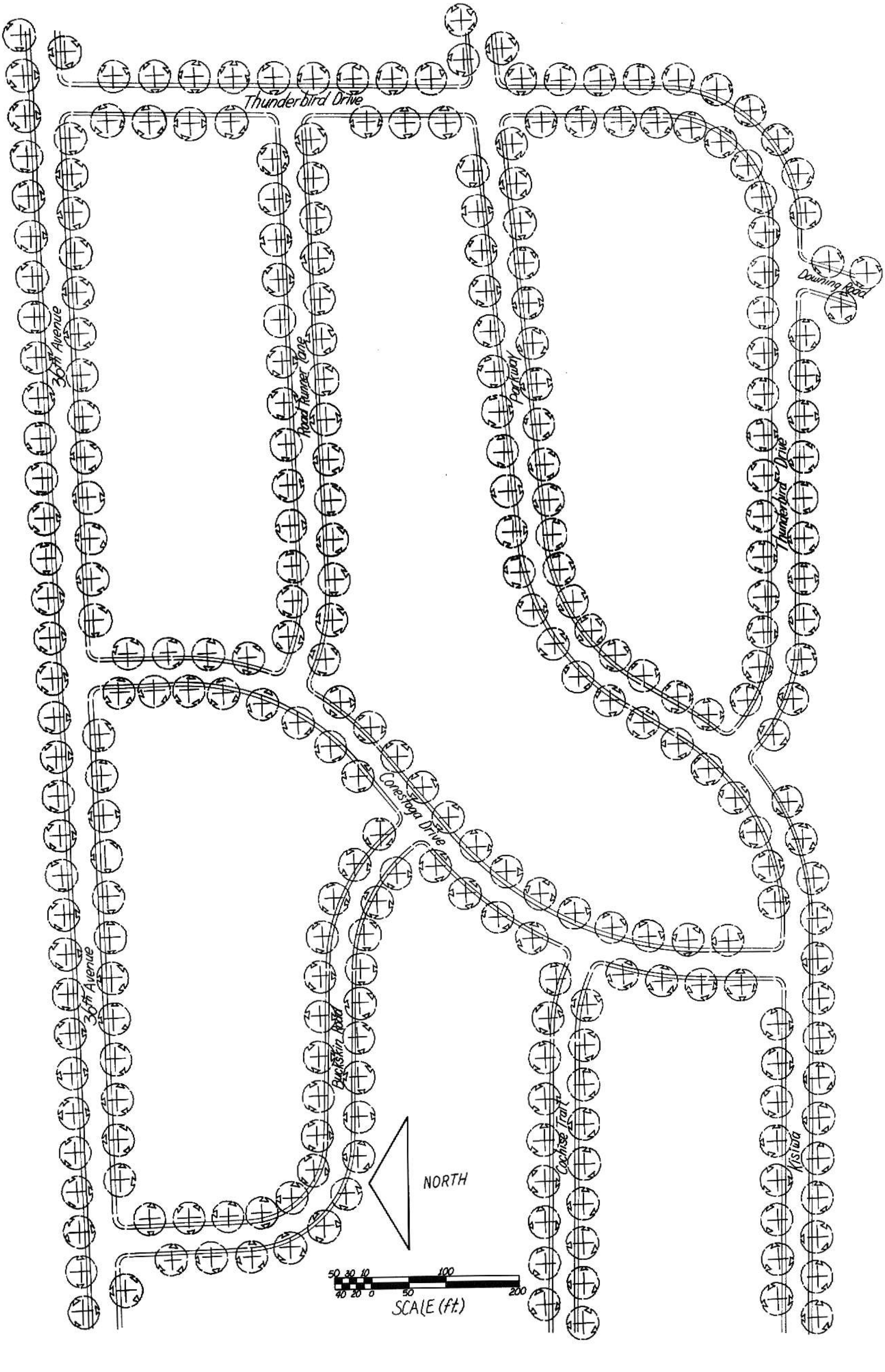
The location of the new, as yet undeveloped, Kisiwa Creek subdivision in Hutchinson which was selected for the illustration of original street tree planting designs.

City of Hutchinson



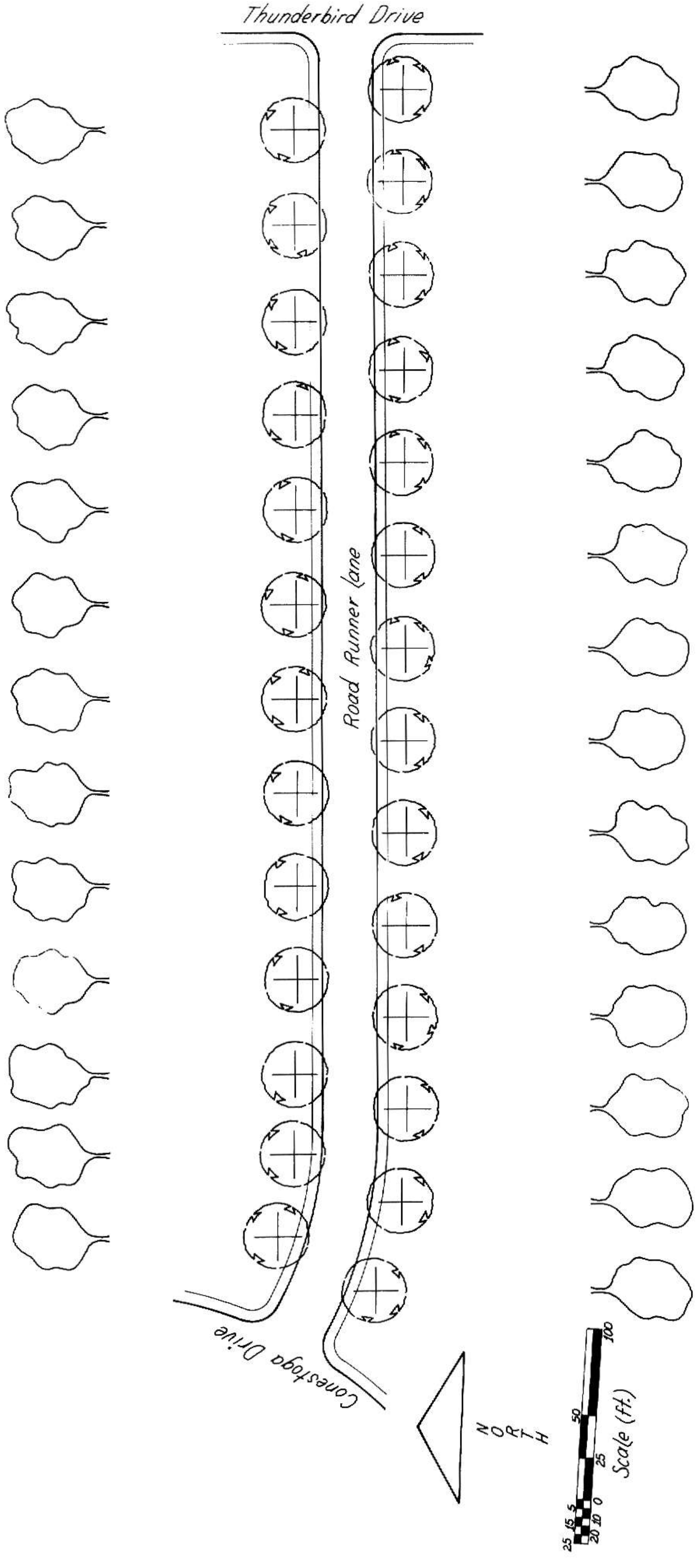
EXPLANATION OF PLATE XV

The Contemporary design, in plan, of a new subdivision as located in plate XIV, and discussed in the text. Species identification is irrelevant to this design because all trees are of the same species.


Thunderbird Drive
36th Avenue
Road Runner Lane
Parkway
Thunderbird Drive
Downing Road
Conestoga Drive
36th Avenue
Buckskin Road
Cochise Trail
Kiowa
NORTH
50 30 10 100
40 20 0 50 200
SCALE (ft.)

EXPLANATION OF PLATE XVI

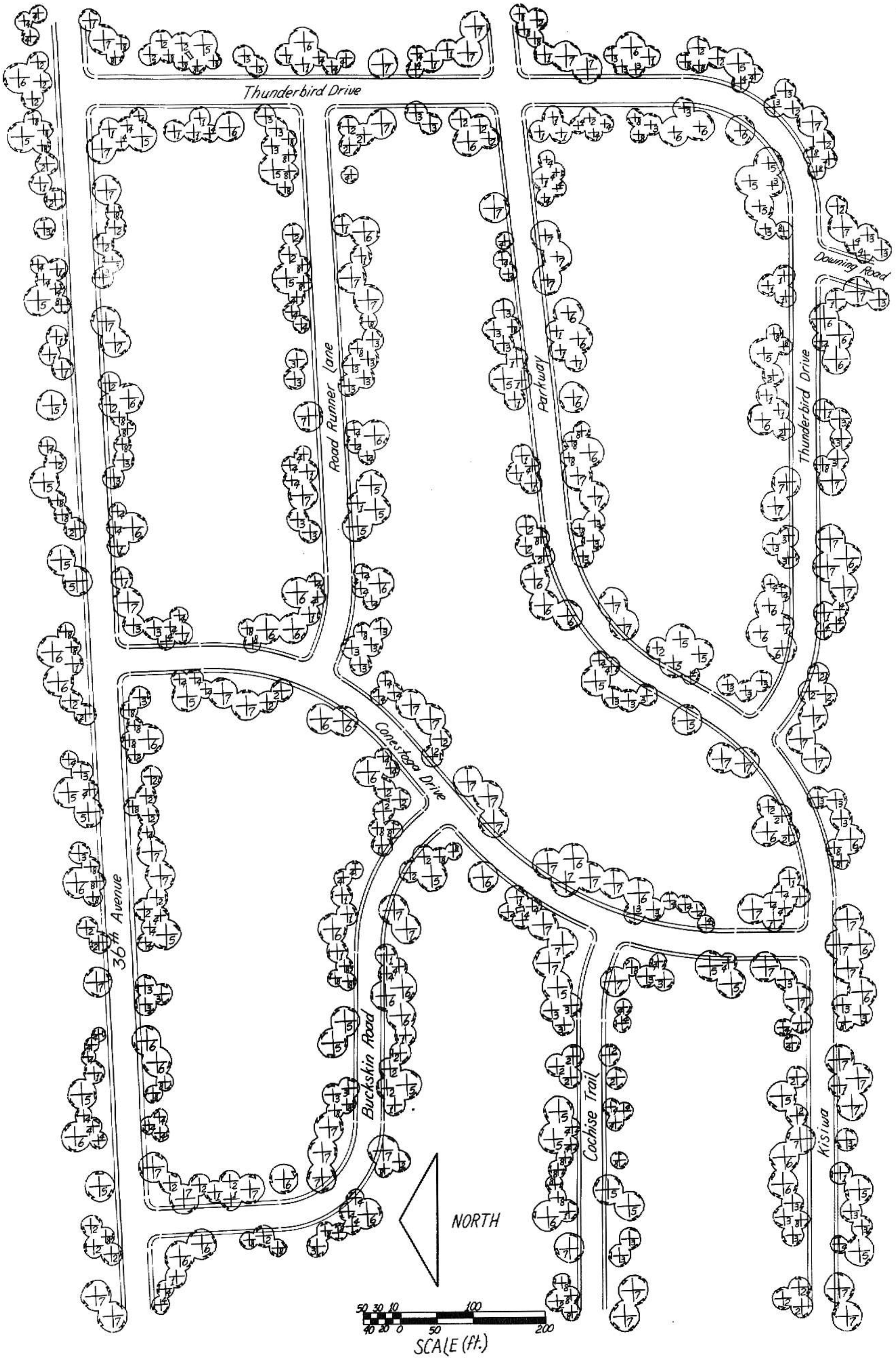
The Contemporary street tree planting design of Road Runner Lane, in plan and elevation, from Plate XV. As in Plate XV, species identification is irrelevant.


Thunderbird Drive
Road Runner Lane
Conestoga Drive
NORTH
Scale (ft.)
25 20 15 10 5 0 25 50 100

EXPLANATION OF PLATE XVII

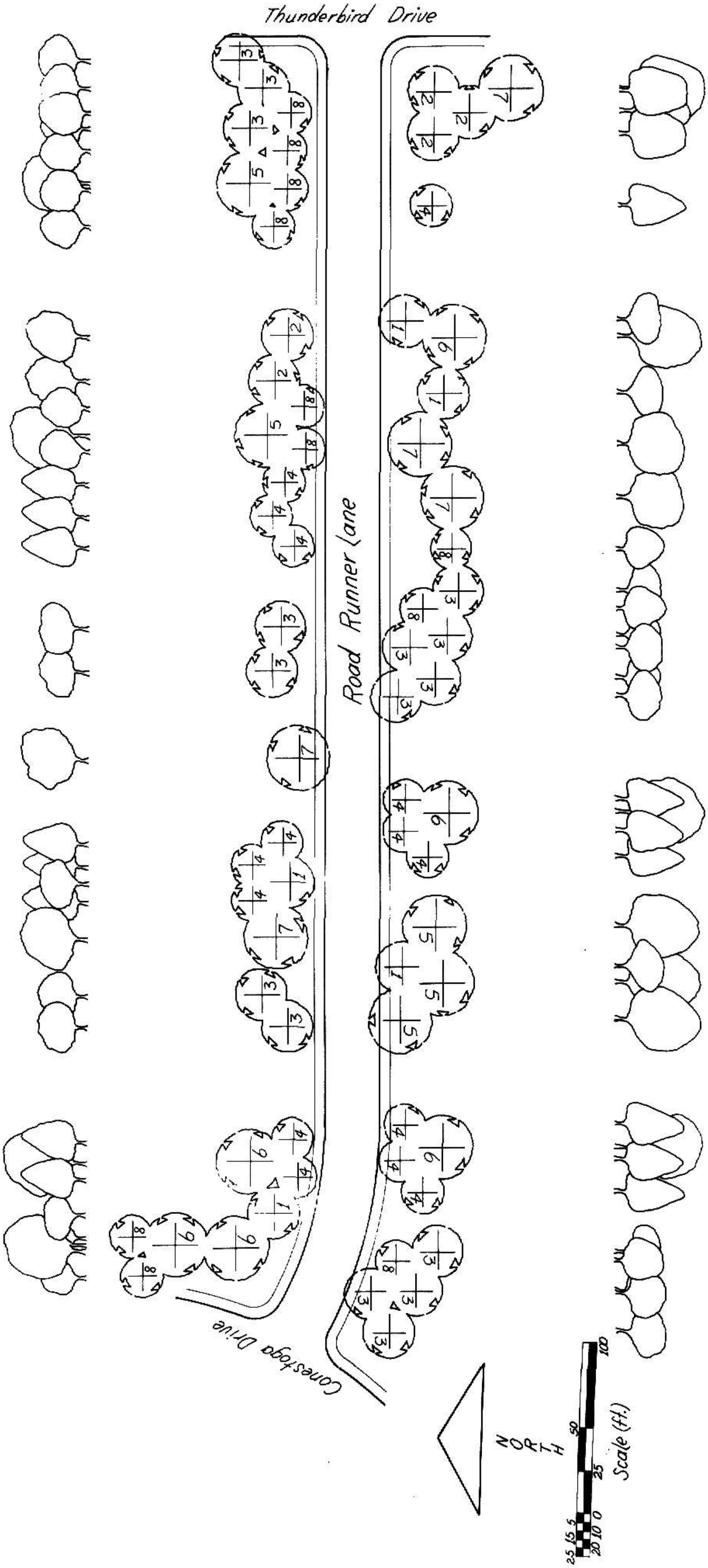
The "Aesthetic" street tree planting design of a new subdivision as located in Plate XIV, and discussed in the text. Species are identified by spot symbols according to the following legend:

- +1 - Eastern Redbud
- +2 - Washington Hawthorn
- +3 - Japanese Tree Lilac
- +4 - 'Chanticleer' Pear
- +5 - Chinese Pistache
- +6 - Western Soapberry
- +7 - Panicled Goldraintree
- +8 - 'Radiant' Crabapple


Thunderbird Drive
Road Runner Lane
Parkway
Thunderbird Drive
Downing Road
Conestoga Drive
36th Avenue
Buckskin Road
Cochise Trail
Kisiwa
NORTH
50 30 10 100
40 20 0 50 200
SCALE (ft.)

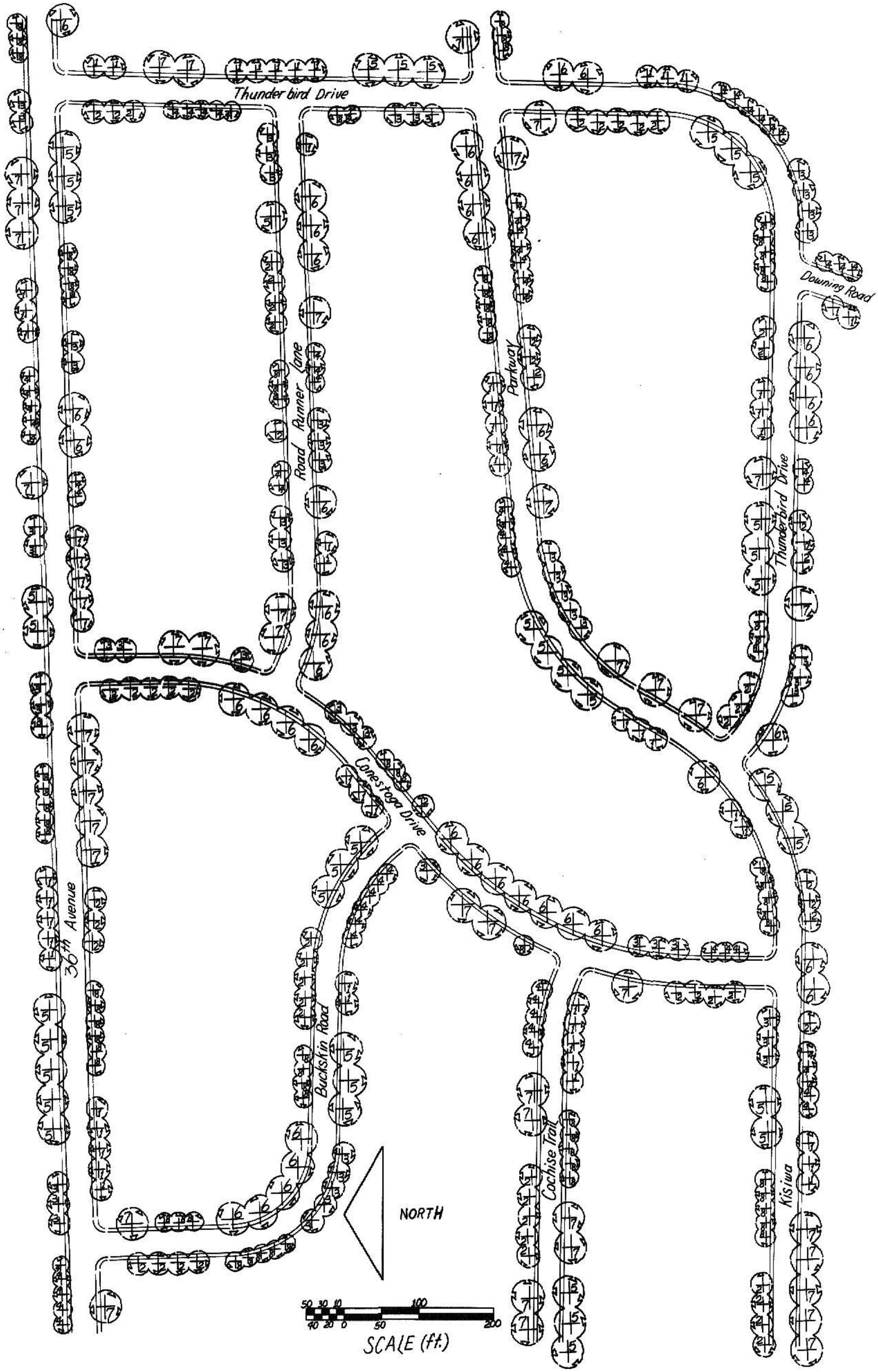
EXPLANATION OF PLATE XVIII

The "Aesthetic" street tree planting design, in plan and elevation, of Road Runner Lane from Plate XVII. Species identification is as in Plate XVII.


Thunderbird Drive
Road Runner Lane
Conestoga Drive
NORTH
Scale (ft.)
25 15 5 0 25 50 100
20 10

EXPLANATION OF PLATE XIX

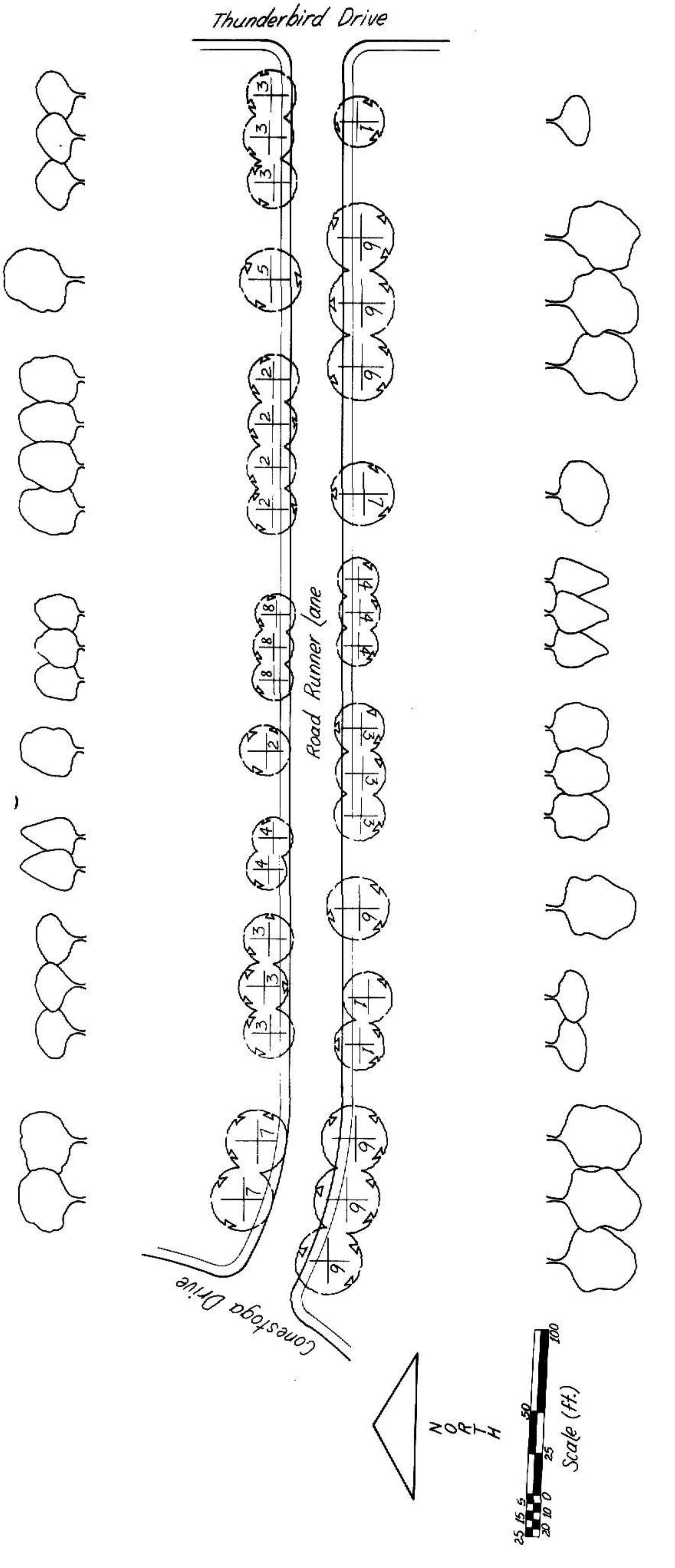
The "Compromise" street tree planting design of a new subdivision as located in Plate XIV, and discussed in the text. Species identification is as in Plate XVII.



Thunderbird Drive
Road Runner Lane
Parkway
Downing Road
Thunderbird Drive
Conestoga Drive
30th Avenue
Buckskin Road
Cochise Trail
Kisiwa
NORTH
SCALE (ft.)

EXPLANATION OF PLATE XX

The "Compromise" street tree planting design, in plan and elevation, of Road Runner Lane from Plate XIX. Species identification is as in Plate XVII.


Thunderbird Drive
Road Runner Lane
Conestoga Drive
NORTH
Scale (ft.)
25 15 5
20 10 0
25
50
100

CONCLUSION

This study would seem to indicate that the street tree plantings in cities like Hutchinson, Kansas are variety poor and numerically affluent, which is slowly leading to their certain demise. It appears that the potential for diversity is much greater than has been exploited. As the deficiencies of popular street tree species are publicised, the excellent qualities of better but relatively unknown species will be recognized and utilized. The excellent patented forms will also come into their own, particularly in difficult locations. This venture will require a closer liason between nurserymen and municipal officials to insure that the supply of these plant materials meets the demand. Aggressive and positive actions tempered with cooperation between public and private entities and all governmental strata will assure that current street tree problems are not perpetuated and that potential problems are avoided. The contents of this thesis should assist those persons who are responsible for the selection and planting of street trees and should challenge co-workers to unite in solving the street tree problems of America.

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Special thanks are also warranted to the members of the graduate committee, Dr. Robert Ealy, Dr. Ray Keen, and Dr. Richard Mattson, for their assistance and careful review of the thesis.

The city officials of Hutchinson, Kansas, especially city manager, George Pyle, and assistant city manager Ed Dawson, deserve gratitude for the opportunity to conduct the survey which formed the basis of this thesis and for their cooperation during the survey.

Richard Haney, who assisted with the drawings included in this work, also deserves thankful recognition.

The author wishes to grant particular thanks to his parents, Mr. and Mrs. Howard L. Sell, for the opportunity to achieve a college education and to Kansas State University, the institution, for that education, without which this effort would have been much more difficult.

Very special thanks and appreciation go to my wife, Barbara, for her encouragement, patience, empathy, devotion, and assistance during the course of this study.

To all others who assisted in the completion of this work, but have not been mentioned by name, I express my sincere gratitude.

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SPECIES EVALUATION OF STREET TREE
ADAPTABILITY IN AN URBAN ENVIRONMENT

by

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The purpose of this study was 1) to determine the status of the street tree plantings in Hutchinson, Kansas, 2) to evaluate potential street tree species for use in Hutchinson or in areas with environmental conditions similar to those of Hutchinson, and 3) to graphically illustrate (a) one possible renovation plan for an improperly planted area and (b) alternative planting plans for a new subdivision area.

A street tree survey was conducted in Hutchinson, Kansas during the summer of 1968. The street trees on 223 square blocks were evaluated for the following criteria: 1) species of tree, 2) size of tree, 3) spacing, 4) condition of tree, 5) presence of insects or disease, 6) presence of or susceptibility to Dutch elm disease (elms only).

The city was quite segregated as to species distribution and was delineated into several characteristic areas on this basis. The primary problems encountered in these areas were the result of 1) the improper selection of street tree species, 2) the over-replication of a single species in an area, and 3) the improper spacing of trees. In many cases, a combination of these factors complicated and magnified the problem.

Although 53 different tree species were observed as street trees in Hutchinson, only 16 species composed 97% of the total sample population. Even more significant was that elms (*Ulmus spp.*) comprised 75% of the total survey population.

The evaluation of potential street trees for the Hutchinson area consisted of an extensive literature review to determine the adaptability of these species for street tree use. The screening process involved the consideration of 147 tree species which were judged on 1) environmental adaptability, 2) size and form, 3) susceptibility to insects and disease, 4) longevity, 5) transplantability, 6) durability, 7) tendency to sucker, 8) tendency to produce litter, and 9) tolerance to pruning.

The area chosen for the graphic illustration of a potential renovation plan was selected from an area characterized by an over-population of American elms and the presence of Dutch elm disease. The renovative steps involved in improving this area were:

1. The recommended removal of old, weak, and competitive trees in order to establish the proper spacing between trees. This was a selective thinning process and not an indiscriminate removal.

2. Where planting was too sparse, the recommended interplanting of suitable species was utilized to establish continuity of the design.

3. Where selective thinning established voids in the design, interplanting with complementary and suitable species was recommended to interrupt the dangerous repetition of elms in anticipation of future elm losses.

Three alternative original planting designs were illustrated and applied to a new subdivision area. These were: 1) a conventional (Utility) design, 2) an "Aesthetic" design, and 3) a "Compromise" design.

The conventional design was characterized by the repetition of a single species at uniform spacing intervals with all trees planted in the public easement. This design contains a minimal number of trees, is relatively easy to install due to the regular planting distance, and is easy to maintain as all possible pests are standardized and require only one spray mixture for control.

The "Aesthetic" design was an attempt to achieve the most satisfying visual effect without regard to expense or ease of maintenance. It is characterized by a large number of individual trees of different species used in mass and as specimens to create visual spaces. In this design, the public-private boundary was ignored, making subsequent maintenance after planting much more difficult. The irregular planting distances and the massing of different species would make location, planting, and maintenance difficult.

The "Compromise" design incorporates desirable characteristics of both the utility and the "Aesthetic" designs with few of the restrictions of either. It is based on the use of several species which are planted in the public easement, in groups of inconsistent numbers, each group being composed of a single species. The landscape interest in this design is derived from the decorative qualities of the component species and the variable mass and form of the trees. Because the trees within a group are evenly spaced and each group is uni-specific, installation and maintenance is relatively simple. The ultimate objective of this design is the achievement of beauty and interest with a minimum of maintenance.