By Ken Simons and Gary R. Johnson

THE ROAD TO A THOUGHTFUL
Street Tree Master Plan

A practical guide to systematic planning and design

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Preface

This manual has been prepared to assist decision makers such as elected officials, city foresters, city engineers, urban planners, and landscape architects with the development of a thoughtful street tree master plan.

The basic intent of the manual is to replace the all too common practice of making subjective decisions during street tree design and tree selection initiatives with an objective step-by-step planning and design process. The manual employs a question and answer format that addresses relevant issues such as:

- Community attitudes
- Capability of street-side environments to accommodate and sustain street tree plantings
- Intended functions and desired benefits
- Degree of species diversity
- Species suitability
- Species selections, arrangements and assignments

A series of yellow boxes have been inserted into the text of this manual as chronological examples and samples of the tasks, tools, actions and products that are the parts of the prescribed planning process.

The city of North St. Paul, Minnesota and its Tower Park neighborhood will serve as the geographic and cartographic source of inputs that are applied to the hypothetical situation tracked through the "example boxes". The fact that North St. Paul, in reality, has an established street tree population is purposely overlooked for illustrative purposes. Although the highlighted examples do not demonstrate every conceivable response, they do impart an abbreviated overview and the essence of a street tree planning project.

Although the content and organization of this manual is directed at communities that do not have a street tree infrastructure, or at most have limited street tree plantings, the information and planning process contained herein is also applicable to communities that are considering the renewal of an existing or reestablishment of a devastated street tree population. Basically, this manual is suitable for any community that is about to address the issue of street tree planting of any scale.

At the onset, decision makers need to prepare for their forthcoming effort by embracing the premise that "it is better to put time and energy into the development of a thoughtful street tree master plan than it is to correct and/or remove deformed, declining, diseased or dead trees resulting from thoughtless decisions". Participating decision makers must overcome personal bias and preconceived opinions in order to address the associated planning issues with an open mind. Unquestionably, a thoughtful plan will eliminate or at least minimize many future tree and infrastructure maintenance and management problems, allowing the street tree population to grow gracefully and flourish.

Introduction

Down through the ages, the roadside planting of trees has mirrored the order, prosperity and achievements of civilized societies. Man-made row plantings of uniformly spaced trees are evidence of man's presence, power and ability to organize his surroundings, and to influence the environment for his comfort, safety and visual pleasure. Row plantings of trees are one of the earliest and simplest expressions of an intentional and functional design.

The "greening" of towns and cities, also known at times as "reforestation" and "beautification", has long been pursued in this country. Interest in urban greening has three notable historic peaks. The first occurred in the mid to late 1800s, when Andrew Jackson Downing and Frederick Law Olmsted, pioneers in the field of landscape architecture, influenced public thinking with their creation and promotion of urban green space and beautification projects. The second peak took place in the 1960's and 1970's when many thousands of trees were lost to Dutch elm disease. The last peak happened as part of the current rise of urban forestry as a profession.

The importance of urban greening is supported by recent research and study that verifies the social, economic and environmental benefits of urban trees. Unquestionably, the urban forest contributes to a community's quality of life. Together with public parks and open space, street trees are a primary component of urban greening.

Primarily, streets serve as transportation and utility corridors. Street trees are an ancillary use and should be regarded as guests within these corridors. As such, decision makers must strive to ensure that street trees will not become unwelcome intruders.

Unfortunately, many street tree planting efforts have not been guided by a thoughtful master plan. All too often, in a rush to qualify for government grants, reforest denuded streets or maintain momentum of volunteer interest, street tree planting initiatives become a haphazard, ill-considered process with no concern for after-care needs. Without a thoughtful master plan, trees that should be long term assets can become costly liabilities.

Street trees are an integral part of a community's infrastructure, and as such, warrant thoughtful planning and budgeted management. Some decision makers have not learned from past mistakes, and they are the reason that negative history repeats itself. For example, in many cities where Dutch elm disease devastated miles and miles of streets that were graced by Gothic-arching elms, decision makers have replanted those barren streets with miles and miles of green ash or Norway maple. One monoculture tree population was replaced by another. Familiarity, popularity, adaptability and availability of certain species can cloud judgments. Today, the threat of emerald ash borer, Asian long horned-beetle and ash yellows causes city foresters to view the future of these replacement ash populations with great anxiety.

Regardless of concerted education endeavors by utility companies, decision makers continue to place tall-growing trees under overhead utility wires, creating potential service disruptions and making such trees candidates for disfigurement by line clearance pruning. Like-minded short sighted decisions also result in the placement of trees in dedicated border areas and limited ground-space locations that, over time, bring the trees into conflict with road improvement projects (e.g. widening), adjacent hardscape infrastructure (e.g. curbing, sidewalks, paths) and underground utilities. Another common error often made by decision makers is the planting of intolerant trees in unsuitable growing environments that, over time, contribute to abnormal growth, decline or mortality.

In order to prevent such negative history from repeating itself, decision makers need to recognize and understand the relevant lessons of the past. Street trees can be a unifying thread that weaves through the urban fabric. If street tree initiatives are to fulfill the good intentions of decision makers, the right tree needs to be planted in the right place for the right reason and given the right after-care. This is the on-going challenge that confronts decision makers. A thoughtful street tree master plan that incorporates intelligent designs, derived through the recommended comprehensive planning process, is the road decision makers need to follow to accomplish their worthy objective.

ISSUE NO. 1.

Is Your Community Street Tree Receptive?

This issue addresses the social, political, economic, and physical aspects of the community. If the overall conclusive answer to this question is "NO", further consideration and action is not warranted.

All communities are not street tree receptive, and if not, a street tree infrastructure should not be imposed on such communities. Although decision makers may be accustomed to seeing tree-lined streets in other communities or have lived on a street lined with trees, these experiences alone are not a valid justification for transference of this preference to the subject community.

This issue has several facets that must be considered as preliminary steps to a final determination. A negative response to any one of the following determinants could be sufficient cause to withdraw interest in a proposed street tree planting program. The critical determinants are:

What level of local support will a street tree planting initiative receive?

The attitudes, expectations, convictions, and perceptions of elected officials, state and local road and tree authorities, business owners, and the general public (tax-paying electorate) need to be identified. Determination of personal opinions can be revealed through public meetings or hearings and survey questionnaires.

Community support can be nurtured and negative perceptions can be changed through education and promotional efforts using the community newsletter, community web site, local newspaper, and cable television. Local awareness and acceptance also can be encouraged through partnerships with and advocacy by citizen action groups and civic organizations that already support a street tree planting program. In the end, the target audience will have to be convinced that the proposed street tree planting program is achievable and the outcome is desirable and necessary (e.g., beneficial to both the community and the individual).

Is the community willing to underwrite both the cost of the street tree planting program and the related ongoing aftercare program?

Communities usually rely on general revenues to fund tree planting initiatives and follow-up maintenance programs. Street tree plantings often qualify for state cost-share grants. However, general tree maintenance programs typically are not eligible for such funding assistance, although tree pest control may be an exception during peak infestation or infection periods. All too often, elected officials appropriate funds for tree plantings because they are popular, conspicuous, and relatively short-term actions. Ongoing maintenance, however, is overlooked as a budget item because these same officials do not appreciate nor comprehend the related need. Generally, in comparison to other budgeted public services, tree maintenance is considered a low priority item.

Enlightenment of elected officials and state and local road authorities by demonstrating and documenting the value and benefits of street trees will improve the probability of receiving adequate funding for both planting and maintenance. It should be remembered that elected officials and departmental directors come and go, as does their support. Consequently, the promotion of street tree programs will have to be repeated periodically to indoctrinate newly elected officials and appointed staff, and to remind incumbent officials. A street tree planting program should not be undertaken until there has been a commitment by elected officials to fund a companion ongoing street tree maintenance, protection and preservation program.

For information on the benefits of trees refer to: McPherson, E.G. et al. 2005. *Midwest Community Tree Guide. Benefits, Costs, and Strategic Planting*. US Department of Agriculture, Forest Service, Northeastern Area, Newton Square, PA.

Is the character of the community and its street system conducive to tree planting?

The ideal character of a street tree-receptive corridor would be described as having a straight to moderately curving paved alignment, level to gentle gradients, comfortable building set backs, absence of overhead utility lines, broad boarder areas with wide flat boulevards, and sidewalks and curbs in place. Figure 1.1 depicts and dimensions the typical ground plane components of an improved street corridor.

A community of wooded lots with naturally established tree masses bordering the edges of narrow winding uncurbed roads does not warrant the planting of street trees. Street tree plantings would violate the naturalness of such a community.

Also, a community where most of the streets have a *rural section* is not street tree receptive. Such streets have no curbs, provide graveled shoulders and parallel drainage channels with sloped sides that leave no suitable space for trees (see Figure 1.2). The status of such a community could be changed if the streets are improved and upgraded to an *urban section* with widened traffic lanes, paved parking lanes, curbs, storm sewers, and level border areas (see Figure 1.3).

Are the physical qualities of boulevards suitable growing environments for trees?

As the designated growing site for street trees, boulevards must accommodate and sustain vigorous tree growth and longevity. Ideally, soil properties should favor tree growth, boulevard dimensions should provide adequate space for root and trunk flare development , overhead space should not be too restrictive allowing for unimpeded lateral and vertical growth, and buildings and structures should have generous setbacks so as not to crowd nor deprive crowns of sufficient sunlight.

If boulevards or border areas are too narrow, if sidewalks are adjacent to curbs, or if ordinances and setback requirements eliminate trees from the boulevard or border areas, street trees could be planted outside the established street right-of-way on private property in accordance with acquired easements. Also, the relocation of sidewalks outside of the right-of-way could be another alternative to mitigate potential obstruction by sidewalks. Such solutions would be similar to the easements acquired by public utility companies. The drawback, however, would be the complexities of related liability and maintenance issues.

Figure 1.2. Rural section

Figure 1.3. Urban section

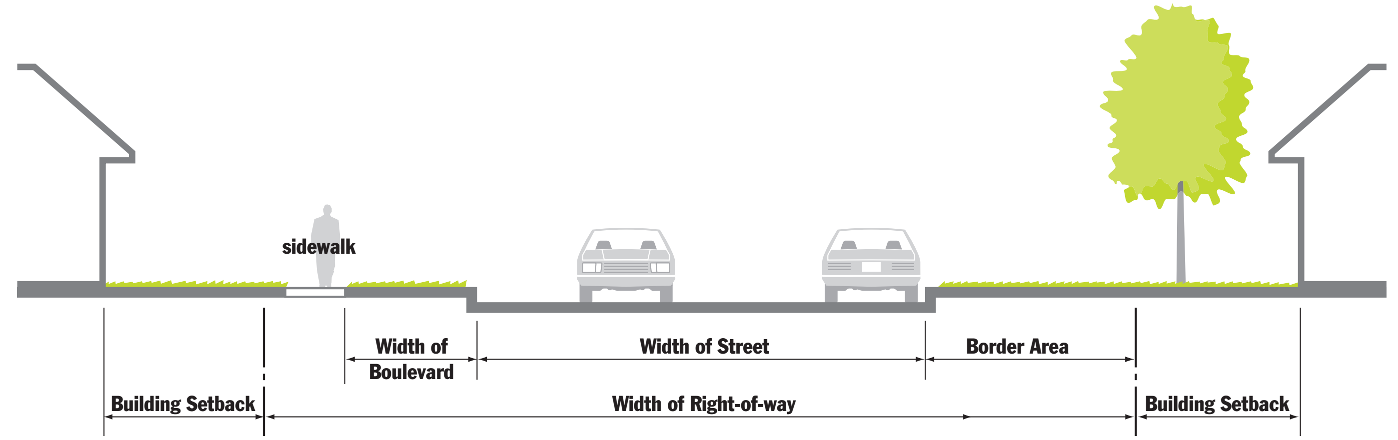

Figure 1.1. Street corridor components and dimensions

Under certain circumstances, an option that has proven to be effective is the exercise of the site plan review and approval authority granted by the local zoning code which enables local governing councils or boards to attach reasonable conditions to their approval of the landscaping plan component of the site plan. Such conditional approvals could stipulate that a new subdivision or land development must include row plantings of trees on the private side of road rights-of-way within the proposed development. Such tree placements are most workable when the proposed project is part of a planned unit development (PUD) and/or when site maintenance will be done through a property owner's association.

Since it would be impractical to modify or amend existing soil in boulevards beyond the planting hole, except in conjunction with major road improvement projects or to increase existing space for below ground and overhead growth, prevailing limitations of the growing site can be counteracted by selecting tree species that will tolerate the existing adversities and physical restrictions of the site.

Does the existing local zoning code or ordinance permit the planting of trees within the right-of-way?

It is not uncommon to encounter municipalities with an ordinance or zoning code that prohibits the planting of street trees to maintain visibility (e.g., sight lines, signage, and lighting) and eliminate tree/gray infrastructure (e.g., hardscape and utilities) conflicts, or a policy that establishes a significant setback requirement within rights-of-way (e.g., 6-8 feet from edge of street or back of curb) to accommodate winter snow storage and minimize the potential for tree/vehicle impacts.

> Example: Provision from city code of Bloomington, Minnesota
>
> SEC, 18.06. REGULATIONS FOR PLANTING TREES.
>
> *(a) The standard location for yard trees shall be three feet or more inside the property for all property lines abutting a City street.*
>
> *(b) In general, trees shall not be planted in public street rights-of-way, or in the clear view triangle at corners. Any person wishing to plant in such areas must first secure a permit from the City Forester. (Code, 1958 S 26.05; Ord. No. 73-25, 4-16-73, renumbered to S 26.06 (A))* (Note: Generally such permits are not granted.)

Such ordinances and policies are often the consequence of elected officials, city managers, public works directors, and/or city engineers who firmly believe that street trees are safety hazards and costly liabilities.

For a comprehensive concise discussion relative to roadside trees and traffic safety, and a bibliography of related source materials refer to: Wolf, K. and N. Bratton. 2006. *Urban Trees and Traffic Safety: Considering U.S. Roadside Policy and Crash Data*. Arboriculture & Urban Forestry 32:170-179.

Fortunately, recent cost/benefit research and analyses demonstrate that the accrued environmental and aesthetic benefits of street trees far outweigh the costs of planting and ongoing maintenance (McPherson et al. 2005), and interestingly, the shade from street trees can have a positive effect on pavement performance (McPherson et al. 2005). If the community and its officials are convinced of the benefits and value of street trees, such ordinances, code provisions or policies could be repealed or amended.

Before the book is closed on street tree planting, and a negative conclusion to this issue is declared, be sure that suggested options or other legitimate circumventions have been explored and/or exercised if a street tree program remains a genuine desire. After all, a community with street trees is a sight to behold and a pleasing place to live.

If the overall answer to the initial question (ISSUE NO. 1) is "YES", you are at the threshold of the planning process. The issues, decisions, and tasks ahead will require both grassroots and professional input and participation. As an attempt to address and represent community values and objectives during the planning process, it will be beneficial to make a concerted effort to involve community stakeholders at critical junctures or decision-making phases throughout the planning process. Depending on the issue or related action phase, such stakeholder participation can involve the entire community or a representative team that includes selected officials, professional staff, civic organizations and property owners. Generally, stakeholder involvement would build from "input" at the onset to "review and consensus" during preparation and "concurrence" at the conclusion of the planning process. The result of stakeholder collaboration and guidance will ensure the responsiveness, acceptability, suitability, and utility of the resulting plan.

Once it has been determined that the community is street tree receptive, the initial objective is validated, and the opportunity is at hand to pursue and prepare a thoughtful street tree master plan. It should be noted that such a declaration is a generalization and does not conclude that every street, every block, every section or every foot is tree friendly. Such suitability will be determined through an analysis of influential environmental and social factors.

Literature Cited

McPherson, E.G. and J.R. Simpson, P.J. Peper, S.E. Maco, S.L. Gardner, S.K. Cozad, and Q. Xaio. 2005. *Midwest Community Tree Guide-Benefits, Costs, and Strategic Planning*. U.S. Department of Agriculture-Forest Service. Newtown Square, PA.

McPherson, E.G. and J. Machnik. 2005. *Effects of Street Tree Shade on Asphalt Concrete Pavement Performance*. Journal of Arboriculture 31:303-309.

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What Public Attitudes and Physical Elements of the Environment Will Have a Direct Influence on Species Selection, Arrangement, and Placement?

This issue addresses the identification of personal preferences of directly affected residents and business owners, and the location, dimension, quantification, and characterization of specific physical factors above, below, and at the ground level within the confines of the respective street corridors and their immediate surroundings.

The collection and documentation of this information constitutes the social and environmental inventory phase of the planning process, and after evaluation, provides the groundwork for forthcoming decisions. Initially, every street within the street tree receptive community should be subjected to the joint social and environmental inventory and subsequent critical review, unless there is no doubt that a particular street should not host a row planting of street trees due to jurisdictional, political or other obvious circumstances. Such streets can be immediately disqualified and exempted from further consideration. The inventory is the gateway to a thoughtful street tree master plan and should be done in an organized and conscientious manner.

Social Inventory

Derived by a questionnaire or personal preference survey delivered to property owners that might have a street tree planted in front of their homes or businesses as determined by the outcome of the planning process.

An accompanying cover letter from the elected authority (e.g., city council or town board) or chief administrative official (e.g., city manager or administrator, town clerk) should explain that the elected officials and the community have decided to initiate a community-wide street tree planting program, and the survey is part of a planning process that will also include follow-up public meetings. Replies would be solicited in response to the following type of queries:

- Do you favor the planting of a street tree in front of your (house/business) at (address)?
If NO, please state the reasons for your opposition.
Check one: Yes ____ No ____
Comments______________________________________
- If a street tree were to be planted in front of your (*house/business*) at (*address*), which of the species on the enclosed list of approved trees would you prefer? List 3 species in descending order of preference.
- If a street tree were to be planted in front of your (*house/business*), would you be willing to volunteer to help water it during the two growing seasons following its planting?
Check one: Yes ____ No ____
Comments______________________________________

Such inquiries could be incorporated into the periodic comprehensive surveys communities use to solicit resident input and ranking of public services prior to budget deliberations. Responses to the survey should be recorded on a summary sheet referenced by the corresponding neighborhood (if applicable) and street addresses.

Environmental Inventory

Derived by interviews, electronic and paper file searches, field measurements, and observations.

A 4-step Process to Accomplish an Environmental Inventory

Step 1. Develop an Information Checklist

To proceed in an efficient and orderly manner, the environmental inventory task should follow a predetermined checklist of influential factors. The prescribed checklist will serve as a procedural guide for the collection and documentation of relevant measurements, descriptions, and classifications. The contents of a typical checklist should include those influential factors that reflect existing environmental conditions and circumstances that are pertinent to the following planning tasks and decisions. An example checklist is provided in Appendix 1: Forms for duplication and direct use or as a model for creating one that meets the specific needs of the reader (see Form 2.1: Inventory Checklist). Typical checklist factors (list not inclusive) are identified and defined in Table 2.1 and discussed in further detail as footnotes in Appendix 2: Footnotes – Inventory Checklist Factors.

Table 2.1. Inventory factors that will affect the selection of species and placement of trees.

Factor	**Definition**	**Design Impact**	**Source** (options)	**Comments** (see footnotes in Appx. 2)
Width of Street	Distance from face of curb to face of curb.	Crown spread, form.	Plan sheets & aerial photos on file. Direct field measurement.	1 See Figure 1.1
Width of Right-of-way	Distance between opposite boundaries of strip of land dedicated for public roadway purposes.	Tree placement.	Plan sheets & aerial photos on file. Direct field location and measurement.	2 See Figure 1.1
Width of Boulevard	Distance from back of curb or edge of pavement to edge of sidewalk.	Crown spread, form, branching habit, rooting habit, trunk flare.	Plan sheets & aerial photos on file. Direct field measurement.	3 See Figure 1.1
Building Setbacks	Distance from face of building to edge of street.	Crown spread, form.	Plan sheets & aerial photos on file. Direct field measurement.	4 See Figure 1.1
Character of Adjacent Buildings	Height, scale, style and function of buildings bordering street.	Tree height, form, foliage texture and color. Shade tolerance.	Field observation.	5
Type of Street	Functional classification influencing design standards and level of service.	Tree height, crown spread, form, branching habit.	Comprehensive community development plan on file.	6
Traffic Composition	Dominant vehicles that frequent street.	Tree height, crown spread, form, branching habit.	Field observation.	7
Traffic Volume	Average daily traffic count (ADT).	Species tolerances. Species selection.	Direct field measurement. Traffic counts on file.	8
Type & Height of Overhead Utilities	Service providers and height of lowest line.	Tree height, crown spread, form.	Plan sheets on file. Field observation. Direct field measurement.	9 See Figure A 2.1
Type & Height of Streetlight.	Source of nighttime lighting.	Tree height, crown spread, form, foliage texture and density, branching habit. Species tolerance.	Plan sheets on file. Field observation. Direct field measurement	10
Location & Depth of Underground Utilities	Service provider and placement within right-of-way.	Tree placement.	Plan sheets on file.	11
Adjacent Land Use	Purpose for which land, premises or building thereon is designed or occupied.	General character and tolerances. Function assignment.	Zoning and land use maps. Aerial photographs. Field observation.	12
Lot Widths	Streetward distance between side yard boundaries.	Tree spacing.	Plan sheets on file. Direct field measurement.	13 See Figure A 2.2
Existing Street Tree Species	Existing trees located in boulevard or right-of-way.	Species selection. Tree placement.	Field observation. Aerial photographs. Tree inventory	14
Existing Trees on Private Property	Existing trees on adjacent private property impacting right-of-way.	Tree height, crown spread, foliage density and texture. Tree placement.	Field observation. Aerial photographs.	15
Existing Soil Conditions	Soil classification and properties.	Species tolerances. Species selection.	Soil survey on file. Field observation. Soil sampling.	16
Salting Patterns and Practices for Snow and Ice Control	Type of deicing agent, rate and frequency of application	Species tolerance. Species selection.	Street maintenance superintendent.	17
Air Pollutants	Airborne chemical, particulate and odiferous contaminants.	Foliage density and texture, flowering habit. Species selection. Species tolerance.	Field observation.	18
Sun/Shade Patterns	Source, orientation and duration of shade.	Species tolerance. Species selection.	Field observation.	19
Prevalent Tree Pests	Destructive epidemic diseases or insect infestations prevalent in the area.	Species susceptibility. Species selection.	Local tree removal records. State agency reports. Field observation.	20

Step 2. Identify Available Sources of Information

Dependant on a community's level of digital sophistication (data processing capability) and the accessibility of relevant electronic information, most of the required information relative to the checklist factors could be extracted and downloaded from existing in-house digitized data layers (e.g., infrastructure as-built maps) and/or online Geographic Information Systems (GIS) mapping files (e.g., property line overlay of rectified aerial photographs). To be useable for inventory purposes, GIS photomaps should be downloaded at a user-friendly scale of 1" = 100'. Most objects, features, and situations (e.g., influential factors) will be easily detectable and measurable at this scale. A typical block (section of a street between two intersecting streets) approximately 650 feet long will adequately fit onto an 8.5" x 11" sheet of copy paper (see Figure 2.1).

If such electronic information is not available, the applicable data can also be obtained from the community's archives (e.g., as-built drawings), community base maps, published comprehensive plan, local plat book, field observations (e.g., drive-by or windshield tours, on-foot spot checks), and miscellaneous printed reports.

Most, if not all, inventories will involve both an indoor file search and an outdoor field inspection. It is very likely that all of the required information will be obtainable from one or a combination of the sources described above. Prior to initiating any information collection activities, an implementation strategy should be developed to identify the probable sources of the required information and establish a plan of action to collect the information in a timely manner (see Table 2.2).

The results of an investigation to confirm the actual availability of the potential sources should be documented for guidance purposes. A suitable format would be a columnar worksheet that pairs each influential factor with confirmed sources.

Table 2.2. Sources of information that will complete environmental inventory checklist queries.

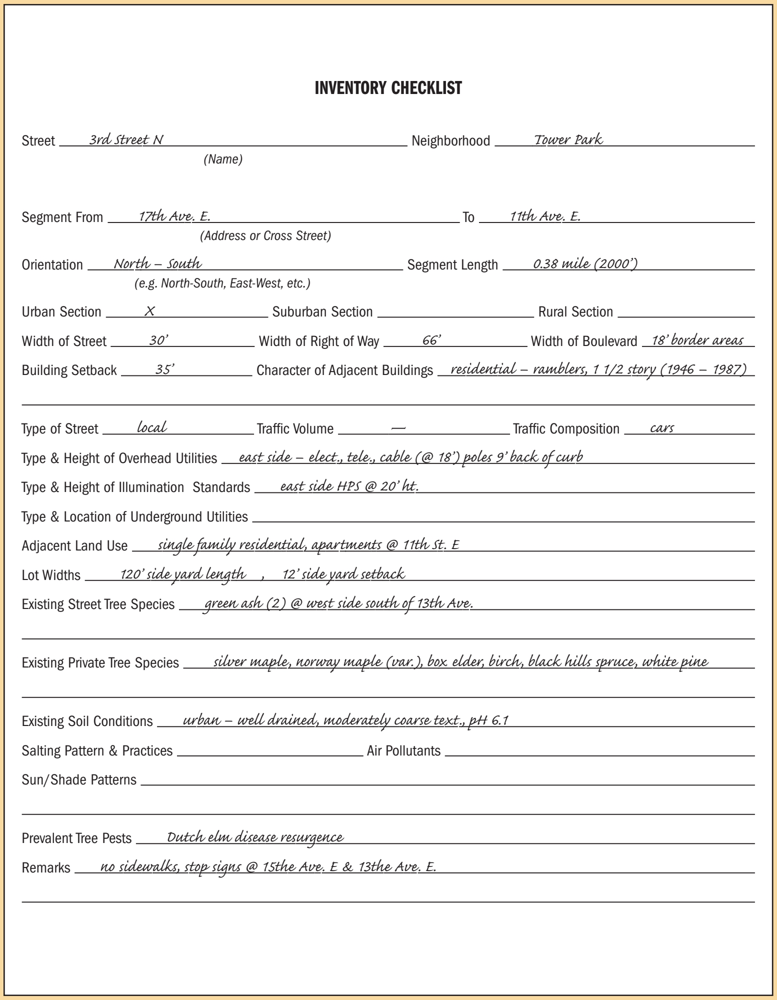
	Source								
Influential Inventory Factors	Community base map	Community comprehensive plan	Plat book	Community record files / as-builts	GIS database (photomaps)	Utility company as-built mapping	Drive-by survey	On-ground spot check or sampling	Miscellaneous printed documents or reports
Street name and location	●						●		
Width of street			●	●	●			●	
Width of right-of-way			●	●	●				
Width of boulevard				●	●			●	
Building setback					●			●	
Character of adjacent buildings							●		
Type of street		●							
Traffic composition							●		
Traffic volume		●							●
Overhead utilities					●	●	●	●	
Illumination standards					●	●	●	●	
Underground utilities						●			
Adjacent land use		●			●		●		
Lot widths			●		●		●		
Existing street tree species					●		●		●
Existing private tree species					●		●		
Existing soil conditions								●	●
Salting practices									●
Air pollution							●		●
Sun-shade patterns							●		
Prevalent tree pests							●		●

Figure 2.1. GIS Photomap downloaded from online website.

DISCLAIMER: This map is neither a legally recorded map nor a survey and is not intended to be used as one. This map is a compilation of records, information and data located in various city, county, state and federal offices and other sources regarding the area shown, and is to be used for reference purposes only.

SOURCES: Ramsey County (September 4, 2007), The Lawrence Group;September 4, 2007 for County parcel and property records data; September 2007 for commercial and residential data; April 2006 for color aerial

Source: Ramsey County GIS User Group



INVENTORY CHECKLIST

Street 3rd Street N (Name) Neighborhood Tower Park

Segment From 17th Ave. E. (Address or Cross Street) To 11th Ave. E.

Orientation North – South (e.g. North-South, East-West, etc.) Segment Length 0.38 mile (2000')

Urban Section X Suburban Section ___ Rural Section ___

Width of Street 30' Width of Right of Way 66' Width of Boulevard 18' border areas

Building Setback 35' Character of Adjacent Buildings residential – ramblers, 1 1/2 story (1946 – 1987)

Type of Street local Traffic Volume — Traffic Composition cars

Type & Height of Overhead Utilities east side – elect., tele., cable (@ 18') poles 9' back of curb

Type & Height of Illumination Standards east side HPS @ 20' ht.

Type & Location of Underground Utilities ___

Adjacent Land Use single family residential, apartments @ 11th St. E

Lot Widths 120' side yard length , 12' side yard setback

Existing Street Tree Species green ash (2) @ west side south of 13th Ave.

Existing Private Tree Species silver maple, norway maple (var.), box elder, birch, black hills spruce, white pine

Existing Soil Conditions urban – well drained, moderately coarse text., pH 6.1

Salting Pattern & Practices ___ Air Pollutants ___

Sun/Shade Patterns ___

Prevalent Tree Pests Dutch elm disease resurgence

Remarks no sidewalks, stop signs @ 15the Ave. E & 13the Ave. E.

Example Box 1: Completed Inventory Cheklist

Step 3. Collect and Document Relevant Information

An inventory checklist form should be assigned to each street and, as determined, segments of the same street that exhibit significant differences. As already mentioned, the checklist identifies the information that needs to be documented, and provides the record of noted information. (See Example Box 1: Completed Inventory Checklist).

Since the end result of the planning process is to match or assign the perfect tree species to each qualified street, it follows that the existing conditions and situations along or within each street corridor need to be inventoried to attain informed selections. Optimistically, the properties and overall character of a corridor will be somewhat uniform for its full length within a small community or neighborhood of a large community. Realistically, the qualities of certain influential factors will change along some street corridors. A significant change of any of the following factors for a significant distance would be justification to separate the incongruous lengths, and identify them as independent segments of the same street for planning purposes (see Table 2.3). Consequently, an inventory checklist form should be allotted to each segment of such streets.

Electronic mapping and data layers can

Table 2.3. Reasons to separate a street into segments.

Factor	Example of significant change
Width of street	Change from 30' width to 44' or two moving lanes to four moving lanes or addition of a plantable median.
Boulevard widths	Change from narrow boulevard to wide boulevard on one or both sides of street.
Sidewalks	Introduction of a sidewalk on one or both sides of street.
Overhead utilities	Introduction of overhead utility lines on one or both sides of street.
Land use	Change from residential to commercial (does not include an occasional commercial or institutional inholding).
Existing soil conditions	Different soil types (sandy soil/clay soil), compaction and/or poor drainage.

be viewed on a computer monitor at appropriate scales that will enable identifications and measurements. The viewed information can be extracted and downloaded, as needed, for future reference and attachment to the corresponding checklist.

Field inventories in a large community can be time consuming and labor intensive. If adequately trained, it is likely that recruited volunteers with professional oversight could accomplish the required data collection in a timely manner (Bloniarz and Ryan 1996). Such training would familiarize volunteers with collection and documentation expectations and techniques, and ingrain an understanding of the influential factors.

Regardless of whether the community is large or small, field inventory activities should follow an itinerary that will establish the route of the related tour. Generally, an effective inspection strategy would follow a pattern that views all of the streets that run in the same direction (e.g., east-west) followed by a viewing of the streets that run in the perpendicular direction (e.g., north-south). To accommodate the expanse of larger communities, inspection tours should be organized by neighborhood or planning district.

Field inventories probably will include the observation of obvious factors from a moving vehicle (e.g., drive-by or windshield assessment) and the hands-on attention to details and unperceivable factors (e.g., on-foot measurement and sampling).

Ideally, field inventories would involve the coordinated efforts of one or more inspection teams. Each team would consist of two crews, a drive-by observation crew of two people and an on-foot ground survey crew of two people, which generally follow the same routes and remain in cellular phone or radio contact during the inspection period. The drive-by crew would include a driver-itinerary monitor and an observer-recorder. The on-foot crew would include a spot-checker and a documenter. If the community is comprised of multiple neighborhoods or planning districts, a single team would be assigned to a planning unit.

Step 4. Evaluate Collected Information

The information collected from digital mapping and/or archive drawings and field observations in response to the checklist of influential environmental factors will need to be evaluated and converted into an associative set of definitive species characteristics, tolerances, and susceptibilities. A cellular worksheet or mosaic-like grid of determinants that categorize selected physical and reactive qualities of tree species has been developed to facilitate the interpretation of collected information and its utilization as the basis for subsequent species selection decisions (see Form 2.2. Species Selection Matrix in Appendix 1: Forms). The determinants are defined and discussed in Appendix 3: Species Selection Matrix Determinants.

The transfer of recorded information is accomplished by assigning a printed copy of the species selection matrix to each street or segments of a street and filling-in by shading or hatching the cells that correspond to the resulting conclusive analytic decisions. Table 2.4 diagrams the interconnection or transferal relationship between the influential factors of the inventory checklist and the determinants of the species selection matrix. For example, the conversion thought process would recognize that a street 30’ wide with sidewalks, 5’ boulevards, and 35’ residential building setbacks will adequately accommodate a very narrow to narrow crowned tree species without branching overlap (e.g., crown spread determinant—very narrow <20’ and narrow 20’-35’ gradations). (See Example Box 2: Completed Species Selection Matrix).

The qualitative determinants have been purposely selected to characterize the adaptability, suitability, and compatibility of a tree species relative to prospective street/tree relationships. The resulting requirements, as defined by each completed matrix worksheet, provide the species selection criteria that can be used to manually or digitally derive street/tree species match-ups. Application procedures are addressed in ISSUE NO. 6.

Literature Cited

Bloniarz, D.V. and H.D.P. Ryan III. 1996. *The Use of Volunteer Initiatives in Conducting Urban Forest Resource Inventories.* J. Arborculture 22:75-82.

Table 2.4. Transferal relationships between influential environmental factors, species characteristics and growing site requirements.

	Determinants																							
Influential Inventory Factors	Hardiness	Height	Crown spread	Form	Mass	Branching habitat	Root pattern	Trunk flare	Foliage duration	Foliage texture	Foliage color-summer	Foliage color-autumn	Flower color	Fruit structure	Soil texture	Soil drainage	Soil moisture tolerance	Soil reaction tolerance	Compaction tolerance	Shade tolerance	Salt tolerance	Artificial lighting	Atmospheric pollutants	Plant sex-Allergen
Street name and location	●																							
Width of street			●	●		●																		
Width of right-of-way			●	●		●																		
Width of boulevard			●	●		●	●	●																
Building setback			●	●		●														●				
Character of adjacent buildings		●		●							●									●				
Type of street																					●			
Traffic composition		●	●			●																		
Traffic volume																					●			
Overhead utilities		●	●	●																				
Illumination standards		●	●	●	●	●																●		
Underground utilities							●																	
Adjacent land use														●					●				●	
Lot width			●	●																				
Existing street tree species		●	●	●					●	●	●	●												
Existing private tree species		●			●				●		●	●								●				
Existing soil conditions															●	●	●	●	●					
Salting practices																				●				
Air pollution																							●	
Tree pests																								

Note: *Some of the determinants (e.g. foliage characteristics, flower color, fruit structure, plant sex-allergen) are not related to the inventory process and have not been bulleted or have been only slightly bulleted. They will have greater significance during the assignment of functions (ISSUE NO. 3) and species selection (ISSUE NO. 6).*

Species Selection Matrix Form

Neighborhood Tower Park **Street** 3rd St N (East side) **From** 17th Ave E. **To** 11th Ave E.

Hardiness								Natural Range		Height				
Zone 2	Zone 3a	Zone 3b	Zone 4a	Zone 4b	Zone 5a	Zone 5b	Zone 6	Native	Non-Native	Very Short < 20’	Short 20’ – 35’	Intermediate 35’ – 50’	Tall 50’ – 75’	Very Tall > 75’
			▨							▨				

Crown Spread					Trunk Diameter				Trunk Flare		
Very Narrow < 20’	Narrow 20’ – 35’	Intermediate 35’ – 50’	Wide 50’ – 75’	Very Wide > 75’	Small < 12”	Intermediate 12” – 24”	Large 24” – 36”	Very Large > 36”	Slight	Moderate	Buttress
▨	▨				▨	▨			▨		

Form									Mass		
Columnar	Conical	Globular	Irregular	Pyramidal	Rounded	Spreading	Upright	Oval	Open	Moderate	Dense
										▨	

Branching Habit					Root Pattern			Foliage Duration	
Upright	Ascending	Horizontal	Recurving	Descending	Shallow Lateral	Deep Lateral	Taproot	Deciduous	Evergreen
▨	▨							▨	

Foliage Texture			Summer Foliage Color									
Fine	Medium	Coarse	Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Bronze	Purple	Maroon
	▨		▨	▨	▨							

Autumn Foliage Color											
Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Orange	Brown	Bronze	Purple	Maroon

Flower Color											
White	Gray	Yellow	Green	Pink	Red	Red-Purple	Purple	Orange	Brown	Blue	Inconspicuous

Fruit Structure													
Seedless	Berry	Pome	Drupe	Multiple	Nut	Cone	Pod	Samara	Capsule	Strobile	Follicle	Achene	Aril
▨								▨	▨	▨			

Allergen			Plant Sex			Soil Texture											
Low	Moderate	High	Perfect	Monoecious	Dioecious	Sand	Loamy Sand	Sandy Loam	Loam	Silty Loam	Silt	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay
							▨	▨				▨					

Soil Drainage			Soil Moisture			Soil Reaction				
Excessive	Moderate	Poor	Dry	Moderate	Wet	Strongly Acid 4.0 – 5.0	Moderately Acid 5.1 – 6.0	Slightly Acid 6.1 – 6.5	Neutral 6.6 – 7.5	Alkaline 7.6 – 8.5
	▨			▨				▨		

Soil Compaction			Shade Tolerance			Artificial Lighting			Spray Salt			Soil Salt		
Sensitive	Moderate	Tolerant	Intolerant	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant
	▨			▨			▨							

Atmospheric Pollutants						
Sulphur Dioxide	Ozone	Oxides of Nitrogen	Peroxyacetyl Nitrate	Hydrogen Fluoride	Hydrogen Chloride	Ethylene

Example Box 2: Completed Species Selection Matrix (Step 4)

ISSUE NO. 3.

What Functions Should the Street Trees Perform?

This issue addresses the determination and assignment of functions to trees to be planted on specific streets. Up to this point, the planning effort has involved diligent research and information collection accompanied by the critical evaluation and analysis of the data. From this point on, the planning process becomes one of integration of designated functions, tree characteristics, and growing site limitations. Definitively, street tree planning is the art and science of arranging the best possible relationship between the formative factors (e.g., function, species, and site), based on the evidence of a sound analysis and a thorough understanding of the relevant issues.

Function designation is the first of five conceptual and implemental design decisions. Subsequent decisions will consider degree of diversity, composition or arrangements, species selection, and placement (see Table 3.1).

Table 3.1. Design decision schedule.

Decision	Classification*
Function designation	Conceptual
Degree of diversity	Conceptual
Composition/arrangement	Implemental
Species selection	Implemental
Planting placement	Implemental

*Conceptual decisions will influence subsequent decisions relative to implemental factors. Implemental decisions will influence the articulation and execution of the resulting plan.

In addition to inventory data, the eventual selection and placement of trees into a streetscape should be based on the intent that they will perform predetermined functions. Intended functions will vary with different situations. Functions may vary between communities, neighborhoods within the same community, streets within the same neighborhood and sections of the same street. The overall street tree master plan will, in effect, be a comprehensive design that uses trees to solve specific problems or enhance specific aspects of the street alignment. Generally, street trees can be used for architectural, engineering, aesthetic and/or climatic purposes (Robinette 1972).

Function Categories (see Table 3.2 for detailed list).

- Architectural—spatial definition.
- Aesthetic—amelioration of physical harshness and visual enhancement of urban surroundings.
- Engineering—prevention and correction of engineering problems associated with human-made urban environment.
- Climatic—alteration of microclimate to improve physical comfort.

The ability of a tree species to perform a specific function is related to its inherent characteristics such as size, form, foliage density, texture, and color. Trees on a given street may perform a single function, any combination of functions or all of the potential functions. Although most functions can be fulfilled by most, if not all street-suitable species, certain functions require that the selected species possess definite characteristics (e.g., accentuation might require colored foliage and/or a contrasting form). (See Table 3.2).

A 2-Step Process to Assign Functions to Each Street

Step 1. Assemble and Sort Completed Inventory Checklists

Assemble the completed inventory checklists (see Form 2.1) for each street or segments of a street, and systematically sort them by neighborhood or planning district (if such divisions have been established), and subsequently arrange them in alphabetical and numerical order. (See Example Box 3: Neighborhood Sorting Schedule). For the purpose of this task, streets that serve as the common border between two adjacent neighborhoods or planning

NOTE: It is recommended for easy reference that completed Inventory Checklists for those streets in the subject neighborhood be sorted and arranged in an alphabetical and numerical order as listed below.

Neighborhood—Tower Park

Castle Ave.
Charles St. N.
Helen St. N.
Henry St. N.
Margaret St. N.
McKnight Rd. N. (W. border)

State Highway 36 (S. border)
State Highway 120 (E. border)

1st St. N.
2nd St. N.
3rd St. N.
11th Ave. E.
12th Ave. E.
13th Ave. E.
14th Ave. E.
15th Ave. E.
16th Ave. E.
17th Ave. E. (N. border)

Example Box 3: Neighborhood Sorting Schedule

Table 3.2. Potential street tree function descriptions (Robinette 1972).

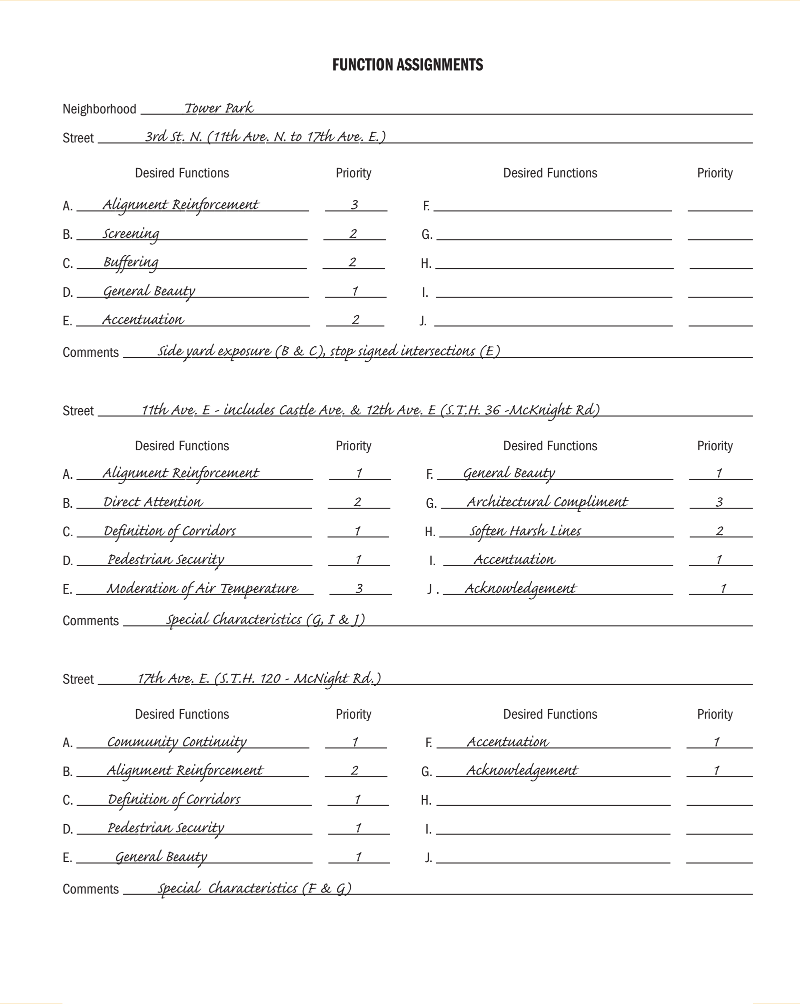
Function	Category	Definition	Contributing Characteristics
Community continuity	Architectural	Unification or connection of divergent community segments.	All
Alignment reinforcement	Architectural Engineering	Strengthening of the linear character of the roadway corridor.	All
Direct attention	Engineering	Define linear direction and provide advanced indication of circulation pattern.	All
Corridor definition	Architectural	Articulation of the spatial limits of vehicular and pedestrian corridors.	All
Pedestrian security	Architectural Engineering	Strengthening of the physical and perceived separation between vehicular and pedestrian ways.	Size Form Mass
Noise abatement	Engineering	Attenuation through deflection, reflection, refraction and absorption of traffic noise.	Size Mass Foliage texture Foliage duration
Air pollution control	Engineering	Atmospheric purification through cleansing and conditioning of the air as well as sequestration of carbon.	Size Mass Foliage texture
Glare & reflection control	Engineering	Interception of bright light from natural (e.g., sun) or human-made (e.g., street lights, vehicle headlights, windows) sources.	Size Mass Foliage texture
Moderation of air temperature	Climatic	Interception of direct and reflected solar radiation, and casting of shadows.	Size Mass Foliage texture
Wind control	Climatic	Obstruction, guidance, deflection and filtration of air flow by affecting its velocity, turbulence, momentum or direction.	Size Form Mass Foliage texture Foliage duration
Screening	Architectural	Blocking visual perception of an objectionable object, activity, and/or view.	Size Form Mass Foliage texture Foliage duration
Buffering	Architectural	Blocking visual intrusion to provide privacy.	Size Form Mass Foliage texture Foliage duration
General beauty	Aesthetic	Stimulation of visual pleasure.	All
Architectural complement	Architectural Aesthetic	Repetition of building scale, colors and shapes.	Size Form Foliage color
Soften harsh lines	Architectural Aesthetic	Counteract the severity of urban architecture and human-made environment.	All
Accentuation	Engineering	Emphasize locations, announce or provide advanced notice of an entrance or intersection.	Size Form Foliage color
Acknowledgment	Engineering	Indicate existence of an important land use.	
Water quality improvement	Engineering	Reduction of stormwater run-off by foliage interception of rain and rain interception by roots.	Size Form Foliage density

districts should be routinely separated and grouped with the streets in the defined area to the east and south, or whichever orientation seems logical.

Step 2. Assign Designated Functions to Street Trees on a Particular Street

Referring to the functional descriptions listed in Table 3.2, the community's land use plan and the collected data entered on the completed inventory checklists, especially "character of adjacent buildings," "type of street," and "adjacent land use," determine which function or combination of functions should be assigned to street trees to be planted on the respective streets. The assigned function or functions and their priority ratings should be recorded in the appropriate blanks on the Function Assignments Form (see Form 3.1 in Appendix 1). (See Example Box 4: Completed Function Assignments Worksheet).

In the case of those streets where the street trees will perform functions (e.g., noise abatement, wind control, architectural compliment, accentuation, acknowledgment) that require trees to have special characteristics (e.g., size, form, crown mass, foliage density and color), a high priority rating should be assigned to those listed functions and the appropriate determinant columns on the corresponding Species Selection Matrix Form. The cells representing the required features (e.g., "pyramidal" form, "dense" mass, "maroon green" foliage color, "coarse" foliage texture) should be hatchured.



FUNCTION ASSIGNMENTS

Neighborhood Tower Park

Street 3rd St. N. (11th Ave. N. to 17th Ave. E.)

Desired Functions	Priority	Desired Functions	Priority
A. Alignment Reinforcement	3	F.	
B. Screening	2	G.	
C. Buffering	2	H.	
D. General Beauty	1	I.	
E. Accentuation	2	J.	

Comments Side yard exposure (B & C), stop signed intersections (E)

Street 11th Ave. E - includes Castle Ave. & 12th Ave. E (S.T.H. 36 -McKnight Rd)

Desired Functions	Priority	Desired Functions	Priority
A. Alignment Reinforcement	1	F. General Beauty	1
B. Direct Attention	2	G. Architectural Compliment	3
C. Definition of Corridors	1	H. Soften Harsh Lines	2
D. Pedestrian Security	1	I. Accentuation	1
E. Moderation of Air Temperature	3	J . Acknowledgement	1

Comments Special Characteristics (G, I & J)

Street 17th Ave. E. (S.T.H. 120 - McNight Rd.)

Desired Functions	Priority	Desired Functions	Priority
A. Community Continuity	1	F. Accentuation	1
B. Alignment Reinforcement	2	G. Acknowledgement	1
C. Definition of Corridors	1	H.	
D. Pedestrian Security	1	I.	
E. General Beauty	1	J.	

Comments Special Characteristics (F & G)

Example Box 4: Completed Function Assignments Worksheet

Aside from the typical function categories, another consideration is the particular use of a species or genus group to represent or reflect the name of a street (e.g., Oak Grove Parkway), neighborhood (e.g., Linden Hills) or municipality (e.g., City of Maplewood).

At this point, with inventory data collected, functions determined, and matrix forms completed, decision makers should have a clear picture of the community's street tree needs and qualifications that must be satisfied. Following a typical planning process sequence, decision makers are ready to address the implemental design issues.

Example:

Use	Namesake	Implementation
Street	Oak Grove Parkway	Planting of oak the full length of namesake street.
Neighborhood	Linden Hills	Planting of different species and varieties of linden on all streets in neighborhood (see discussion of ISSUE NO. 4).
Municipality	City of Maplewood	Planting of different species and varieties of maples on collector and minor arterial streets that transect and unify the community.

Literature Cited

Robinette, G.O. 1972. *Plants, People and Environmental Quality. U.S. Department of the Interior-National Park Service*. Washington D.C.

ISSUE NO. 4

What is the Practical Degree of Species Diversity for a Street Tree Population?

This issue addresses the determination of a basic strategy to achieve a rational level of species diversity within the street tree population. The diversity or species richness of a street tree population is the sum of the different street tree species within the community, within the neighborhoods of the community, on the streets within the neighborhoods and on the same street.

The possible degree of species diversity (composition percentages) is best visualized as a continuum with monoculture or a population based on a single species at one extreme and total diversity within a street tree population or no duplication of a species (or genus) within the population at the opposite extreme. (Note: total diversity would be numerically impossible, except in a very small community). The concept of the continuum implies that an initial species diversity goal can be one of many options, differing by the slightest or greatest measure.

The use of too few species may heighten the vulnerability of the subject street tree population to disastrous devastation, and the use of too many species may diminish the perceived continuity and harmony within the population. As long as overall monoculture is rejected, it would be conjecture to conclude that, in general, any one goal is more appropriate than another. However, a conscious effort should always be made to prevent an over dependence on a few species. As a concept, species diversity can be viewed as an insurance policy against catastrophic loss due to biotic and abiotic challenges. The accepted level of species diversity should evolve as a compromised position on the continuum, resulting from the actual match-up of proven-adapted species with established design objectives and existing conditions and situations, rather than the product of a predetermined species richness standard or diversification formula.

It is a common planning practice to adopt a species evenness or equity standard that dictates that "no one species should comprise more than a designated uniform percentage (usually a 5%-10% ceiling) of a community's street tree population". Such standards or numerical rules-of-thumb are sound in theory, but are not an effective guideline when subjected to realistic situations, as few species are equally adapted to the wide range of existing conditions present in street corridors in most communities. If practiced, such quotas may encourage the selection of species that are ill-suited for the proposed use and location. Typically, existing conditions that require "proven-adapted" species will nullify such artificial numerical limits. (Richards 1993). Although monocultures or virtual monocultures should be discouraged, the degree of species diversity should be the direct result of correlating existing site conditions and limitations with the proven adaptability, suitability and tolerances of available species. In other words, species diversity should be the variable product of the interrelationship between the following factors:

- Existing character of respective street corridors (reflected by inventory data).
- Proven adaptability and suitability of tree species (influenced by respective growth habits and tolerances).
- Availability of selected tree species (influenced by market supply).
- Fulfillment of designated functions (influenced by respective species characteristics).

Based on the dynamic nature of the factors listed above, it is likely that the species percentages derived by the planning process will be "uneven", and certain species and genuses may dominate the population, regardless of initial intentions. The apparent dominance of a certain species can be countered by selecting other proven alternative species that will perform as well as "over-used" species and limiting use to those streets where they are the best choice. (Richards 1993). In most cases, the "species of choice" should be the one that is best suited to existing site conditions.

If overuse of a particular species or genus remains a concern, a reasonable cap can be imposed that limits the allowable percentage of any species or genus in the composition of the street tree population in a neighborhood and/or community. For example, an effective standard might limit a species to only 20% and a genus to only 35% of the total tree population.

Achieving the optimum street/tree species match-up is the underlying objective of this manual. The level of species diversity that is achieved at the conclusion of the species selection phase may differ greatly from the original species diversity goal.

Strategically, dependent on the size of the community, species diversity should be manipulated within each identifiable neighborhood, and the collective outcomes coordinated to achieve an attainable level of diversity within the community. (See Example Box 5: Species Diversity Goal Statement for Example Community).

Resulting species percentages may also be modified during the plan implementation phase in response to confirmed availability or updated species performance evaluations. Species availability is dependent on the supply of hardy stock obtainable from sources located within the limits of the "acceptable growing range" or respective plant hardiness zone. Compliant stock would include trees continually cultivated and grown within the boundaries of a designated growing range (same hardiness zone as subject community) for at least two years or trees grown outside the acceptable growing range provided the seed source or root or graft stock originated within the acceptable range. (Minnesota Department of Transportation 2005).

Generally, the larger the street tree population, the greater the obtainable degree of species diversity, especially if street side environments are generally tree friendly or conducive to sustaining the growth of most tree species. Streets with the same species should be somewhat evenly dispersed throughout the community and respective neighborhoods, and an adequate distance (e.g. proportional to the size of the community and neighborhoods and number of species) should separate streets that repeat the same species.

If the palette of proven-adapted species has been lessened in response to existing site limitations, and a wider range of choices is desired, a selected list of "unproven" species might be assembled for consideration. Such "experimental" trees should only be used on "friendly" or favorable sites and in limited quantities so that establishment failures will not significantly impact the overall street tree population or the neighborhood where they are located. As a safeguard, this group of species should be restricted to less-prominent streets that are dispersed and widely-separated and/or used in combination with proven species companions.

Aside from species diversity within a street tree population, there will also be genetic variation of individuals

Given Constraints:

1. There are 115 different tree species on the established list of potential candidates for use as street trees.
2. These trees can be grouped into 19 genera.
3. The subject community consists of 15 neighborhoods.
4. There are 166 streets or segments of the same street separated by neighborhood boundaries, minor arterial or collector streets.
5. The number of such streets within each neighborhood ranges from 6 to 20 producing an average of 11 streets per neighborhood.
6. Of these streets 4 are county roads and 2 are state highways. (It is unlikely that the jurisdictional agencies will permit the planting of street trees on these 6 streets.)
7. There are approximately 5,035 vacant sites where street trees can be planted within the subject community.
8. Generally there would be approximately 20 trees per average front yard block (both sides of street) and 12 trees per average side yard block (both sides of street).

Percentages:

1. A 10% ceiling on a given species would allow 504 trees of the subject species in a potential tree population of 5,035 (e.g., 5,035 x 10% = 504). This percentage could be easily achieved given a species palette of 115 species.
2. A 20% ceiling on a given genus group would allow 1,007 trees of the subject genus in a potential tree population of 5,035 (e.g., 5,035 x 20% = 1,007). This percentage could be easily achieved given a genus palette of 19 genera.
3. At the 10% ceiling, the neighborhood with the largest number of vacant tree spaces (e.g., Tower Park—1,101 spaces) would be allowed 110 trees of each species.

Conclusive Concept:

Given the size of the species/genus palette and number of vacant tree spaces, the typical species evenness or equity standard should be somewhat achievable in the example case. Although it is likely that there will be situations where two or more species will be used in combinations on a particular street, due to design decisions or existing site conditions, the designated uniform species percentages should not be threatened. Also, although some species on the species palette may be disqualified because they do not satisfy site and assigned function requirements, it is likely that several of the actual species and genus percentages will be lower than the anticipated goals. Hypothetically, in an oversimplified and unconditional model, given a species palette of 115 different tree species and 5,035 potential planting spaces, adherence to a species evenness or equity standard would allow the planting of 44 trees of each species (e.g., approximately 2 front yard blocks) in the community which equates to a species ceiling of 1%.

NOTE: *Regardless, it should be remembered that the species diversity goal is an achievement target based on an idealistic concept and can be sidetracked or redirected by realities encountered during the following phases of the planning process.*

Example Box 5: Species Diversity Goal Statement For Example Community

within those species that are sexually propagated. Inherently, each species is naturally adapted to tolerate and survive a certain set of conditions. In nature, however, no sexually produced (e.g. seed source) individuals or progeny of two parents are exactly alike. These genetic variations can produce a subtle or severe alteration of an individual's tolerance, resistance or vulnerability to certain environmental and pathogenic challenges. Due to genetic diversity, some individuals of the same species located in the same row planting could survive an otherwise lethal disease, destructive insect or environmental stress. Tree species that are asexually produced by vegetative propagation or cloning (e.g. progeny of a single parent from cuttings or budding) do not posses genetic variation and will sustain certain desired and undesired traits. Due to the genetic uniformity of cloning, all of the individuals of the same species located in the same row planting will exhibit the same susceptibilities, immunities and physical characteristics (e.g. size, form and shape). These elementary biogenetic principles deserve consideration during the species selection phase of the planning process.

Literature Cited

Hubbard, H.V. and T. Kimball. 1917. *An Introduction To The Study of Landscape Design*. Macmillan Company. New York, NY.

Minnesota Department of Transportation. 2000, *Standard Specifications for Construction*. Minnesota Department of Transportation. St. Paul, MN.

Richards, N. 1993. *Reasonable Guidelines For Street Tree Diversity*. J. Arboriculture 19:344-349.

Simonds, J.O. 1961. *Landscape Architecture*. McGraw-Hill. New York, NY.

At this point in the planning process, it is an opportune time to restate the overriding premise that a street is the primary element and organizing axis of the road right-of-way corridor, with street trees serving a subordinate and supportive role. Such rights-of-way can concurrently provide circulation and access routes for motorized and non-motorized vehicles, as well as pedestrians.

As vehicular trafficways, streets are "lethal lines of force" (Simonds 1961) requiring the focused attention of vehicle operators. Although safe movement or a friction-free experience for drivers, passengers and pedestrians is paramount, passage through the corridor should also provide a pleasant movement experience (Simonds 1961). As a physical three-dimensional border, street tree plantings signify the importance of the adjacent street, encourage the eye of a vehicle operator to move through the corridor in an orderly manner and define vehicle and pedestrian spaces. (Hubbard 1917). Along with surrounding landscapes and buildingscapes, street trees contribute to the pleasurable quality of the corridor. Appreciation of the hierarchical relationship between streets and street tree plantings should provide the focus for the forthcoming discussions relative to arrangements and species selections.

Predetermined decisions relative to function assignments (See ISSUE NO. 3) and level of species diversity (See ISSUE NO. 4) need to be transformed into an implementable comprehensive schematic that is based on fundamental landscape design principles and depicts a purposeful integration of arrangement patterns and species selections.

What Factors Should be Considered When Arranging or Combining Trees to Achieve an Effective Street Tree Planting?

This issue addresses the application of time-honored principles of design to proposed street tree plantings in order to attain compositions or arrangements that will achieve the desired unity, continuity and utility.

In most cases, the decision to initiate a street tree planting program presupposes or implies that the trees will be planted at uniform spacings in rows that parallel the adjacent streets. Generally, such plantings should reflect some level of adherence to certain fundamental principles of design or rules of order.

These elementary principles of design will help program the viewer's conscious and unconscious perception of the arrangement patterns or compositions of street tree plantings to evoke certain predetermined psychological and physical responses. The resulting application of these principles can range from decisively subtle to obvious.

Generally site design professionals strive to achieve a sense of three-dimensional unity or cohesion within their respective plans or designs. As the primary goal of every design, unity is the result of the effective application, intermingling, and interaction of the referenced principles of design.

Since the composition of the street tree population of any neighborhood or the whole community cannot be viewed in totality, except from an airplane or skyscraper, pictorial unity of an overall street tree population is not a necessary measure of success. However, row plantings on a street or segment of a street (between cross-streets) can be easily viewed at a particular moment in time from a particular stationary or moving position, allowing the observer to perceive the desired and/or resulting unity of the composition on that street. Row plantings or linear groupings of trees constitute one of the oldest and simplest forms of composition, and unity is achieved only when the planting is perceived as a continuous row rather than as individual elements.

The pertinent principles of design include “repetition”, “sequence”, “balance”, and “scale”, and their conscientious application will produce a pleasurable and functional community-wide streetscape. Table 5.1 provides a concise explanation of each of the applicable principles of design. The order provided by these principles ensures that there will be a harmonious and complimentary relationship between the resulting row plantings and the immediate surroundings, and the physical characteristics of combined species within the street-side row plantings. Application of the principles of design requires that choices be made relative to the respective physical characteristics of candidate tree species, particularly mature size, form, foliage texture and color. Often, in use, these principles are not distinct, but instead overlap and coalesce.

Table 5.2 provides abbreviated descriptions of the four physical characteristics that have the greatest influence on planning and design decisions that affect function fullfillment, arrangement and combination assignments and related species selections (see ISSUES NO. 3, NO. 5, and NO. 6).

If, for design or species diversity purposes, it is determined that two or more species should be combined in an orderly pattern on a street or segments of the same street, such combinations should, in most cases, provide a visually compatible and complementary association. The arrangement of trees in parallel uniformly spaced streetside row plantings heightens visual sensitivity to the mixing of species that have noticeably different characteristics. Although the most uniform outcome will be achieved by the repetition of a single species, most species are mutually complementary, regardless of specific variations in their respective physical characteristics. The exception to this generalization would be the combining of species that exhibit extreme differences in their size, forms, and/or foliage color. The perceptible impact of such variations is less apparent when the different species are combined as modular blocks or groupings of the same species (see Figure 5.2 and 5.16). Extreme differences might be desirable in situations where one of the intended functions of the trees is to gain the viewer's attention, as is the objective of “accentuation” and/or “acknowledgment” (see Table 3.2).

Under certain circumstances it might be appropriate to hybridize a basic pattern by inserting a repetitive block of a single species into a prevailing sequential

Table 5.1. Principles of design: definitions; comments on qualifications and effects; and graphic representations that pertain to each principle.

Design Principle	Comments	Graphic Explanation
Repetition = produced by duplication or repeated use of identical or similar units, or combinations of units (module).	• Most fundamental and frequently used form of order. • Similar units share the same characteristics except for a variation of one quality (e.g., two species, each having same color and form but different texture). • Absolute repetition (e.g., overuse of a single species) provides absolute harmony, but can become monotonous. • Variety is the antitheses of monotony and will provide visual relief. Variety is introduced by changing a characteristic or adding sequential patterns.	See Figures 5.1 and 5.2
Sequence = produced by consecutive or successive interchange of differing units or modules.	• Achieved through *repetition* or continuation—simplest form of sequence. • Achieved through *gradation*—progressive change of characteristics in uniform and gradual steps or degrees. • Achieved through *alternation*—repetition of modules establishing a rhythm. When row planting is separated repeatedly at equal intervals. • Should be a logical connection and relationship between units or modules. • All of the characteristics should not be changed at once as the change will not appear to be sequential. • As an effect, sequence suggests movement, direction, modulation and cadence. • Rhythm relies on anticipation of change and continuation of regularly occurring breaks or accents. • Sequential changes can lead to an ending or emphasis.	See Figure 5.2 See Figure 5.3 See Figures 5.4, 5.5, and 5.6
Balance = produced by equal distribution or symmetrical placement of units about a horizontal axis (centerline of composition).	• Exact inverted repetition on one side of the axis (street) every unit that occurs on the other side. • Symmetrical units need not be identical provided they are similar.	
Scale = produced by complementary relationship between the size or mass of a unit and other units or its surroundings or passersby.	• Size of units should be controlled by rather than controlling the design.	See Figure 5.7

Unit = The common denominator in a row planting—a single species or same combination of species (module).
Module = Component of the whole or pattern that consists of a single unit or a combination of multiple units that are repeated.

Table 5.2. Primary physical characteristics: description of hereditary properties (appearance factors) of healthy mature tree species under normal conditions.

Physical Characteristic	Comments
Size = mature dimensions that will be attained in an indigenous open area.	• Tree height, crown spread, trunk diameter. • A function of the rate of growth. • Cause of spatial conflicts. • Basis for scale and proportion relationships. • Affected by variable environmental conditions.
Form = crown shape a species will develop in an open area.	• Outline or silhouette of mature crown. • Volumetric description. • Influenced by dimensional relationship between height and spread or horizontal and vertical axis. • Usually changes as tree matures. • Habit of growth. • Strongest design element.
Texture = aggregation of leaf forms.	• Size, shape, pattern, and proportion of leaves. • Also influenced by tips and margins, stiffness, veining, thickness and surface quality of leaves. • Influences density and mass of crown. • Course texture is dominant over other textures.
Color = coloration of summer foliage-gradations of green or green admixtures.	• Green is the predominating plant color in nature. • Influenced by nutritional and soil conditions. • Color can affect emotions. • Colored foliage is an excellent accent.

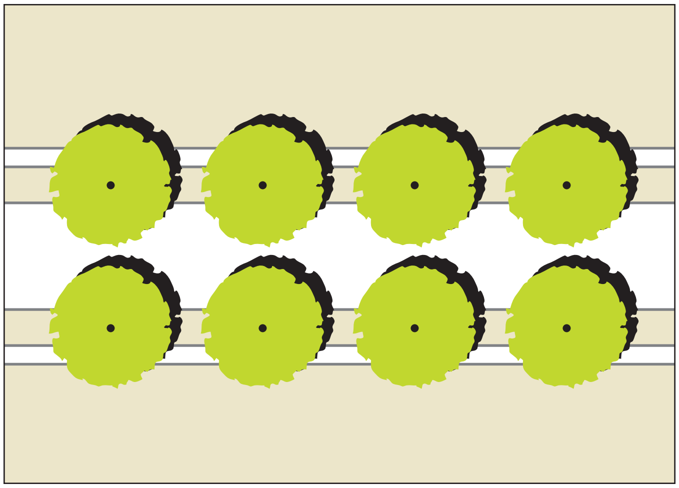


Figure 5.1. Repetition of a single species on both sides of street.

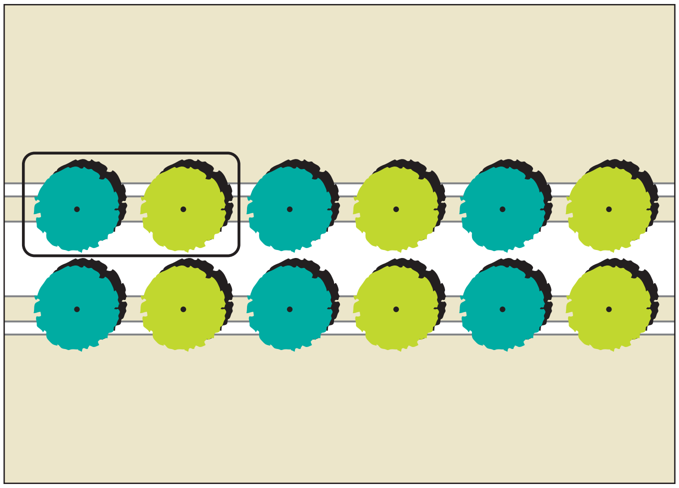


Figure 5.2. Repetition of a "module" comprised of two species, duplicated on opposite sides of street. Also a basic example of sequence.

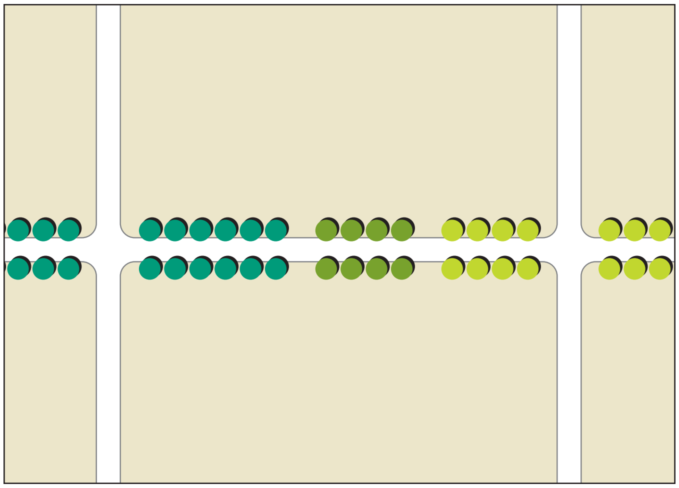


Figure 5.3. Sequence provided through gradation of a physical characteristic (e.g. foliage texture or color).

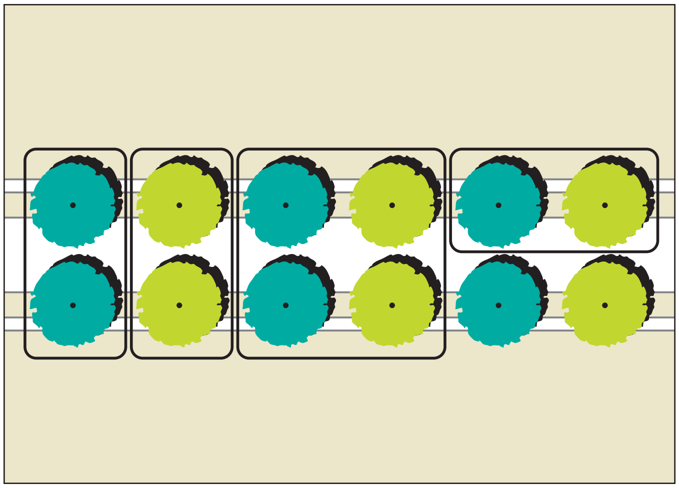


Figure 5.4. Sequence provided through the repeated alternation of two species or alternation of a modular block comprised of a two-species combination.

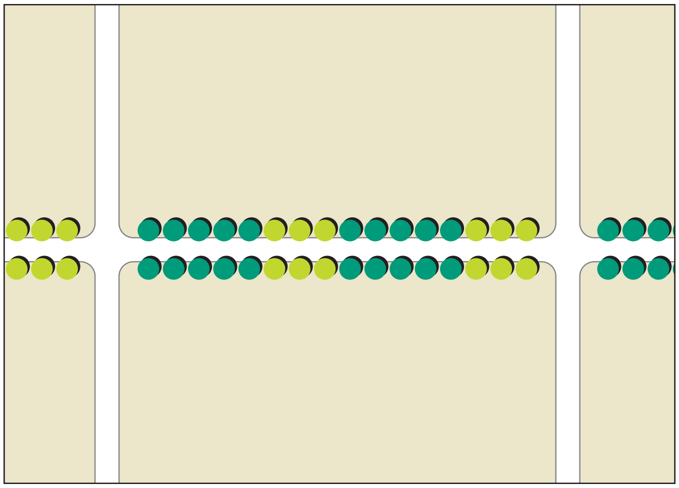


Figure 5.5. Sequence provided through repeated alternation of two single-species modules.

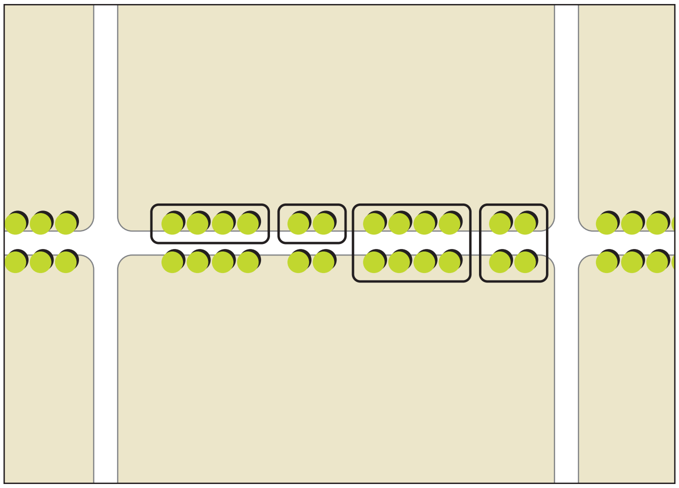


Figure 5.6. Sequence provided through repeated alternation of single-species modules with repeated uniform separations or gaps between modules.

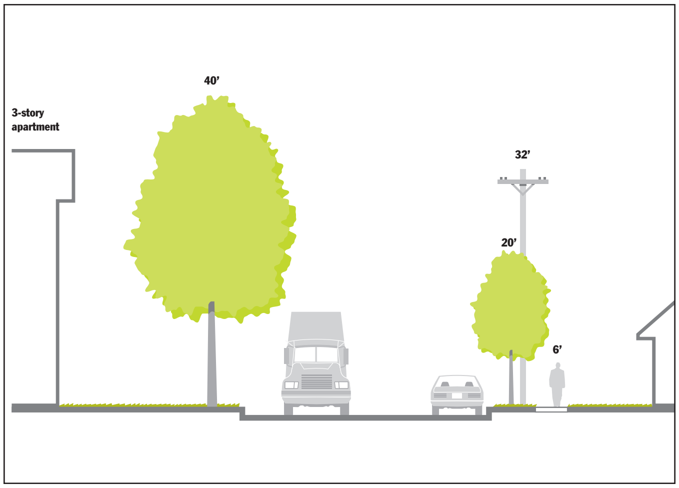


Figure 5.7. Scale relationships within street corridor.

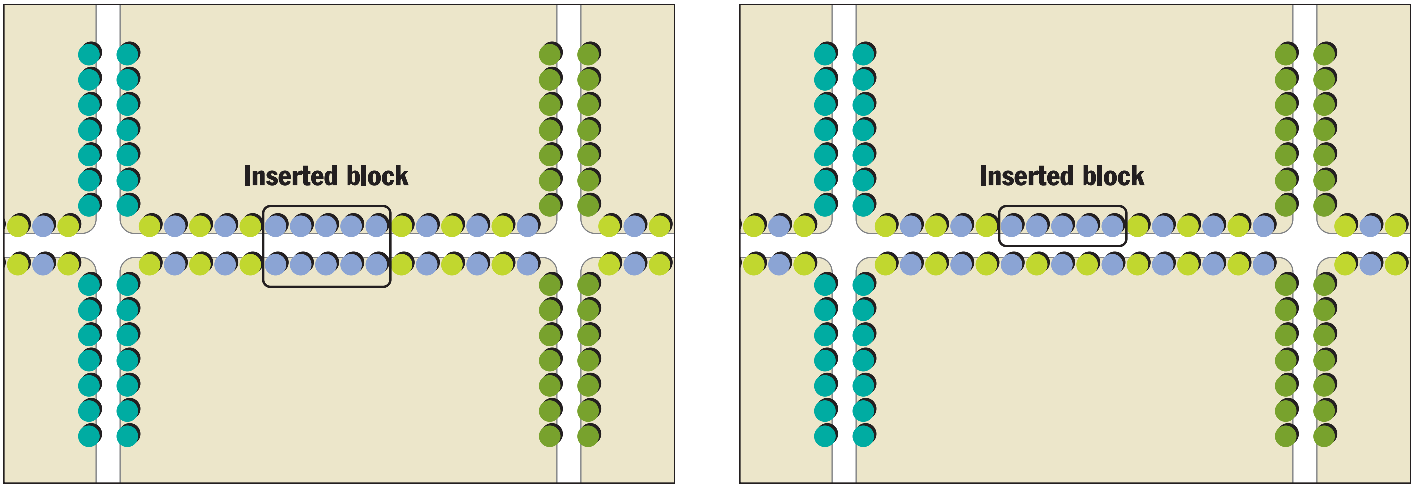


Figure 5.8a and b. Hybridized pattern. Insertion of a block of a single species into a sequential arrangement of two species, one of which is the same as the inserted block.

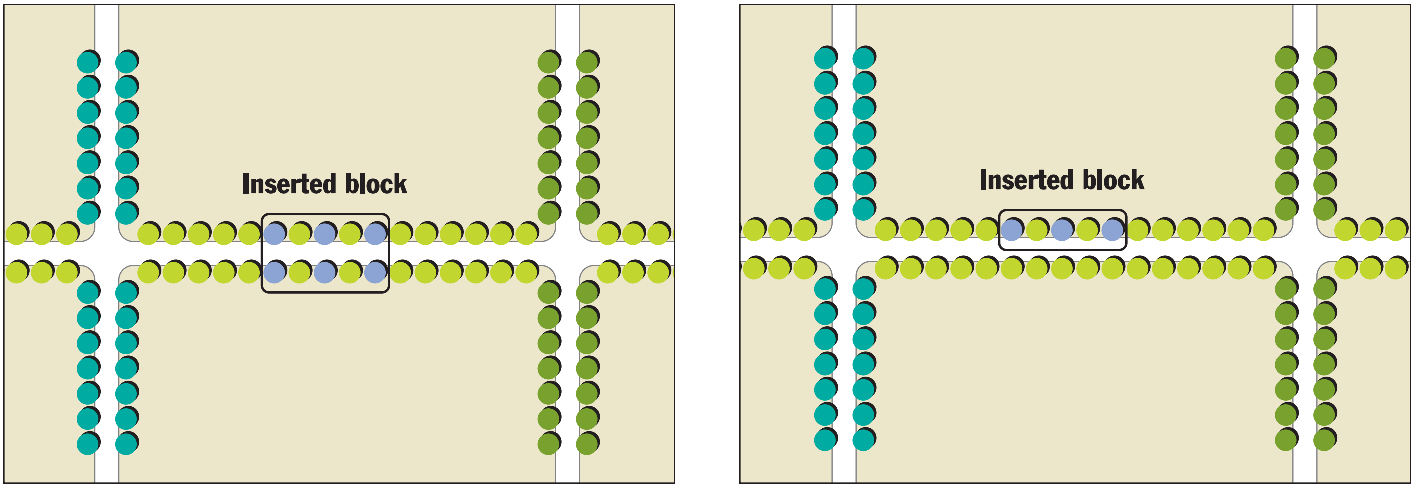


Figure 5.8c and d. Hybridized pattern. Insertion of a block of two alternating species into a repetitive arrangement of a single species which is the same as one of the inserted alternating species.

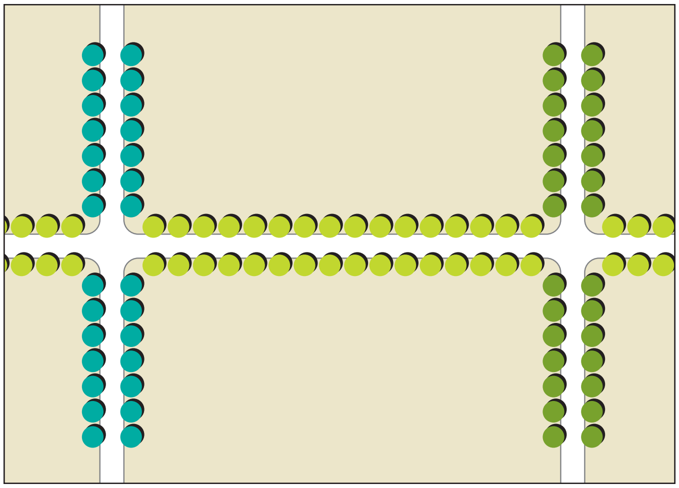


Figure 5.9. Repetition of a single species on both sides of street. Opposite configuration.

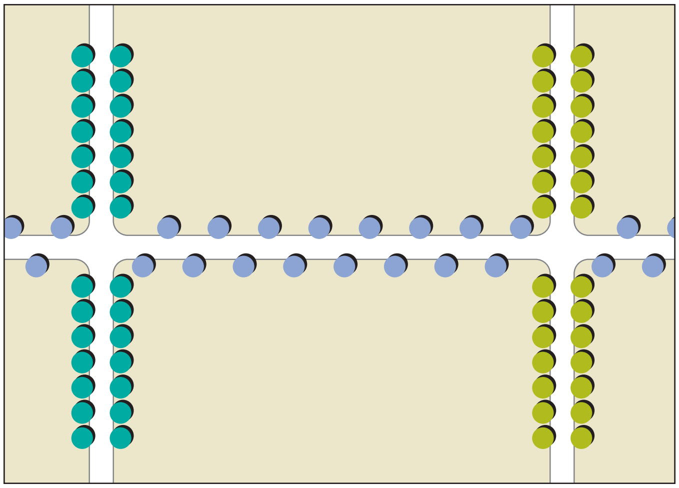


Figure 5.10. Repetition of a single species on both sides of street. Alternate configuration.

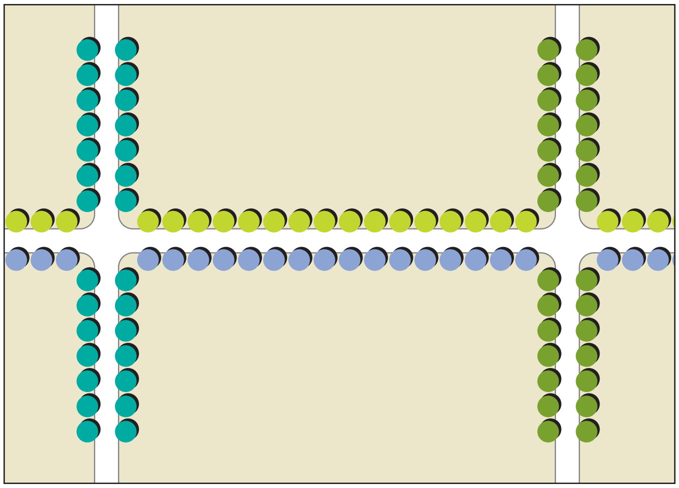


Figure 5.11. Repetition of a single species on one side of street and another species on the opposite side. Opposite configuration.

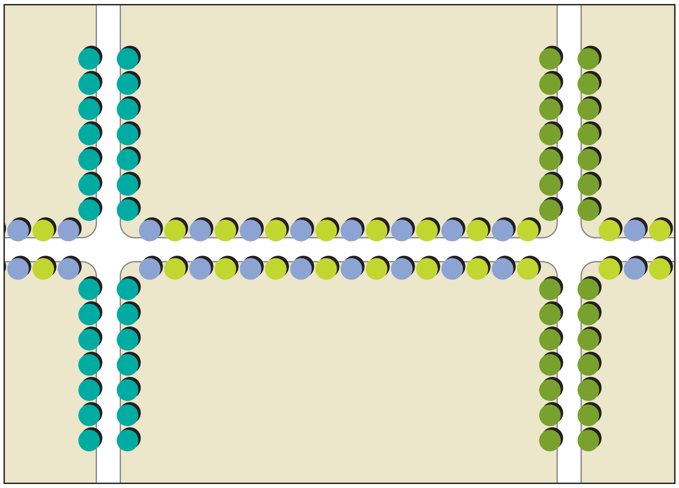


Figure 5.12. Repetition of a two-species module with an alternation of the two species on the same and opposite side of street. Opposite configuration of same species on opposite side of street.

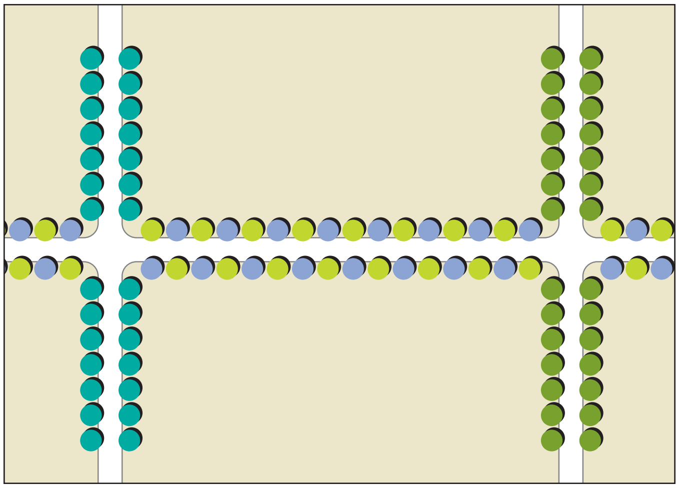


Figure 5.13. Repetition of a two-species module with an alternation of the two species on the same and opposite side of street. Alternate configuration of same species on opposite side of street.

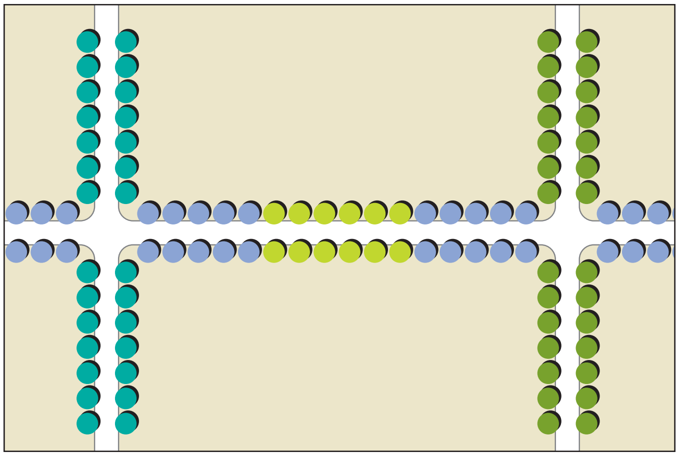


Figure 5.14. Alternation of different single-species modules with repetition of a single species within each modular block. Opposite configuration of same species modules on opposite side of street. Repeat of same-species module on opposite side of intersection.

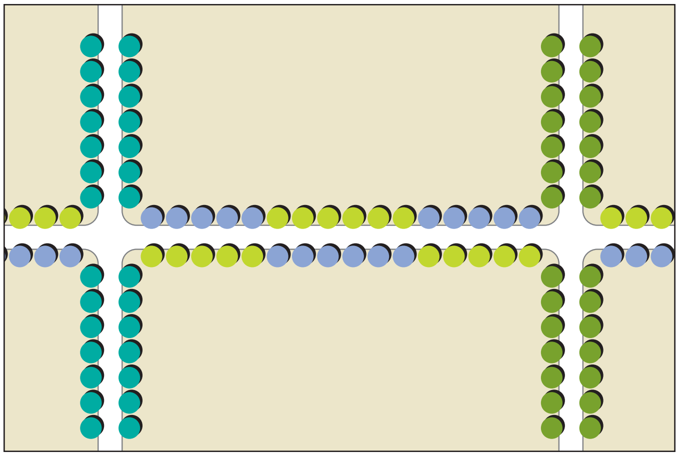


Figure 5.15. Alternation of different single-species modules on same side of street. Alternate configuration of same-species modules on opposite side of street.

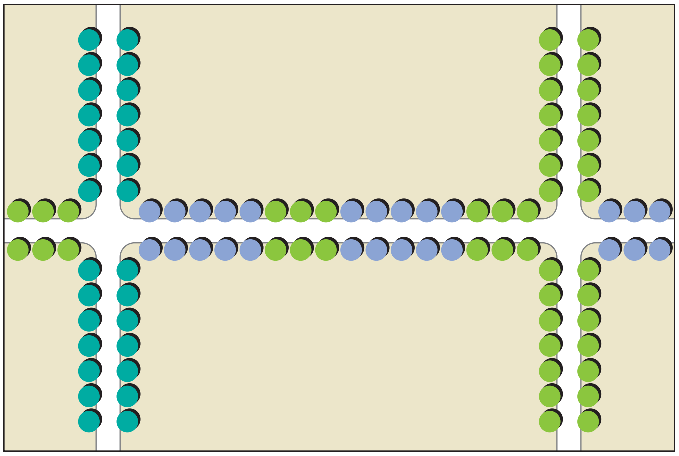


Figure 5.16. Alternation of different single-species modules on same side of street. Opposite configuration of same-species modules on opposite side of street. Different same-species module on opposite side of intersection.

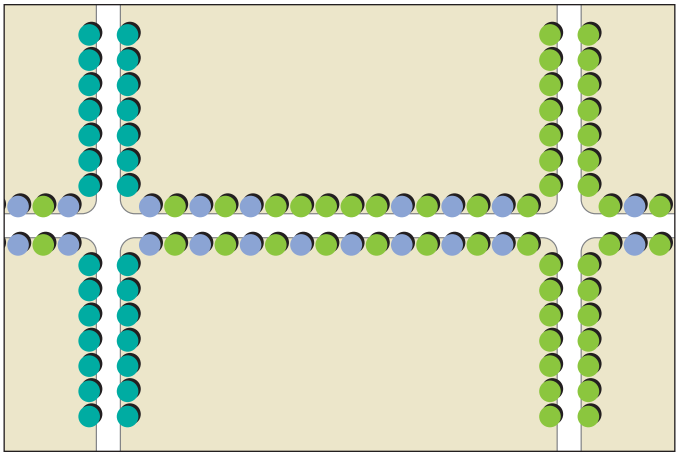


Figure 5.17. Alternation of two species or a two-species module with the insertion of a repeated single-species module to acknowledge location of a special land use or destination.

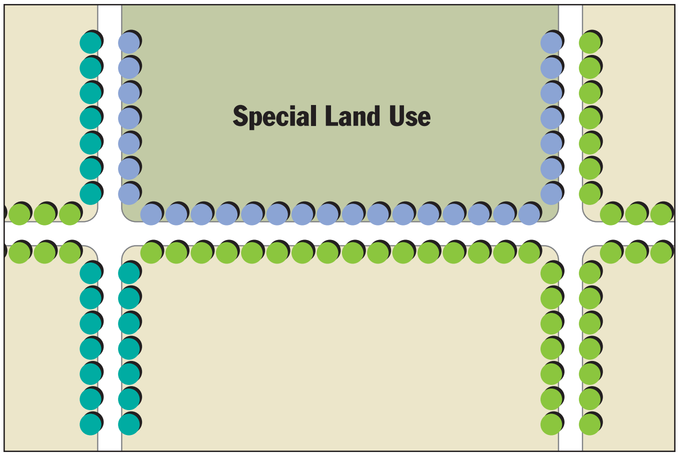


Figure 5.18. Repetition of a single species around perimeter of special land use that is different than species on opposite side of bordering streets to identify boundaries of special land use.

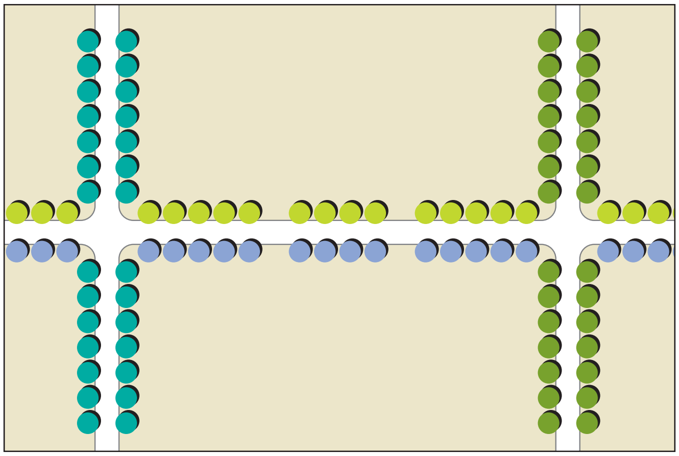


Figure 5.19. Repetition of single-species modular block on one side of street and different single-species modular block on opposite side of street. Opposite configuration of modules on opposite sides of streets. Uniform gaps between modular blocks on same side of street and opposite modular blocks on opposite side of street.

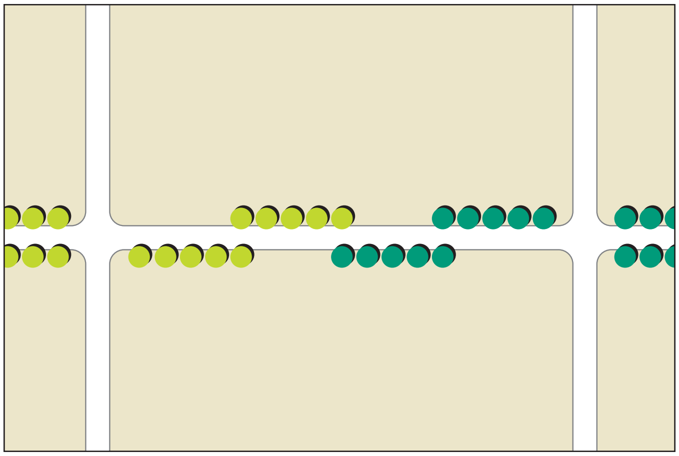


Figure 5.20. Alternation of different single-species modular blocks on same side of street. Alternate configuration of modules on opposite sides of street. Uniform* gaps between modular blocks on same side of street and modular blocks on opposite side of streets.

* Gaps between modular blocks do not have to be uniform and might be influenced by existing roadside elements or situations.

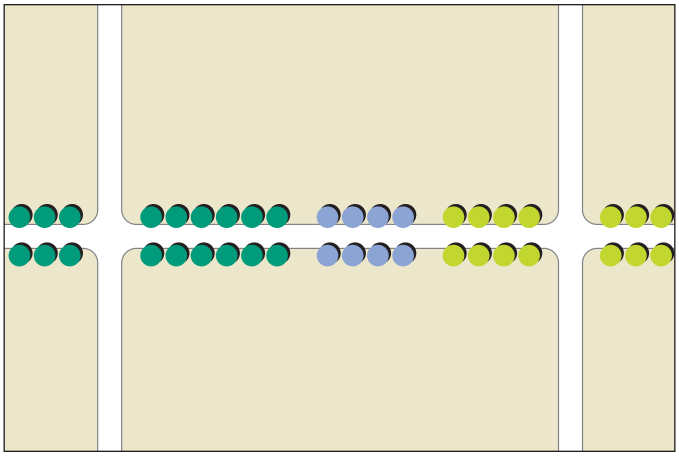


Figure 5.21. Gradation of different single-species modular blocks involving change of same characteristics and/or number of trees per module. Opposite configuration of same modular block on opposite side of street. Gaps between modular blocks on same side of street.

arrangement of two species or by inserting a block of two alternating species into the prevailing repetitive arrangement of a single species (see Figure 5.8 a-d).

Sequential patterns based on gradation, alternation or separated modular blocks are best suited for the more lengthy, wider streets having few cross-street intersections such as minor arterials and major collectors that lead to major destinations (e.g., shopping center, government complex, high school, churches), points of interest or neighboring communities.

There is a tendency to use gradation as a gimmick rather than as a skillful fulfillment of a functional assignment or species diversity goal. As a design tactic, gradation should be used sparingly in very special situations.

The harmonious blending of species characteristics is a fundamental design objective. Given a bountiful palette of suitable tree species, the possible combinations of respective species characteristics is somewhat limitless and can pose a taxing exercise. Although the principles of design (see Table 5.1) will provide a basis for pairing or combining different species, final judgments are often guided by personal taste. Obviously, subtle physical differences will produce the most compatible and complementary combination of species, whereas combinations that are noticeably dissimilar will be more incongruous. When respective variations are greater than one step on a gradation continuum or involve more than one characteristic, the visual compatibility of such species combinations tends to diminish accordingly.

If it is determined that a combination of species is the appropriate design or arrangement objective for certain streets, a primary species should be selected first, followed by the complimentary supporting species. Primary species should be those that best satisfy most, if not all of the selection determinants for the respective streets. Prior to selecting the companion species, criteria should be established to set the parameters that will help coordinate the parings.

Typical considerations could include the following as well as other relevant issues:

- Should the combined species be from different genera?
- Should the combined species have similar or nearly identical physical features?
- Are there any prevailing popular objections to a particular species?
- What species have been selected for adjacent parallel streets?
- Are there any species that are a prevailing favorite with residents?

Realistically, few if any tree species having similar tolerances and site requirements, especially if they are different genera, will posses all of the same type of physical qualities. It is also unlikely that they will differ only by a one- or two-step variation of only one feature. Regardless, it should be remembered that drastic differences can disrupt the otherwise harmonious pattern of row plantings by creating a jerky or discordant rhythm.

Not withstanding, all efforts to ensure the continuity of street tree plantings, the presence of interruptions by other elements such as light standards, utility poles, hydrants, driveways, and remnant trees of differing species, size or characteristics can jeopardize planned arrangements.

Figures 5.9 through 5.21 (thumb-nail diagrams) depict numerous arrangements that utilize the principles of design discussed above. These schematic vignettes by no means include every arrangement possibility. They are presented as suggestions and a catalytic reference. The representation of individual trees is for graphic purposes only and is not intended to reflect a recommended number of trees per block. Any arrangement pattern depicted on the example east-west oriented figures can be used on parallel and intersecting north-south streets. Selection of arrangement patterns on intersecting and parallel streets becomes a mix and/or match decision.

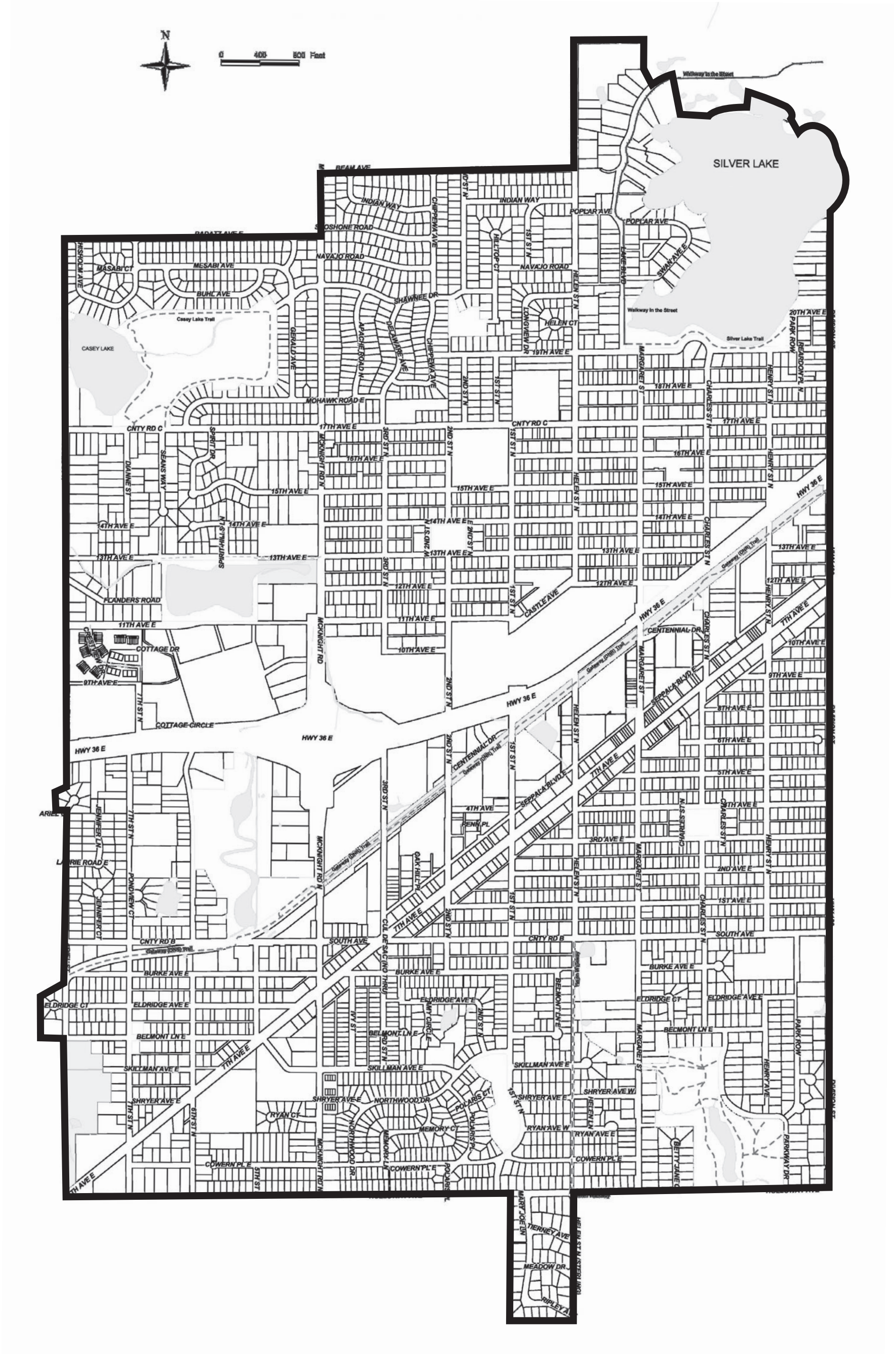
A 5-Step Process to Formulate a Comprehensive Tree Arrangement Plan

Step 1. Select a Suitable Base Map

The product of this design phase of the planning process is a hand-drawn or computer generated color-coded map or series of maps that graphically depict the decisions or choices that will be made relative to the assignment of an arrangement pattern to each tree friendly street. In combination with the inventory checklists, species selection matrices and function assignment forms, the arrangement pattern maps will direct the subsequent selection and assignment of tree species to particular streets (see ISSUE NO. 6).

If possible, the base map for this phase should include the entire community, and be of a scale that will adequately accommodate the application of the lined markings that will represent the various arrangement selections. Generally, a community will have an existing map that will be of a suitable size and scale. A ready source for a base map would be a community's street map or published comprehensive plan.

An ideal scale would be in the range of 1” = 660’ (8 inches per mile) to 1” = 1000’ (5.28 inches per mile). At the scale of 1” = 1000’, a rectangular shaped commu-



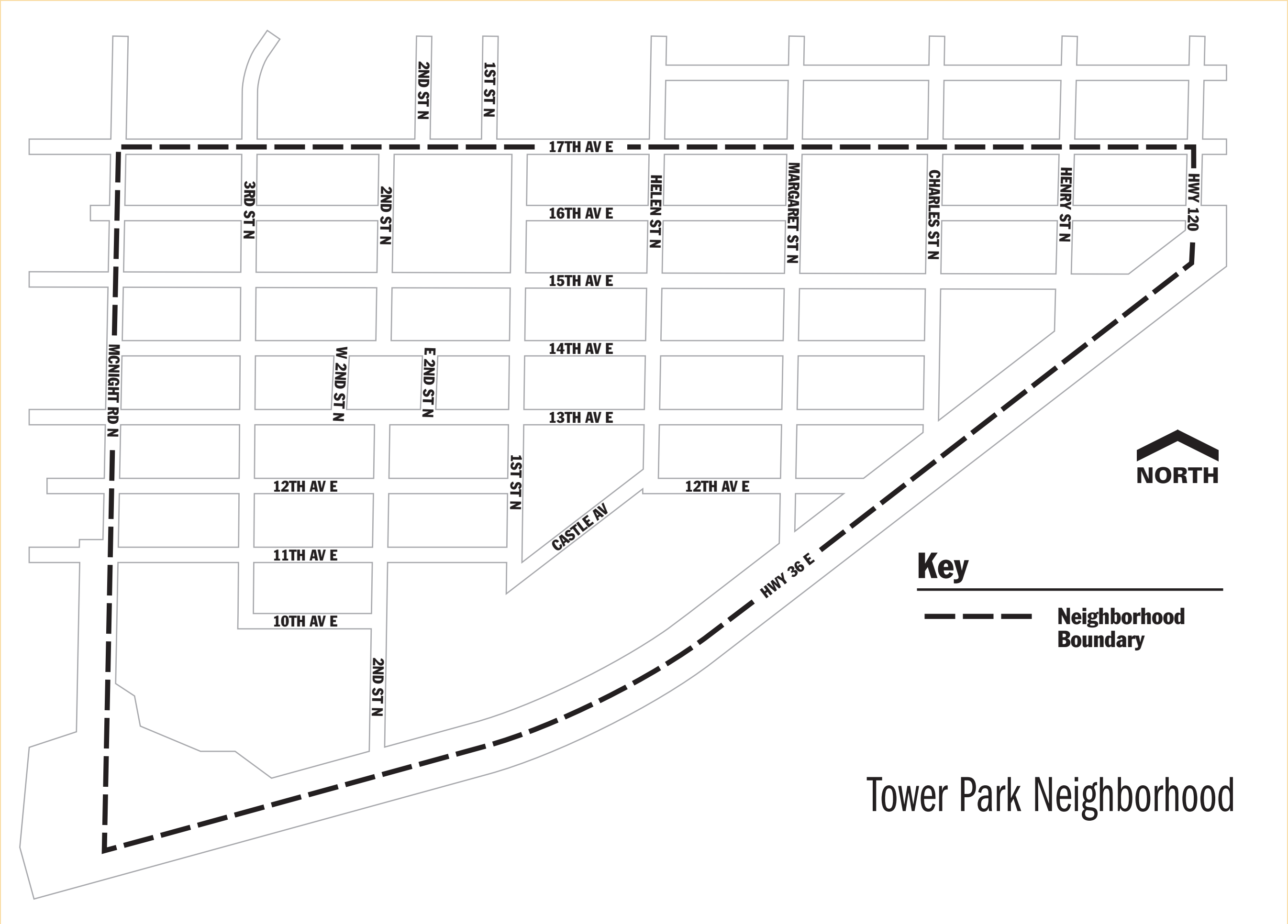
Note: A full-sized 11" x 17" example community base map has been reduced to fit onto an 8.5" x 11" page to accomodate the electronic downloading of the manual text from a pdf file. The reduction is not representative of an "ideal scale" with street dimensions that will accommodate the art marker lining described in Step 1.

The neighborhood base map depicted in Example Box 7 is a full-sized extraction from a community base map with adequate street dimensions.

Example Box 6: Community Base Map (Step 1)

nity approximately 1.5 miles x 2.5 miles (3.75 square miles) could be fit onto an 11” x 17” sheet of paper. As a guide, the streets should be represented by parallel lines approximately 1/16” to 3/32” apart (see Example Box 6: Community Base Map). These dimensions are receptive to double lining by fineline art markers. Since the completed map will serve as a planning tool and will not be incorporated into the master plan document, the layout of larger communities can be sized to fit onto standardized blueprint paper measuring 22” x 34” or 24” x 36”.

If the community map is too large or untractable, neighborhood or planning district base maps should be used to display arrangement patterns (see Example Box 7: Neighborhood Base Map). Generally, such areas have already been established and are physically delineated by a border of significant streets (e.g., arterials and collectors), railroad rights-of-way, common land use, and natural barriers. (e.g., rivers, marshes, bluffs). Streets that serve as neighborhood or planning district boundaries should appear on both base maps of the abutting areas. Also it is likely that in larger communities, segments of some streets will occur in more than one area. If a community has established neighborhoods, it is likely that representative maps may already exist. Species selections and assignments will be depicted on neighborhood base maps during that phase of the planning process. Copies of neighborhood base maps will be incorporated into the master plan document with noted species assignments, and thereby should be of a scale that can be legibly reproduced at a later time on 8.5” x 11” or 11” x 17” paper.



Example Box 7: Neighborhood Base Map (Step 1)

Step 2. Identify the Streets That Will Be Exempt From Street Tree Plantings

Assemble responses to personal preference surveys, minutes from any public meetings, copies of petitions and the previously prepared inventory checklists, data maps, and function assignment forms. For various reasons, not all of the streets in the subject community will qualify to host street tree plantings, nor will all adjacent property owners be street tree receptive. For political and horticultural reasons, it is advisable that the designated street corridors be tree friendly. Exemption of a particular street from a street tree planting program could be the effect of one or more of the causal issues listed in Table 5.3.

After a review of all available data and forms of public input, develop a comprehensive list of all streets that appear to be reasonable candidates for exemption (see Example Box 8: Neighborhood Street Exemption Schedule). Submit the list with accompanying recommendations for concurrence to the person or elected body that has review and approval authority over the master plan (e.g., city administrator, mayor, city council, town board, park board). Following official adoption of a list that identifies deleted streets or segments of streets, transfer the approved omissions to respective base maps by using a black or colored broadline art marker to block-out all streets that have been exempted (see Example Box 9: Neighborhood Street Exemption Map). If questions remain relative to the exempt status of a street, or if there is the possibility that a street will be reinstated as a tree friendly street, indicate the particular street on the base map by a dashed or dotted line (see Example Box 9).

If only one side of a street is to be exempted from street tree plantings, such decisions can be indicated on the base map by a thinner black line on the designated side of the street or another graphic representation such as black hachures.

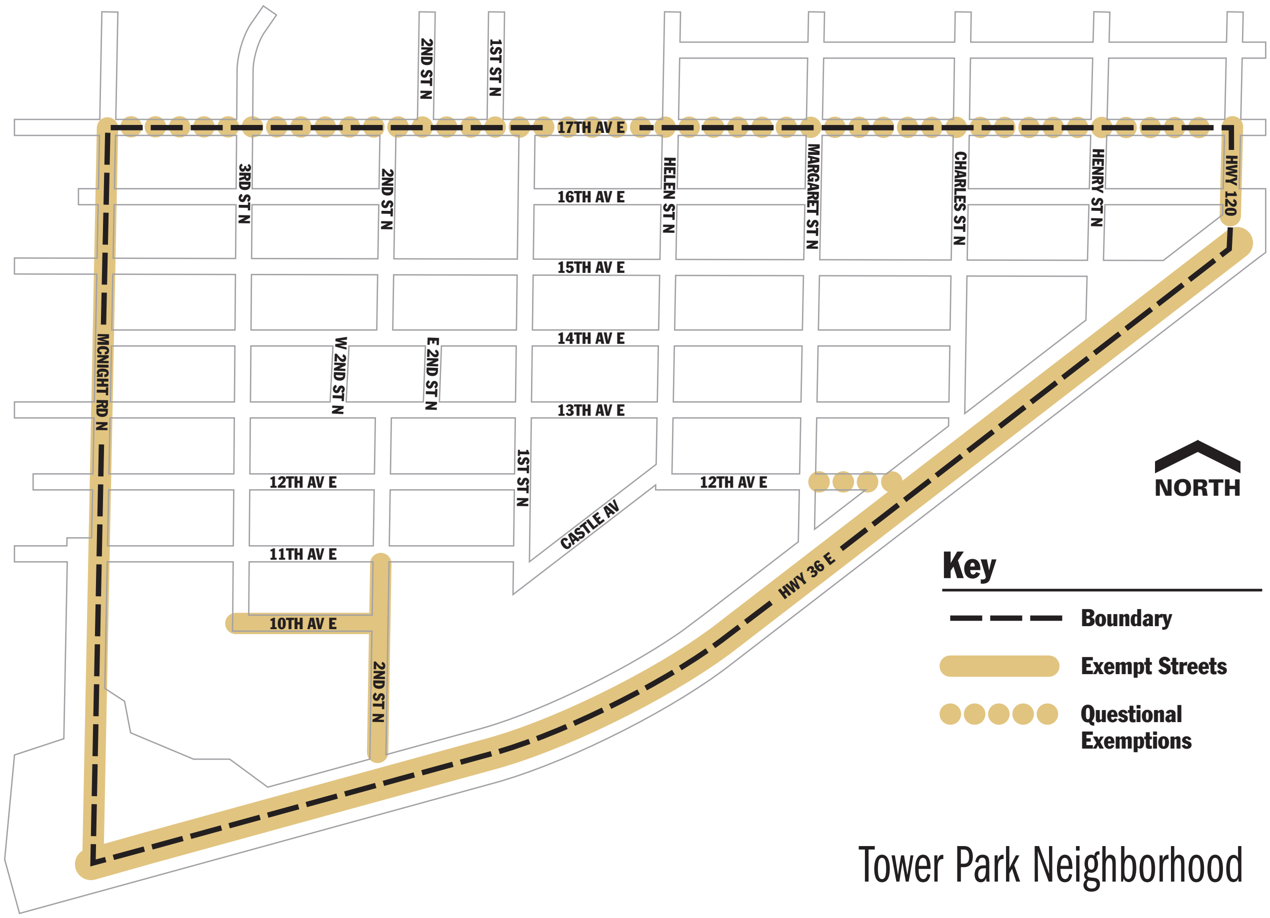
Table 5.3. Reasons streets or segments of streets should be exempted from tree planting.

Reason for Rejection	Source of Information	Explanation
Boulevard is not a suitable growing environment for trees.	Inventory Checklist	Unless corrected poor soil conditions will not support tree growth and sustain longevity.
Presence of overhead and/or underground utilities.	Inventory Checklist and Data Map	Probable conflict with wires, cable, lines, and/or conduits is inevitable.
Boulevard width is inadequate (below minimum standard).	Inventory Checklist and Data Map	Probable conflict with adjacent curb and sidewalk is inevitable.
Right-of-way has topographic impediments.	Inventory Checklist and Data Map	Inadequate ground space due to upward or downward sloping embankments, presence of retaining walls.
Border area width is inadequate (outside sidewalk).	Inventory Checklist and Data Map	Probable encroachment of tree over adjacent property.
Type of street.	Inventory Checklist	Street trees are not appropriate in some major and minor arterial corridors due to safety conflicts. (e.g., clear zone setbacks).
Right-of-way under jurisdiction of another unit of government.	Inventory Checklist	State or county highways. The respective road authority might have policies that restrict placement of street trees (e.g., safety clear zone set backs) or have their own planting agenda and schedule. Note: street tree plantings would require a permit from the agency with jurisdiction.
Opposition from majority of adjacent property owners.	Survey, Petition, Public Meetings	Concerned with cost of planting and maintenance program, blocking of business signage, clean-up of fall leaf litter.
Sidewalk tangent to curb and adjacent buildings.	Inventory Checklist and Data Map	Inadequate ground and overhead space for root and crown development. Probable overhead conflict with buildings.
Large natural area adjacent to street.	Inventory Checklist and Data Map	Formal row planting bordering a large natural area or open space (e.g., woods, wetland, prairie, farm field, pond, lake) might be out of character with the land use.
Existing trees on adjacent property.	Inventory Checklist, Data Map and Aerial Photograph	Large trees would suppress or interfere with development of proposed street trees.
Right-of-way shared by two communities (common border).	Inventory Checklist and Data Map	Planting initiative could be done as a joint venture or one community could acquiesce or planting only on one side of street.

Street	Reason For Exemption
1. McKnight Rd	County jurisdiction, authorization rejected due to inadequate border areas.
2. State Highway 36	*State jurisdiction, principal arterial, street tree plantings not appropriate.
3. State Highway 120 (Division St.)	*State jurisdiction, minor arterial, authorization rejected due to inadequate border areas.
4. 2nd St. N. & 3rd St. N. (between 11th Ave. E. and S.T.H. 36)	Incorporated into High School campus.
5. 17th Ave. E.	County jurisdiction, authorization might be rejected due to narrow blvd. on north side and setback requirements.

* Note: *Although typical boulevard type row plantings might not be appropriate on state highways, and are contrary to road authority policies, this position does not preclude landscape plantings at suitable selected locations within a right-of-way.*

Example Box 8: Neighborhood Street Exemption Schedule (Step 2)



Example Box 9: Neighborhood Street Exemptions (Step 2)

Step 3. Identify Major Streets, Critical Intersections and Destinations

Factors such as minor arterials and collector streets that traverse or border the community and neighborhoods, hazardous or complex intersections, and significant destinations (e.g., shopping centers or malls, court house, city hall, schools, churches, parks) might benefit from distinctive or extraordinary tree arrangement patterns on the respective thoroughfare or streets leading to or bordering these points of interest (see Table 3.2).

Use existing maps typically included in a community's comprehensive plan as ready information resources. Such maps depict land use, zoning, parks and trails, transportation systems, and environmental resources (e.g., lakes, rivers, wetlands, forest preserves, prairies). These maps can be reviewed individually, as needed, or the desired information can be transferred to the community base map or series of neighborhood base maps using colored art markers.

If the information is to be transferred, the major streets can be indicated by a colored line down their centers, critical intersections can be denoted by a colored dot or circle, and the points of interest can be filled-in by selected colors to represent each type of land use. A color key should be prepared for reference as an indicator of the color assignments (see Example Box 10: Transferred Information Map).

Tower Park Neighborhood

1. Fresh Anointing International Church (in adjacent neighborhood)
2. Richardson Elementary School
3. Christ Lutheran Church & School (in adjacent neighborhood)
4. St. Peter Catholic Church & School
5. North Presbyterian Church & School
6. Tower Park
7. St. Mark Evangelical Lutheran Church & School
8. North High School
9. McKnight Fields

Example Box 10: Transferred Information Map (Step 3)

Step 4. Sort Inventory Checklists and Function Assignment Forms

The previously completed inventory checklists and function assignment forms (see Form No. 2.1 and Form No. 3.1) for each street or segments of a street need to be assembled and systematically sorted and organized for subsequent review.

Although the method for sorting assembled information is open to personal preference, the following tried-and-true process is presented for consideration. The assembled constituent materials should be sorted by neighborhood or planning district if the size of the community warrants such division for purposes of manageability. Subsequently, the sorted materials should be further organized by dividing and subdividing the completed forms in a descending order by "type of street" (e.g., minor arterial, collector, local), "orientation" (e.g., north-south, east-west), and "alphabetical and numerical order" of street names (e.g., Arthur St., Buchanan St., Cleveland St., Coolidge St. etc.; 1st Ave., 2nd Ave., etc.). (See Example Box 11: Neighborhood Sorting Profile).

Step 5. Assign Arrangement Patterns to Streets

At this point, an art marker color code should be established that includes an assigned color for each of the arrangement principles which include "repetition,", "alternation," and "gradation." Since repetition can also involve the repeating of a module or combination of two or more species, separate colors should be reserved for the intended repetition of a single species and repetition of combined species. If it is decided to have a repetition of different species on opposite sides of a street, this combination pattern would be represented by a separate color in the color key. (See Example Box 12).

"Unbalanced" situations where trees will be omitted from one side of the street due to poor site conditions, lack of adequate space or type of adjacent land use will be the exception rather than the rule and can be indicated on the base map by either leaving a gap in the assigned color line at the respective map location or using a thinner colored line on the side of the street that will continue the row planting (see Figure 5.22). The representative colors can be chosen from available selections of colored fineline art markers. The standard color code can also be used without amendment to represent an assigned arrangement pattern that is a hybridization of the basic arrangement patterns. For example, a repetitive block of a single species that is interjected into a prevailing alternating arrangement of two species (one of which might be the inserted species) to acknowledge the location of a special land use (e.g., church, school) can be depicted as shown in Figure 5.23.

The maps developed in Step 2 and Step 3 should be added to the materials assembled and sorted in Step 4. Keeping in mind predetermined species diversity goals (see ISSUE NO. 4), the pertinent information relative to each street should be reviewed on a street by street basis following the established sorting schedule. Subsequently, an arrangement pattern should be determined for each corresponding street, and the respective design decision or pattern assignment should be recorded on the appropriate base map as a colored line using a designated fineline art marker. If uncertainties exist relative to a particular street, it should be entered as a dashed line of the color that represents the questionable arrangement pattern.

Upon completion of the assignment of arrangement patterns to all of the qualified streets, the total plan should be reviewed to determine if there are any incongruities or inconsistencies. Modifications fostered by second thoughts should be implemented as needed. (See Example Box 12: Neighborhood Arrangement Pattern Map).

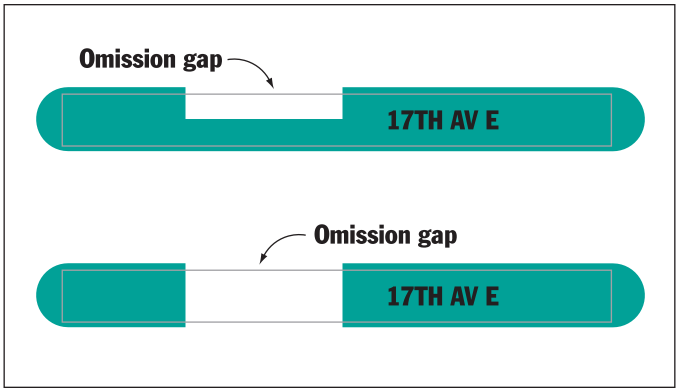


Figure 5.22. Arrangement pattern map graphic that reflects an "unbalanced" situation where trees will be omitted.

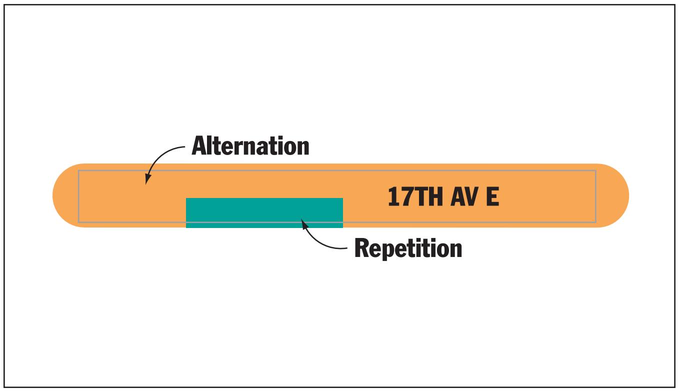


Figure 5.23. Arrangement pattern map graphic that reflects the segmented interjection of a pattern variation into a prevailing pattern to achieve "acknowledgement" or "accentuation".

Tower Park Neighborhood

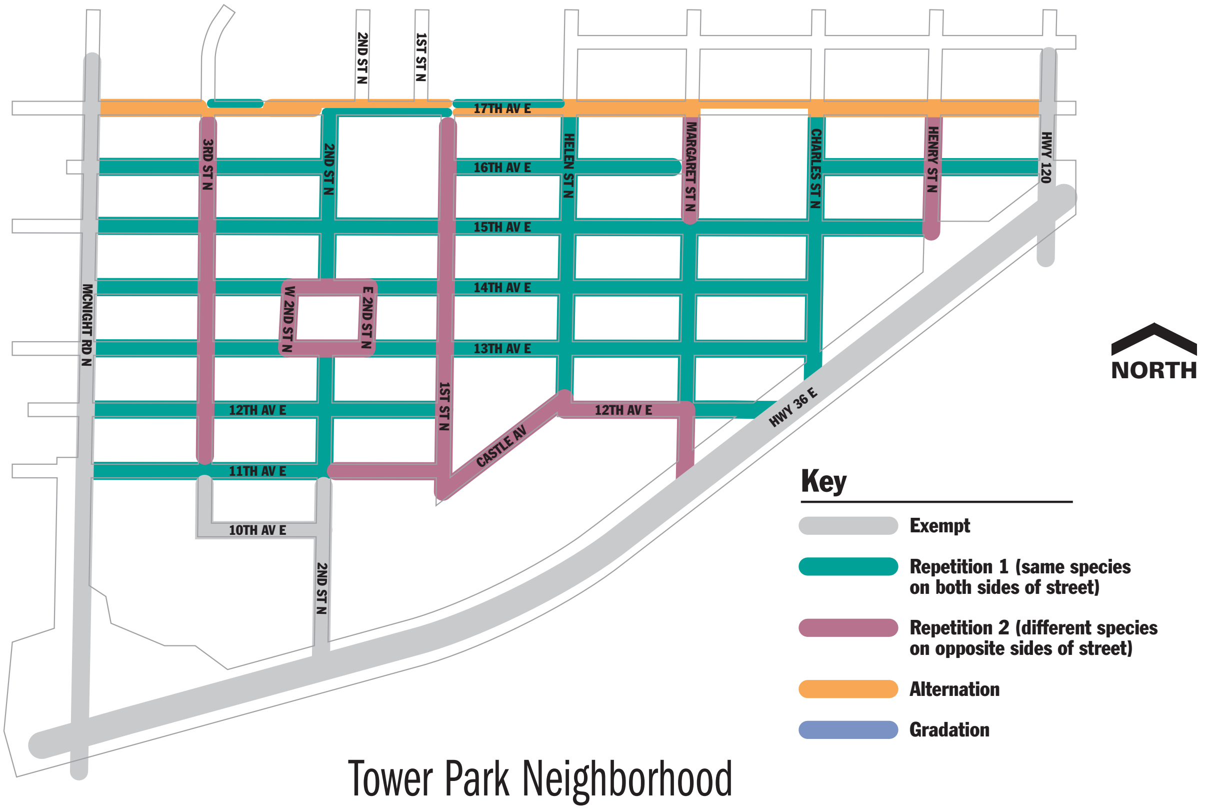
Type of Street	Minor Arterial**		Collector		Local	
Orientation*	N-S	E-W	N-S	E-W	N-S	E-W
Street Names	McKnight Rd. S.T.H. 120	17th Ave. E.	Helen St. Margaret St. N.	*** Castle Ave. N. 11th Ave E. 12th Ave. E.	Charles St. N. Henry St. N. 1st St. N. 2nd St. N. 3rd St. N	12th Ave. E. 13th Ave. E. 14th Ave. E. 15th Ave. E. 16th Ave. E.

* Note: *diagonal, circular or arced streets can be collectively established as a separate "orientation" classification or integrated into the standard N-S and E-W orientation groupings, dependant on their dominant inclination or starting point.*

** *Principal arterials such as S.T.H. 36 (see Example Box 9) are typically exempted from community street tree planting programs.*

*** *Attached segments of three streets blend and fuse to form a single collector.*

Example Box 11: Neighborhood Sorting Profile (Step 4).



Example Box 12: Neighborhood Arrangement Pattern Map (Step 5)

Which Species Should be Assigned to Tree Receptive Streets?

This issue addresses the pairing of each tree-friendly street with the tree species or combination of species that is the most suitable proven-adapted choice. Tree-friendly streets are those that will accommodate the placement and flourishing of trees within the street corridor. Suitable and proven-adapted tree species are those acclimated to the region, compatible with the surroundings, tolerant of existing conditions, resistant to biotic threats and responsive to design objectives.

Decisions affecting the selection of appropriate species and their subsequent placement within the street corridor must anticipate potential biotic and abiotic challenges as well as potential conflicts or negative interactions that could occur, over time, between street trees, and the built-environment (Dwyer 1995). Such negative interactions may include:

- falling tree litter (e.g., leaves, fruit) and branches
- uplifting and cracking of sidewalks
- displacing and uplifting of curbs
- blocking street lighting patterns
- blocking of sight lines
- blocking of signs
- interfering with overhead wires
- shading of solar collectors
- invading of sanitary sewers
- causing of allergies

Depending on the size of the subject community as influenced by the number of neighborhoods, number and length of streets, and variety of existing site conditions, the successful selection of the best or most suitable tree species from a lengthy list, and their subsequent assignment to wanting streets can be the most complex task of the planning process.

If the desired degree of species diversity (see ISSUE NO. 4) is comparatively low (e.g., 10 species per neighborhood with repeats in the subject neighborhood and adjacent neighborhoods), the selection and decisive assignment of appropriate species will be relatively simple. However, if the expected level of species diversity is comparatively high (e.g., 20-30 species per neighborhood with no repeats in the subject neighborhood and some in adjacent neighborhoods), the required discriminatory judgments will make the selection process more complex.

At the turn of the 19th century, as American society began to recognize that trees made cities a healthier, more attractive place to live, street tree plantings began to find favor with elected officials and the general public. The ideal street tree was expected to possess certain qualities. A street tree had to be hardy, long lived, moderately fast growing, free from insect and disease attack, litter free, and have a straight trunk and well-filled symmetrical crown that changed color in the fall (Solotaroff 1911). Although there were numerous native species to choose from, it was soon realized, after trial and error, that only a limited number of these species would be suitable or useful as street trees. Foreign introductions soon helped to supplement the otherwise limited species palette (e.g., Norway maple, European linden, ginkgo, horse chestnut, lombardy poplar, oriental plane, sycamore maple).

Over time, city codes and ordinances across the country began to prohibit the planting of earlier standbys such as catalpa, black locust, cottonwood, Carolina poplar, silver maple, box elder, and Chinese elm along public streets and highways. The list of tree species proven to be suitable and dependable as street trees remains a challenge today. Nurseries are continually propagating new varieties, and cities are experimenting with the new introductions. However, as always, "many are called, but few will be chosen."

A 6-Step Process to Formulate a Comprehensive Tree Species Selection Plan

Step 1. Compile an Inclusive List of Suitable Tree Species

Guided by common sense and personal familiarity, the attributes of the ideal street tree as recommended by Solotaroff (1911) and the historical acceptance or rejection of certain species as related above, develop an all-inclusive list of tree species that would be suitable for use as street trees in the given area. The latest editions of toxonomic tomes, university factsheets, commercial websites and current product catalogs provided by wholesale and retail nurseries that grow and/or supply trees to the subject area will be the most productive resources for this task. The comprehensive list of 115 tree species that was developed to serve as the selection pool for the "example neighborhood" is contained in Appendix 4: Inclusive Species List.

Generally, the number of potential candidate species will be directly influenced by the U.S.D.A. Hardiness

Zone that incorporates the subject community. For example, the northern most zones (e.g. zones 2 and 3) will qualify fewer species than the more southern zones (e.g. zones 4 and 5). However, there are exceptions to this generality. Since environmental factors such as soil type, growing season precipitation and evapotranspiration potential impact species survivability, it is likely that arid or xeric areas that are commonly located in the country's southern hardiness zones will favor fewer street-suitable tree species.

Step 2. Select a Suitable Base Map

The final product of the species selection phase of the planning process is a color-coded map or series of maps that graphically depict the decisions made relative to the selection and assignment of a tree species or combination of species to each tree-friendly street or segments of a street. In the master plan document phase, these color-coded species selection maps will be replaced by copy ready species assignment maps sized to fit the 8.5" x 11" document format (see ISSUE No. 8).

The base map or maps for this phase should be the same as those used for the charting of arrangement pattern assignments (see ISSUE NO. 5, Step No. 1). If the subject community is of a size that warrants a series of maps based on neighborhoods or planning districts, a map of the entire community, with the respective neighborhoods or planning districts outlined and labeled, should be prepared as an index for reference during this phase and subsequent inclusion in the master plan document. (See Example Box 13: Neighborhood Index Map). This map should also be sized to fit the 8.5" x 11" document format.

Step 3. Assemble and Sort Planning Material

Assemble all of the completed matrices (see ISSUE NO. 2, Step 4), function assignment worksheets (see ISSUE NO. 3, Step 2) and color-coded arrangement pattern maps (see ISSUE NO. 5, Step 5). The information and decisions contained on these tools will provide the basis for determining which tree species should be assigned to a particular street or segment of a street.

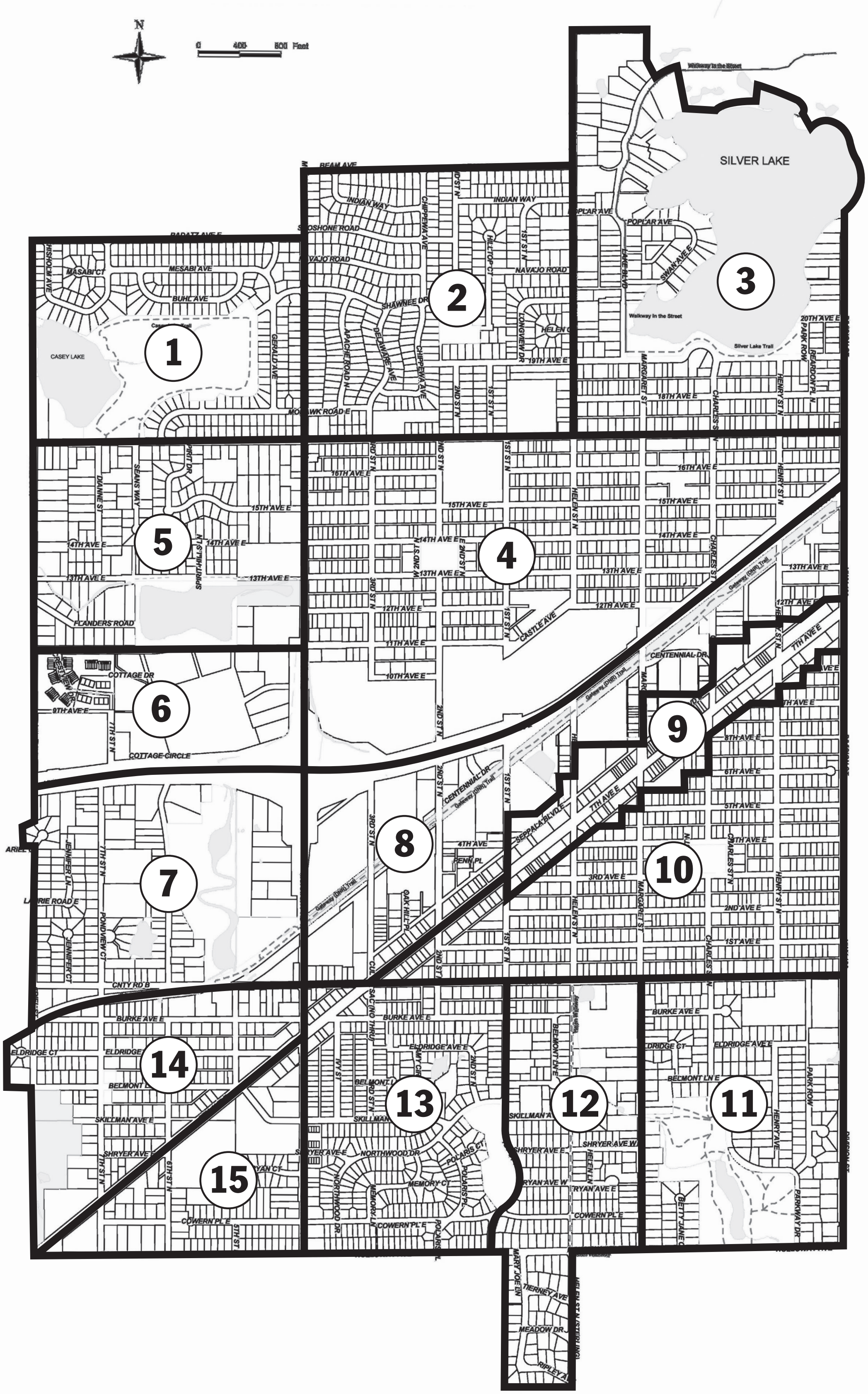
If applicable, as outlined in Step 4 of the 5-Step Process to Formulate a Comprehensive Tree Arrangement Plan (see ISSUE NO. 5), the assembled constituent materials should be sorted by neighborhoods or planning districts (see Step 1) and further organized by dividing and subdividing the assembled materials in a descending order by "type of street," "orientation," and "alphabetical and numerical order of street names". (See Example Box 11 in ISSUE NO. 5, Step No.4).

Step 4. Evaluation of Assembled Information

After the sorting has been completed, the organized material will be ready for a manual or electronic street-by-street evaluation, with the objective being the derivation of a list of candidate tree species for each qualified street. The prescribed evaluation is a search and identification process that involves either the manual or electronic comparison of each completed matrix (see Example Box 2 in ISSUE NO. 2) with the physical characteristics and growing site requirements of suitable tree species described in toxonomic texts and detailed nursery catalogs (manual search) or online tree selector websites (electronic search). Ideally, after the search has been completed, each street will have an allocated listing of at least three tree species that have proven to be a perfect or nearly perfect match with the subject street's matrix determinants. Those species that satisfy the defined requirements of the respective matrices should be entered on a species selection options form (see Form 6.1) and "ranked" according to their respective degree of suitability for future processing and consideration in accordance with Step 5. An example form is provided in Appendix 1: Forms Section for duplication and direct use or as a sample for creating a customized format.

Whether species selections are derived by a manual or electronic process will be influenced by the size of the subject community, number of qualified streets, number of participants, accessibility of an online regional tree selector data base, availability of comprehensive species reference books and the electronic capabilities of decision makers. Either search method will accomplish appropriate street/species match-ups, provided inventory data has been correctly interpreted and noted on the matrices.

The key to the evaluation of matrix determinant assignments (see ISSUE NO. 2, Step 4) and subsequent identification of suitable tree species is the assignment of a priority rating to each determinant or matrix factor. Such priority ratings are not a constant and can vary from block to block, street to street and neighborhood to neighborhood. Priority assignments will be influenced by the relative impact of certain corridor conditions, function assignments and design objectives. The prioritization of selection determinants or matrix factors will facilitate the manual search for suitable candidate species by reducing the need to simultaneously scrutinize all of the determinants. Even electronically, it is unlikely that an existing tree selector program (e.g. computer retrieval system) will be able to locate a tree in its data base that equally or fully satisfies every chosen attribute.



- 1 Casey Lake
- 2 Indian Hills
- 3 Silver Lake
- 4 Tower Park
- 5 Spirit Hills
- 6 Greatland
- 7 Sod Farm
- 8 Hwy 36 Corridor
- 9 Downtown
- 10 Hause Park
- 11 Southwood Park
- 12 Cowern
- 13 Northwood Park
- 14 Colby Hills
- 15 Webster

Example Box 13: Neighborhood Index Map (Step 2)

Prioritization will provide a streamlined short list of the most critical determinants that must be satisfied and tiers of less important factors that, if not completely satisfied, will not totally disqualify a particular species. The most important or highest priority determinants will be those that have the greatest influence on favorable growth, survivability, avoidance of potential infrastructure conflicts and unique design objectives. The intent is not to disregard certain factors, but instead to keep their particular relevance in perspective.

Once determined, priority ratings should be entered on the respective matrix form in the blank space at the top of each determinant column. (See Example Box 14: Matrix Priority Assignments).

If preferred reference sources (e.g. manuals, handbooks, texts, CD-ROMs or websites) do not provide all of the corresponding information required by the assembled species selection matrices, the search for the needed data should be extended to other qualified references to fill in the deficiencies. It is likely that reference texts and online tree selector websites, in some instances, will use terms and parameters that are at odds with the terminology of the species selection matrix form. However, the extraction and interpolation of such information will be aided by the determinant glossary in Appendix 3.

If information relative to particular species, especially cultivars (e.g. clones and hybrids), is not available from standard references, it might be appropriate to extrapolate speculative assumptions from the established characteristics of the parent species as provided in reliable resources (e.g. *Acer rubrum for Acer rubrum 'Northwood'*).

Although statistics for determinants such as "trunk flare" and "trunk diameter" are not addressed by typical species selection references, such data might be obtained by field verification, personal knowledge and/or gleaned from a specialized handbook devoted to the silviculture of forest trees.

The higher the priority assigned to a particular determinant, the more important it is to locate missing information that will validate the subject determinant. If miscellaneous information relative to some or all species is unavailable, and it is apparent that the resulting deficiency will not disqualify the related outcome, the search process should continue undaunted.

Manual Search

A manual evaluation and species search involves the personal hands-on or direct visual comparison of recorded matrix criteria and reference book descriptions. A manual search can also involve the use of a CD-ROM program or online tree selector website if the internal species fact sheets are viewed and evaluated as individuals rather than as an interactive scan of the collective database.

Prior to any attempt to manually coordinate street/species matchups, in addition to prioritization, it will also be beneficial to develop specialized reference lists that group species that show the same attributes (e.g. ecological relationships, visual characteristics or cultural requirements). The intent of such organized dissection is to narrow the potential choices to a manageable number. This can be accomplished by separating and regrouping those species on the inclusive species list compiled in Step 1 that share the same categorized attribute.

Since it is unlikely that two tree species share all of the same attributes, it will be advantageous to develop separate species lists that correspond to the top priority determinants. For example, after headlining the top priority determinants (e.g. "height") consult selected species references such as *Native Trees, Shrubs and Vines for Urban and Rural America* (G. Hightshoe, 1988) for the corresponding species performance criteria that describes each species relative to the designated determinant's gradations (e.g. height: very short-< 20', short- 20' to 35', intermediate- 35' to 50', tall- 50' to 75', very tall- 75' to 100'), and subsequently list each species in alphabetical order according to its scientific name under the applicable determinant gradation or value heading. It follows that if one of the top priority determinants or matchup criteria for a particular street requires a species that will not interfere with existing overhead utility lines, referral to the predetermined "very short height" list will quickly display those species that will fulfill this expectation.

This procedure is applicable to all of the top priority determinants, as well as lower priority factors, and in turn, should be applied to the requirements of each street. The selection process can be further simplified and propelled by grouping all of the streets that share all or most of the same requirements as defined by the designated gradations of the matrix determinants.

It will remain a given that "hardiness" is always a top priority in all cases. After that, in most situations, top priority factors will usually include "height", "crown spread", " trunk diameter", "trunk flare", "foliage duration" and "soil texture". In special situations, where certain function and/or design schemes are a principal objective (e.g. "accentuation", "acknowledgement", "screening", "buffering", "gradation", and "alternation") factors such as "form", "foliage duration",

Species Selection Matrix Form

Neighborhood *Tower Park* **Street** *3rd St N (East side)* **From** *17th Ave E.* **To** *11th Ave E.*

H								NC		H				
Hardiness								Natural Range		Height				
Zone 2	Zone 3a	Zone 3b	Zone 4a	Zone 4b	Zone 5a	Zone 5b	Zone 6	Native	Non-Native	Very Short < 20'	Short 20' – 35'	Intermediate 35' – 50'	Tall 50' – 75'	Very Tall > 75'
			▨							▨				

H					M				M		
Crown Spread					Trunk Diameter				Trunk Flare		
Very Narrow < 20'	Narrow 20' – 35'	Intermediate 35' – 50'	Wide 50' – 75'	Very Wide > 75'	Small < 12"	Intermediate 12" – 24"	Large 24" – 36"	Very Large > 36"	Slight	Moderate	Buttress
▨	▨				▨	▨			▨		

NC									L		
Form									Mass		
Columnar	Conical	Globular	Irregular	Pyramidal	Rounded	Spreading	Upright	Oval	Open	Moderate	Dense
										▨	

M					NC			H	
Branching Habit					Root Pattern			Foliage Duration	
Upright	Ascending	Horizontal	Recurving	Descending	Shallow Lateral	Deep Lateral	Taproot	Deciduous	Evergreen
▨	▨							▨	

M			M									
Foliage Texture			Summer Foliage Color									
Fine	Medium	Coarse	Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Bronze	Purple	Maroon
	▨		▨	▨	▨							

NC											
Autumn Foliage Color											
Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Orange	Brown	Bronze	Purple	Maroon

NC											
Flower Color											
White	Gray	Yellow	Green	Pink	Red	Red-Purple	Purple	Orange	Brown	Blue	Inconspicuous

M													
Fruit Structure													
Seedless	Berry	Pome	Drupe	Multiple	Nut	Cone	Pod	Samara	Capsule	Strobile	Follicle	Achene	Aril
▨								▨	▨	▨			

NC			NC			H											
Allergen			Plant Sex			Soil Texture											
Low	Moderate	High	Perfect	Monoecious	Dioecious	Sand	Loamy Sand	Sandy Loam	Loam	Silty Loam	Silt	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay
							▨	▨				▨					

M			M			H					L		
Soil Drainage			Soil Moisture			Soil Reaction					Soil Compaction		
Excessive	Moderate	Poor	Dry	Moderate	Wet	Strongly Acid 4.0 – 5.0	Moderately Acid 5.1 – 6.0	Slightly Acid 6.1 – 6.5	Neutral 6.6 – 7.5	Alkaline 7.6 – 8.5	Sensitive	Moderate	Tolerant
	▨			▨				▨				▨	

L			L			NC			NC		
Shade Tolerance			Artificial Lighting			Spray Salt			Soil Salt		
Intolerant	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant
	▨			▨							

NC						
Atmospheric Pollutants						
Sulphur Dioxide	Ozone	Oxides of Nitrogen	Peroxyacetyl Nitrate	Hydrogen Fluoride	Hydrogen Chloride	Ethylene

Example Box 14: Matrix Priority Assignment (Step 4)

"foliage texture" and "foliage color" also might be considered a top priority.

Remembering that the objective, at this point, is to identify those tree species best suited to the particular street being subjected to review, this should be a judicious process that will quickly and confidently extract the few suitable species from the many pages of a comprehensive regional species list similar to the one in Appendix 4.

If an inadequate number of tree species satisfy the high priority requirements or characteristic factors, the natural tendency will be to lower the standards or disregard the predetermined basic qualifiers in order to increase selection options. Such action violates the premise that is the foundation of the planning process recommended in this manual. The resulting selection of tree species that are not the best suited for the respective sites could contaminate an otherwise thoughtful street tree master plan. Given this situation, decision makers must compare two unsatisfactory alternatives and determine the lesser of two evils—a street tree population with limited (less than ideal) species diversity vs. the sporadic use of unproven and unadapted tree species.

If match-up efforts determine that fewer species are adapted to existing conditions than required to satisfy liberal species diversity objectives, proven-adapted species will need to be re-used or repeated more often. Although species diversity goals may have been established, they may need to be revised in deference to the primary goal of selecting and assigning the best species choice to each street. As mentioned earlier, experimental species can be used to supplement a limited species palette. In any case, when it is known that a species will not be able to adapt to existing street corridor conditions, that species should not be used.

Electronic Search

An electronic evaluation and species search involves the use of an interactive online tree selector website (see addresses below) or CD-ROM program to make an electronic collective comparison of the required species attributes and environmental constraints identified by the assembled species selection matrices (see Example Box 2) and the duplicated criteria displayed as program related dialog box controls (e.g. tabs, check boxes, option buttons, drop-down list boxes and text boxes).

Existing Website Addresses:

- Mn/DOT Plant Matrix: *http://plantselector.dot.state.mn.us.html/* (Minnesota)
- Northern Trees: *http://orb.at.ufl.edu/TREES/index.html/* (Northeastern States)
- SelecTree: *http://selector.calpoly.edu/* (California)

At this point in time, available tree selector programs have some inherent limitations that affect their application and retard the associated interactive search process. In particular, most if not all of these programs do not accommodate the entry of multiple values nor priorities for each determinant. The resulting drawback is that entered information and database information cannot be simultaneously correlated and processed as a single electronic task. Generally, under such circumstances, it is likely that an initial entry of unprioritized determinant values will not yield a responsive listing of suitable species. No one species, and certainly not several, would match every equally weighted selection factor.

In order to produce useable species lists using existing tree selector programs, it might be necessary to perform a series of entries for each matrix, with each attempt being an aggregate of related determinants (e.g. environmental, physical, cultural). For example, the first submission of checked values might include only the size related determinants (e.g. "height", "crown-spread", "trunk flare" and "trunk diameter") with subsequent submissions grouping foliar related determinants, soil related determinants and tolerance related determinants. Each submission of related entries will produce a separate list of tree species which, in turn, will require a manual comparison to identify those species that are repeated on each list, thereby being suitable candidates for the subject street.

To alleviate the above mentioned shortcomings, a customized interactive program and website could be developed to provide an electronic information resource that simplifies the related entry tasks, overcomes potential gridlock due to numerous unprioritized determinants and quickly produces the anticipated species search results. The overriding difference between a program of this type and other available electronic tree selector programs would be its inherent capacity to accommodate the entry of multiple values for each determinant and, most importantly, to assign priorities.

Since existing tree selector databases do not include every potentially suitable species and lack data relevant to some of the selection factors or determinants such as "trunk flare", "trunk diameter" and "artificial lighting tolerance", such deficits can be handled by supplementing the electronic search with a manual search for any missing information relative to a particular determinant and applicable species.

The entered information will document the corresponding requirements noted on the assembled species selection matrices. The end product of the electronic search will be lists of tree species suitable for use on the designated streets. The listed species may then be rated and ranked relative to their ability to match the entered requirements. It might be advantageous to set a minimum acceptable rating, e.g. 85% of criteria met. If no species attains the minimum standard, the initial entries might have to be revised (e.g. increase scope of acceptable values and/or lower the priority assigned to some influential determinants). In reality, it is likely that there will not be a 100% perfect tree species for every street.

Step 5. Selection and Assignment of Species

Up to this point in the planning process, prior efforts and products have been preparatory and prerequisite to the principal goal of selecting the actual tree species that is suitable for placement on a given street or section of a street. These issue oriented decisions and actions are metaphoric to "cutting bait before going fishing". At this point, the concurrent review of function assignments (ISSUE NO. 3), degree of diversity goals (ISSUE NO. 4), arrangement pattern assignments (ISSUE NO. 5) and species selection options (ISSUE NO. 6, Step 4) will provide the basis for the thoughtful selection and assignment of a designee tree species from the list of candidates to a given street (see Species Selection Options Form 6.1 and Example Box 15: Neighborhood Species Selection Options).

The assignment of a particular tree species to a particular street or segment of that street should follow a predetermined process. For example, one such method would focus on the streets within each neighborhood or planning district. The process would start with the streets in the defined area or neighborhood in the upper left corner of the index map (see Step 2) and move on to the streets in the adjoining area, and so on, from side to side, down the page, similar to a patchwork quilt. The progressive evaluation of the individual streets in a particular neighborhood or planning district should start with the minor arterial streets, followed by collector streets and finally local streets, all in alphabetical and numerical order (see Step 3 and Example Box 16: Neighborhood Species Assignment Schedule).

Certain streets may have a special significance in the subject community such as Main Street passing through downtown, a memorial parkway or civic center drive surrounding government buildings. If this is the case and these streets have not been "exempted" (see ISSUE NO. 5, Step 2), they should be among the first streets in the species selection process to be assigned a suitable tree species. A situation where the tree species might be predetermined is when a row planting will be adjacent to a wooded park. In this case it might be desirable to duplicate one or a combination of species that are naturally occurring in the park. If it has been decided in advance to assign namesake species (see ISSUE NO.3) to streets or neighborhoods named for trees (e.g., Linden Hills), the species included in the corresponding genus group

SPECIES SELECTION OPTIONS

Neighborhood *Tower Park*

Street *3rd Street N —east side*

	Suitable Species	Ranking	Selection
A.	*Amur Maple*	*1*	*Ivory Silk Lilac*
B.	*Embers Amur Maple*	*1*	
C.	*Flame Amur Maple*	*1*	
D.	*Japanese Tree Lilac*	*2*	
E.	*Ivory Silk Lilac*	*2*	
F.	*Blue Beech*	*3*	
G.			
H.			
I.			
J.			

Comments *Overhead wires-small tree; priority selection over west side; no fleshy, pod or nut fruits.*

Street *3rd Street N. - west side*

	Suitable Species	Ranking	Selection
A.	*Commemoration Sugar Maple*	*3*	*American Sentry Linden*
B.	*Scarlet Sentinel Maple*	*2*	
C.	*Celebration Maple*	*2*	
D.	*Foothills Ash*	*3*	
E.	*American Sentry Linden*	*1*	
F.	*Redmond Linden*	*1*	
G.	*Littleleaf Linden*	*1*	
H.	*Shamrock Linden*	*1*	
I.			
J.			

Comments

Example Box 15: Neighborhood Species Selection Options (Step 5)

Neighborhood-Tower Park

Priority	Street	Reason for priority ranking
1.	11th Ave. E. with Castle Ave. & 12th Ave. E. (Margaret St.-Helen St.)	Collector to High School
2.	Helen St. N.	N-S collector to Hwy. 36
3.	Margaret St. N.	N-C collector past important church/school complex
4.	1st St. N.	Overhead wires
5.	3rd St. N.	Overhead wires
6.	Henry St. N.	Overhead wires (short segment)
7.	2nd St. N.	Includes Tower Park, completes N-S streets west of Helen St.
8.	Charles St. N.	Completes N-S streets east of Margaret
9.	13th Ave. E. (McKnight Rd.-Helen St.)	Section borders Tower Park
10.	14th Ave. E. (McKnight Rd.-Helen St.)	Section borders Tower park
11.	15th Ave. E. (McKnight Rd.-Helen St.)	
12.	16th Ave. E. (McKnight Rd.-Margaret St.)	
13.	12th Ave. E. (McKnight Rd.-1st St. N.)	
14.	13th Ave. E. (Helen St.-Charles St.)	
15.	14th Ave. E. (Helen St.-Charles St.)	
16.	15th Ave. E. (Helen St.-Henry St.)	
17.	16th Ave. E. (Charles St.-Division St.)	

Example Box 16: Neighborhood Species Assignment Schedule (Step 5)

(e.g., Tilia - Linden) should be among the first assignments. Also, special function assignments (e.g. "architectural compliment", "accentuation", "acknowledgement") that will require species having contrasting, unusual or pronounced attributes (e.g. size, form, foliage features) might warrant early attention.

To facilitate intended combinations of species, it would be prudent to make an advanced assignment of the primary species in these pairings. Examples of primary species would include:

- The species to be placed under the overhead wires that occur only on one side of the subject street.
- The species to be placed in the narrow boulevard that occurs only on one side of the street.
- The species to be placed only in front of a destination such as a church or school for "accentuation".

Together, these types of initial species assignments will provide the framework for the following assignments.

Some minor arterial and collector streets pass through multiple neighborhoods and often the community. In such cases, assignment of a single tree species or combination of species to the full length of the particular street will provide area-wide or community-wide continuity. It is an effective species diversity and arrangement design practice to assign the same species or combination of species to the segment of a street between the intersecting collector or primary local streets that define and separate such segments. Such segments can include 3 to 8 intermediate blocks.

Some communities will prescribe to the philosophy and subsequently adopt the policy that only native tree species should be used for street tree plantings. Although 25 species may qualify as being native, having existed in the area, region or state from the time prior to European settlement (pre-1850 in Minnesota), it should be realized that the number of such trees that are actually suitable for use as street trees will probably be substantially less. It is very likely that street trees will be exposed to harsher conditions than experienced in their otherwise natural habitats, and parent soils will have been altered by construction activities. Street corridors are not the indigenous environments where native species normally thrive. In most instances, the optimal relationship between a native species and its habitat no longer exists within the street corridor.

In many communities, existing city codes contain provisions that regulate the development of new subdivisions or planned land use projects. Such ordinances can require the planting of boulevard trees by the developer, and the submission and local approval of a related landscape plan that designates the placement and species of such trees. In addition to evaluating site conditions and species selections, the required plantings should be reviewed relative to the adopted community street tree master plan, especially species diversity objectives and species assignments on existing nearby streets adjacent to the proposed development.

Step 6. Record Species Assignments

The final pairing of a street with a suitable tree species or combination of tree species should be recorded on a copy of the base map(s) selected in conformance with ISSUE NO. 5, Step 1.

Respective assignments should be recorded by marking each corresponding qualified street with a designated fineline/broadline art marker that represents the assigned tree species (see Example Box 17: Neighborhood Species Assignment Map) and each assignment should be simultaneously noted on a corresponding neighborhood species assignment list (see Example Box 19: Neighborhood Species Assignment List).

A color key that matches each assigned tree species with its representative color should be prepared for reference and identification purposes. (See Example Box 18: Neighborhood Species Assignment Map Color Key). Colored art markers are available as individual selections or in sets of 24, 48, 72, and 120 colors at local art supply stores.

The resulting multicolored line or grid-like composites will facilitate a later critical evaluation of assignment relationships. Colored graphics will visually simplify the preliminary layouts enabling decision makers to confirm that initial planning objectives such as community and neighborhood unification, species/genus diversity, and species/genus separation have been achieved. The comparison of species assignments in contiguous neighborhood or planning areas can be accomplished by placing the respective maps side-by-side in a mosaic-like arrangement.

Typically, a solid colored line would represent a repeated species, alternating colored dots would represent a repeated combination of species, and multiple tones of the same color would represent those species within the same genus (see Figure 6.1a).

If two species are assigned in combination to a street but on opposite sides, they both should be represented by parallel colored lines on the corresponding side of the street (see Figure 6.1b). If questions remain relative to a particular species assignment, it should be entered on the map as a dashed line of the represented color (see Figure 6.1c).

Detected design errors such as overuse of a species, assignment of the same species to immediately parallel streets, assignment of species in the same genus to streets in close proximity to one another and over-extended use of a species on consecutive blocks of the same street can be corrected by entering revisory notations at appropriate points on the colored maps.

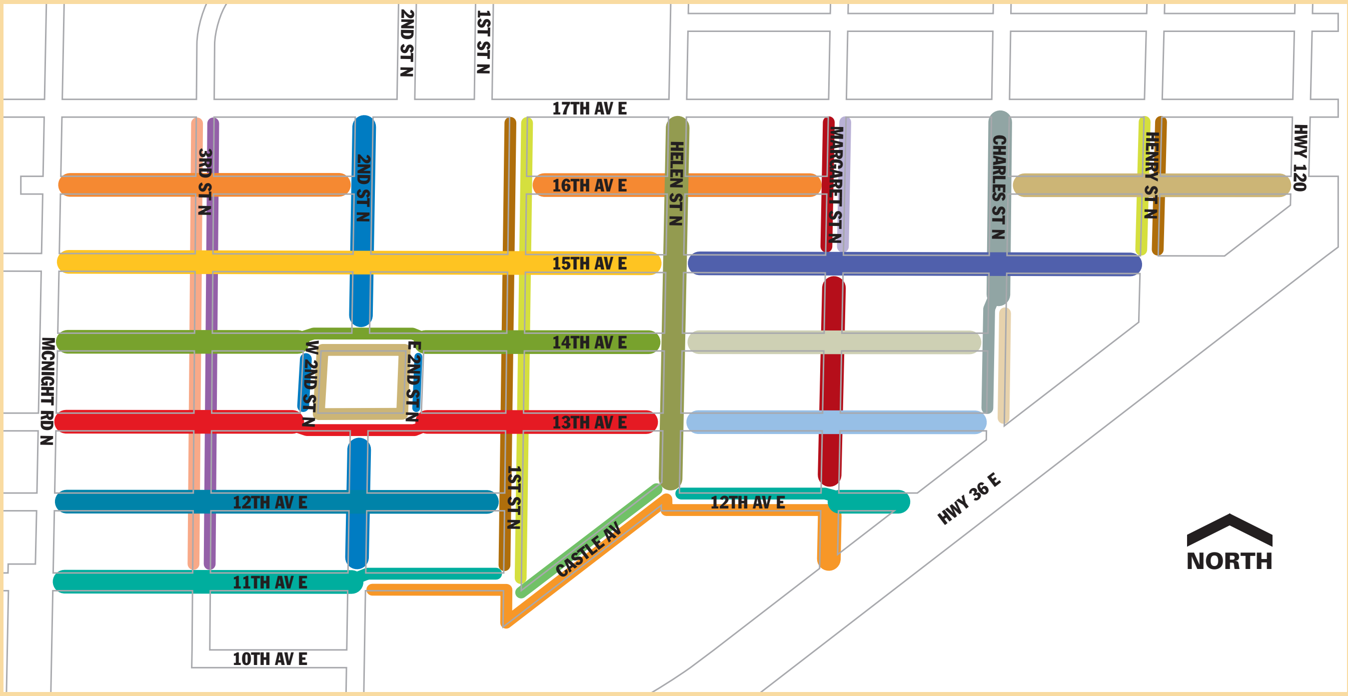
Being the conclusive act of the design phase of the planning process, the colored maps are the materialization of all the data collection, analyses, and decisions that have preceded this step, and provide the source for the derivation of the printed species assignment maps that will become the core of the street tree master plan document (see ISSUE NO. 8).

Literature Cited

Dwyer, J.F. 1995. *Trees and Building Sites: Proceedings of an International Workshop on Trees & Building Sites.* International Society of Arboriculture. Savoy, IL.

Hightshoe, G.L. 1988. *Native Trees, Shrubs and Vines for Urban and Rural America.* John Wiley & Sons. New York, NY.

Solotaroff, W. 1911. *Shade Trees In Towns and Cities.* John Wiley & Sons. New York, NY.



Example Box 17: Neighborhood Species Assignment Map (Step 6)

Since the Example Boxes have been used to demonstrate the progressive actions associated with a thoughtful planning process, the following noted issues have been inserted to add a sense of reality to the hypothetical case.

1. Initially, the exemption status of 17th Avenue E. (northern limit of Tower Park neighborhood) was uncertain (see dashed line Example Box 9: Neighborhood Street Exemption Map) and the street was subsequently assigned a complex arrangement pattern (see Example Box 13: Neighborhood Arrangement Pattern Map). Following the formal submission of a permit request and a joint meeting, the county road authority denied the permit to authorize the community's planting of trees within the right-of-way of 17th Avenue E. As a result, species have not been selected for assignment to the subject street.

The county has a policy that requires that any roadside tree plantings must be located at least six (6) feet from the curbline, and does not grant setback variances. In the subject case, the county road authority determined that without a waiver of the existing restrictions, the existing boulevard width, sidewalk placement, overhead utility wire location and unused border area dimensions precluded any roadside tree planting.

2. Three (3) species of ash have been incorporated into the neighborhood species assignment map depicted in Example Box 17 . Although emerald ash borer, a destructive invasive insect pest, has not been detected in Minnesota, the "green menace" looms as a potential threat 500 miles away.

This selection and assignment of ash is not intended to be an endorsement of "burying ones head in the sand" nor "throwing caution to the wind", but instead illustrates a common "real life" issue that decision makers might have to address during the species selection phase of the planning process. Since ash are a popular proven-adapted genus and provide several suitable species selection alternatives (see Appendix 4: Comprehensive Species List), their deletion from the candidate species palette would place a noticeable strain on the selection task. Looking ahead in such cases, decision makers must judge between prudence or gambling on uncertainty. The correct answer will be a product of the particular circumstances and will be validated over time. Although deleting the genus was not the decision in the subject case, it is obvious that the safest or risk-free choice would have been "to error on the side of caution".

- ■ **Autumn Spire Red Maple**
- ■ **Red Sunset Red Maple**
- ■ **Celebration Maple**
- ■ **Flame Amur Maple**
- ■ **Unity Sugar Maple**
- ■ **Silver Queen Maple**
- ■ **River Birch**
- ■ **Common Hackberry**
- ■ **Autumn Blaze Ash**
- ■ **Fallgold Ash**
- ■ **Northern Treasure Ash**
- ■ **Shademaster Honeylocust**
- ■ **Northern Acclaim Honeylocust**
- ■ **Ironwood**
- ■ **His Majesty Corktree**
- ■ **Pin Oak**
- ■ **Swamp White Oak**
- ■ **Ivory Silk Lilac**
- ■ **Greenspire Linden**
- ■ **American Sentry Linden**
- ■ **Harvest Gold Linden**
- ■ **Discovery Elm**

Example Box 18: Neighborhood Species Assignment Map Color Key

Neighborhood Tower Park (In priority order)

	Street	Tree Species
1	11th Ave. E. with Castle Ave. & 12th Ave. E. (Margaret St.-Helen St.)	Autumn Spire Red Maple at Church, Red Sunset Red Maple, Shademaster Honeylocust at High School
2	Helen St. N.	Celebration Maple
3	Margaret St. N.	Pin Oak at Church, Greenspire Linden
4	1st St. N.	Flame Amur Maple, Ironwood
5	3rd St. N.	Ivory Silk Lilac, American Sentry Linden
6	Henry St. N.	Flame Amur Maple, Ironwood
7	2nd St. N.	Fallgold Ash, Hackberry at Tower Park
8	Charles St. N.	His Majesty Corktree, River Birch at Church
9	13th Ave. E. (McKnight Rd.-Helen St.)	Harvest Gold Linden
10	14th Ave. E. (McKnight Rd.-Helen St.)	Unity Sugar Maple
11	15th Ave. E. (McKnight Rd.-Helen St.)	Northern Acclaim Honeylocust
12	16th Ave. E. (McKnight Rd.-Margaret St.)	Discovery Elm
13	12th Ave. E. (McKnight Rd.-1st St. N.)	Northern Treasure Ash
14	13th Ave. E. (Helen St.-Charles St.)	Autumn Blaze White Ash
15	14th Ave. E. (Helen St.-Charles St.)	Silver Queen Maple
16	15th Ave. E. (Helen St.-Henry St.)	Swamp White Oak
17	16th Ave. E. (Charles St.-Division St.)	Common Hackberry

Example Box 19: Neighborhood Species Assignments (Step 6)

Figure 6.1a-c. Species selection – arrangement pattern recording color codes.

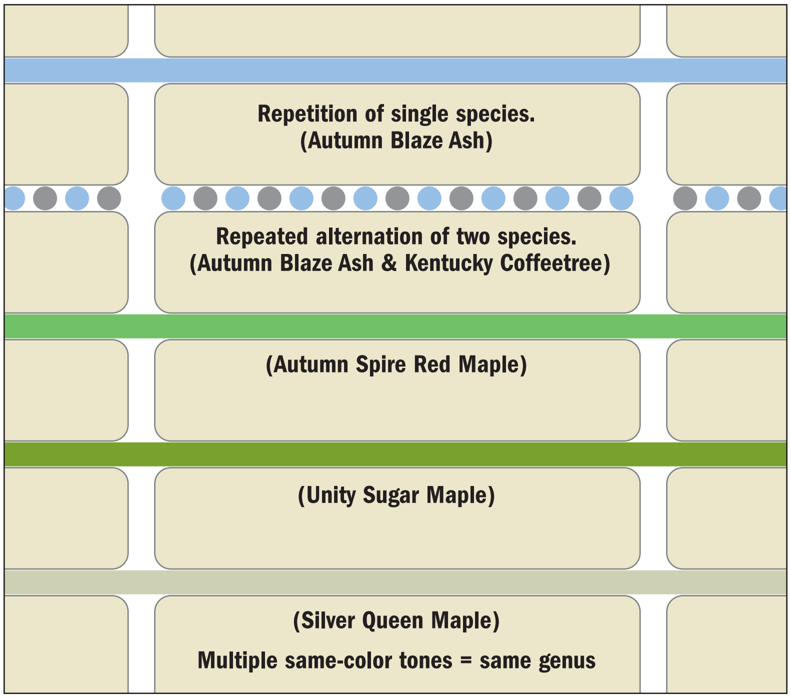


Figure 6.1a. Repetition of same species on both sides of street.

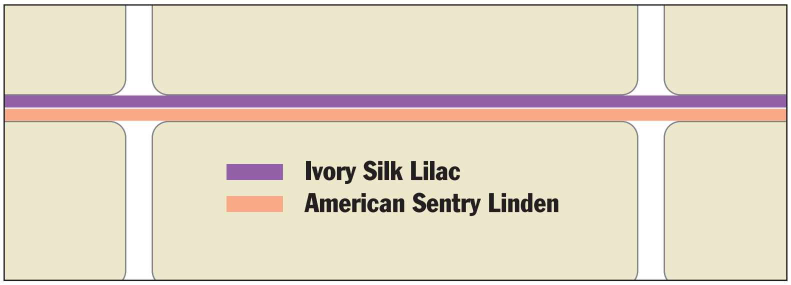


Figure 6.1b. Repetition of single species on one side of street and another species on opposite side of street.

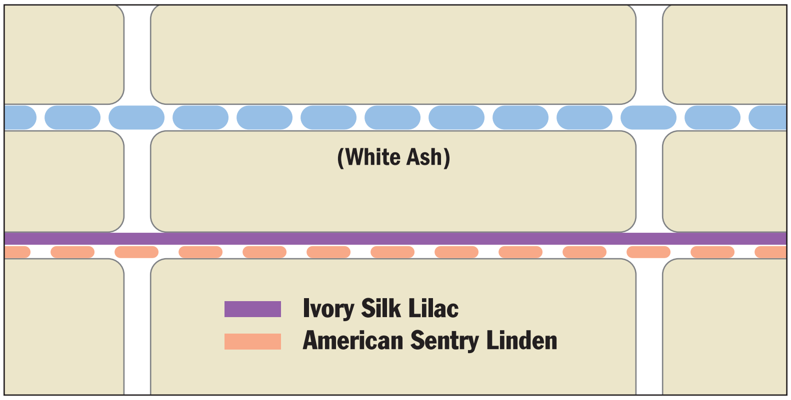


Figure 6.1c. Questionable assignments.

What Factors Determine Where Street Trees Should be Placed and Positioned?

This issue addresses the placement of row plantings and positioning of individual trees within the street corridor. Placement involves the location of a row planting parallel to the curb or edge of street, and is influenced by the presence and location of a sidewalk and/or unused border area. Positioning involves the maneuvering or relocation of individual trees within the row to meet recommended setbacks, spacing standards and offsets, and to avoid interference with other established elements. Together, placement and positioning are functions of available space, and represent the culmination of locating street trees on the ground. Placement and positioning decisions integrate various issues such as right-of-way dimensions (ISSUE NO. 2), function assignments (ISSUE NO. 3), arrangement assignments (ISSUE NO. 5), species selection assignments (ISSUE NO. 6), locations of intrusions, spacing standards, and configuration patterns. Collectively, these definitive decisions are the precursor to the preparation of the planting plan or map that fixes the location for the installation of each individual tree.

Placement decisions will vary, depending on existing and impending corridor situations (see Table 7.1). In certain situations involving environmental limitations, satisfaction of design principles and/or social opposition, the placement of a row planting of trees on only one side of a street may be the most desirable or practical arrangement outcome.

If it has been decided to place trees in street-side raised (above ground) or grade-level (vault, pit) planters in situations where the sidewalk completely covers the area between the curb and face of the adjacent buildings (see Table 7.1, Situation No. 4), it should be realized that such trees typically have a relatively short life expectancy after planting and require a commitment to an intensive maintenance program. Generally these trees live only 3 to 10 years due to related water stress (e.g., either excess or deficit) and inadequate rooting space.

Research involving grape vines and experience with bonsai trees suggest that if containerized trees are pruned to maintain a balance between root and shoot growth, their longevity might be significantly increased (Krizek 1987). However, it is likely that such pruning will, over time, artificially dwarf and distort the natural form of the tree. The shortened longevity and premature death of street trees grown in planters can be directly related to the inadequate rooting space or soil volume of the planters. The recommended soil volume of 2 cubic feet of soil for every square foot of crown projection (e.g., total ground area under dripline canopy) is a critical factor in predetermining the tree size a given planter will support (Bassuk 1991). For example, a raised planter 6’ square x 3’ high (108 cubic feet) will provide ade-

Table 7.1. Placement assignment criteria.

Situation	Placement Setting	Figure No.
1. Adequate area between curb and detached sidewalk.	Placement of trees in area between curb and sidewalk.	Fig. 7.1
2. Inadequate area between curb and detached sidewalk, adequate border area between sidewalk and property line.	Placement of trees in border area between sidewalk and property line. Avoid placement of trees between curb and sidewalk.	Fig. 7.2
3. Sidewalk adjacent to curb, adequate border area between sidewalk and property line.	Placement of trees in border area between sidewalk and property line.	Fig. 7.3
4. Sidewalk between curb and buildings (e.g., downtown, retail strip).	Placement of trees in raised planters or grade-level planters.	Fig. 7.4
5. No sidewalk with adequate border area between curb and property line.	Placement of trees in border area between curb and property line with allowance for future street widening or sidewalk, if warranted.	Fig. 7.5
6. No adequate area within right-of-way.	Placement of trees outside of right-of-way on private property at least three feet inside property line subject to easements or agreements. Avoid placement of trees in right-of-way.	Fig. 7.6
7. No adequate area between curb and property line. Adequate area in median.	Placement of trees in median. Avoid placement of trees in border area.	Fig. 7.7
8. Adequate area between curb and detached sidewalk or border area and in median (e.g., parkway).	Placement of trees in area between curb and sidewalk and in median. Optional placement of two rows in median at least 25 feet wide. Optional placement of two rows of trees on side of street that has adequate area between curb and sidewalk and between sidewalk and property line.	Fig. 7.8 Fig. 7.9

Figure 7.1. Adequate area between curb and sidewalk.

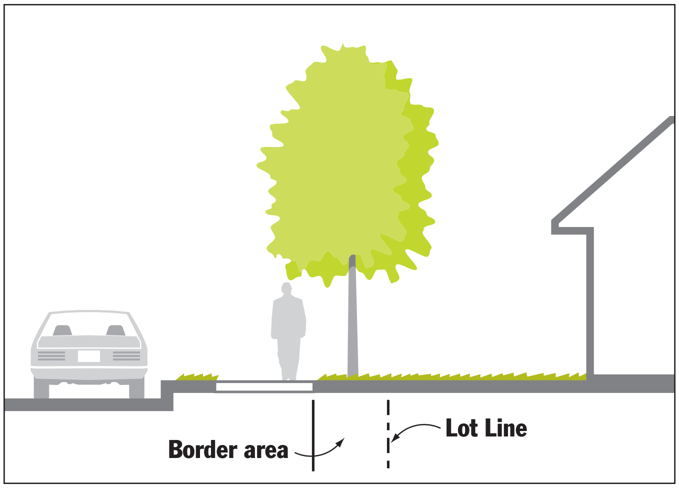


Figure 7.2. Inadequate area between curb and sidewalk. Adequate area between sidewalk and property line.

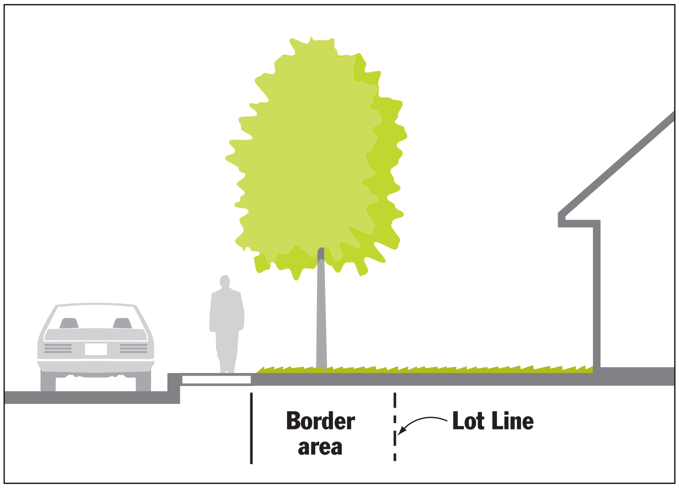


Figure 7.3. Sidewalk adjacent to curb. Adequate area between sidewalk and property line.

Figure 7.4. Sidewalk between curb and buildings.

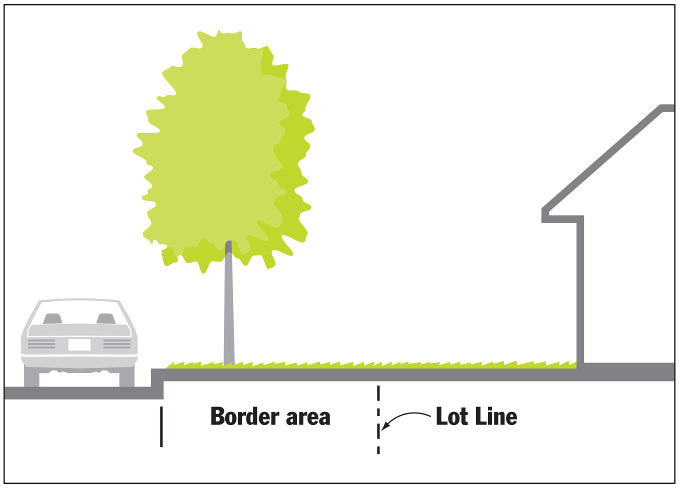


Figure 7.5. Unused border area (no sidewalk).

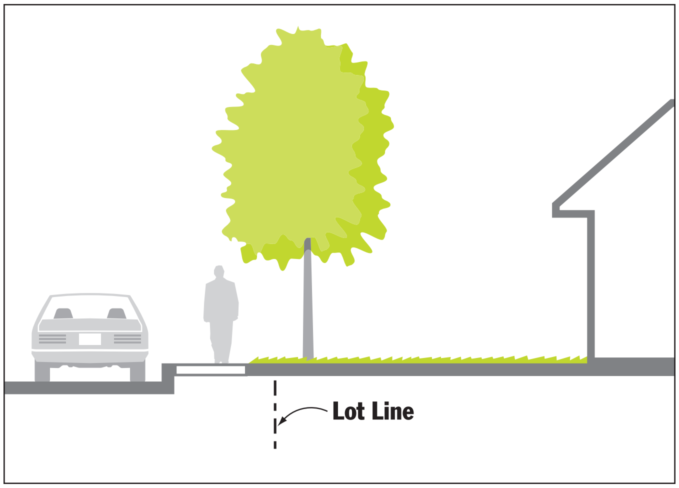


Figure 7.6. Inadequate area between curb and property line. Placement of trees outside of right-of-way.

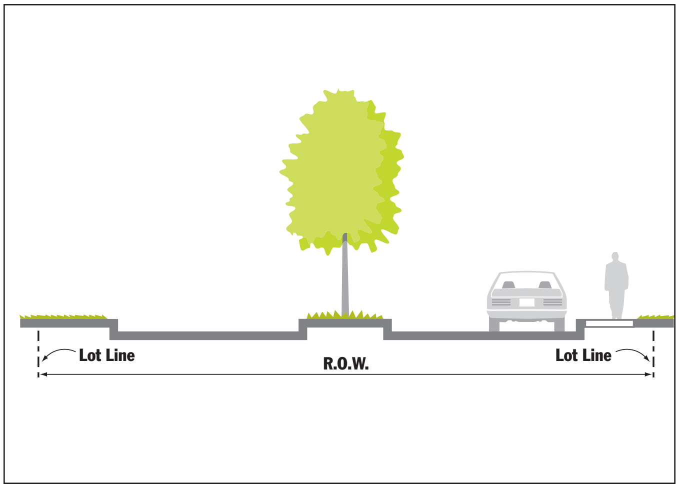


Figure 7.7. Inadequate area within right-of-way except for median.

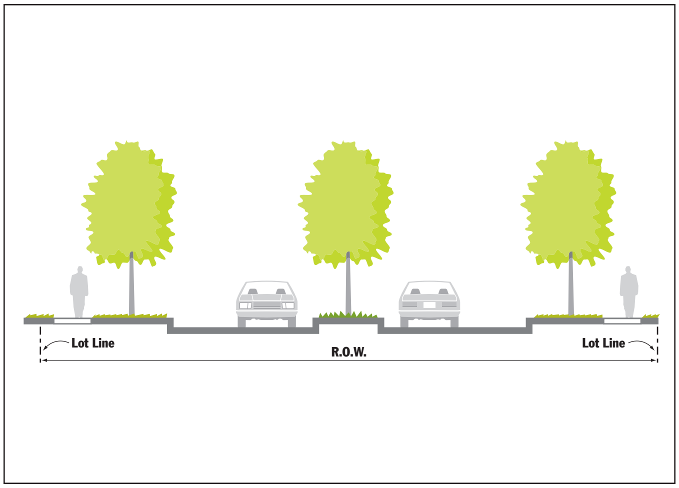


Figure 7.8. Adequate area in boulevard and median.

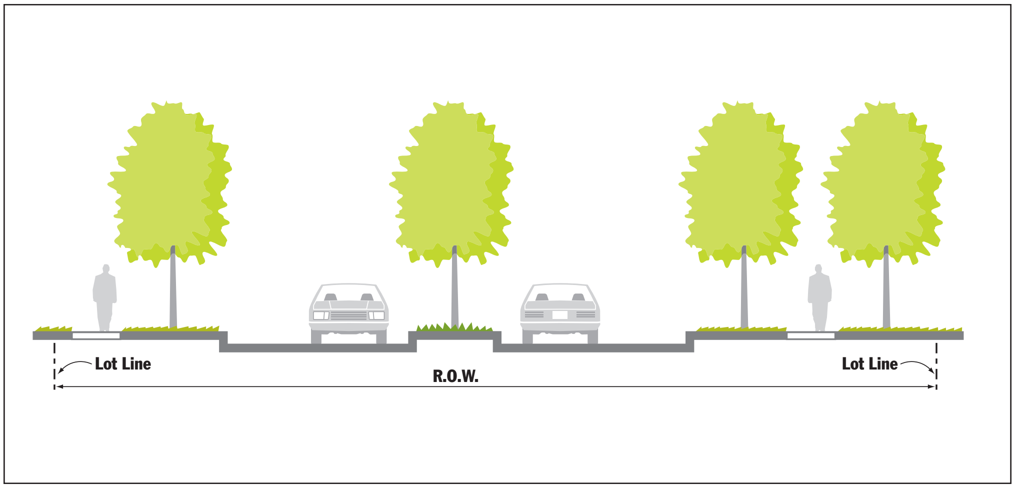


Figure 7.9. Adequate area in border area for double row of trees.

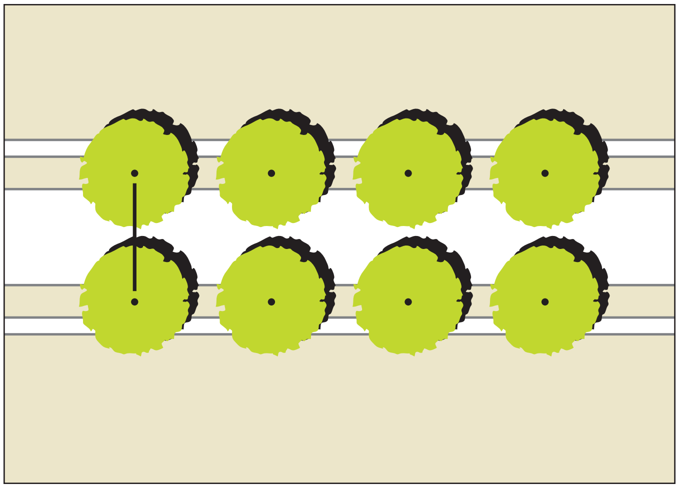


Figure 7.10. Opposite configuration.

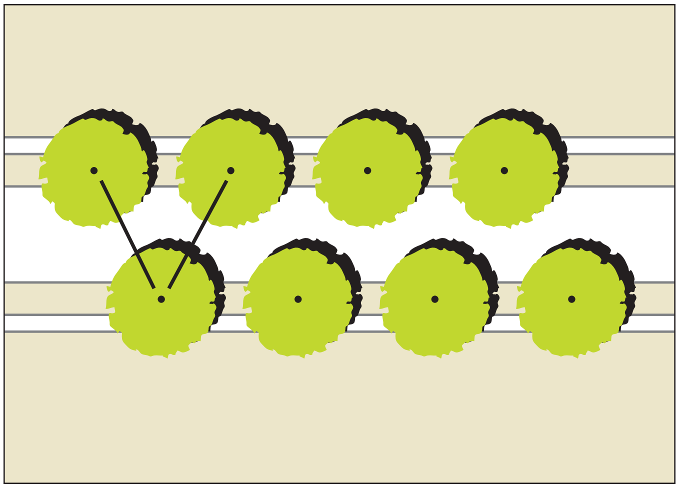


Figure 7.11. Alternate configuration.

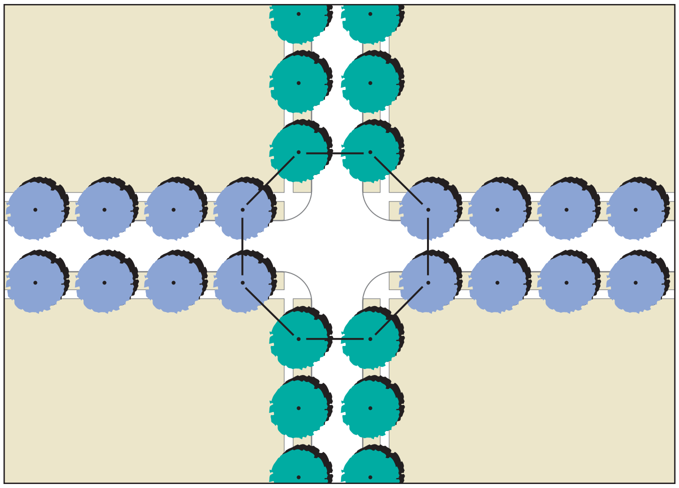


Figure 7.12. Visual balance at intersection provided by opposite configuration.

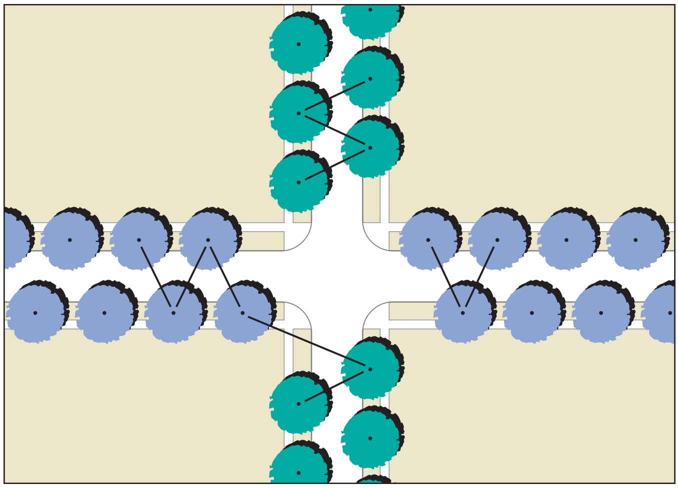


Figure 7.13. Visual imbalance at intersection caused by alternate configuration.

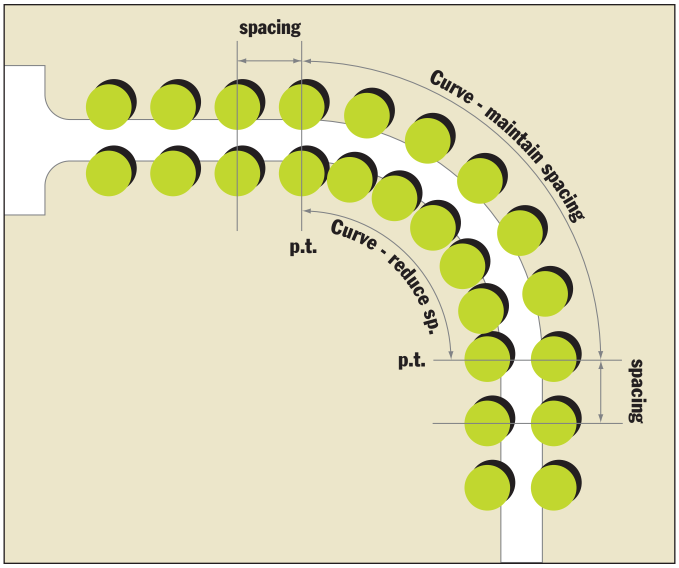


Figure 7.14. Corrective adjustments on curves.

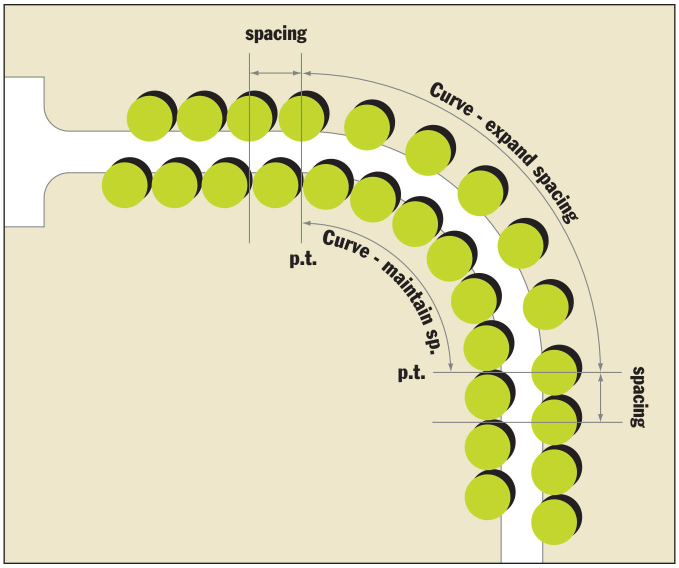


Figure 7.15. Corrective adjustments on curves.

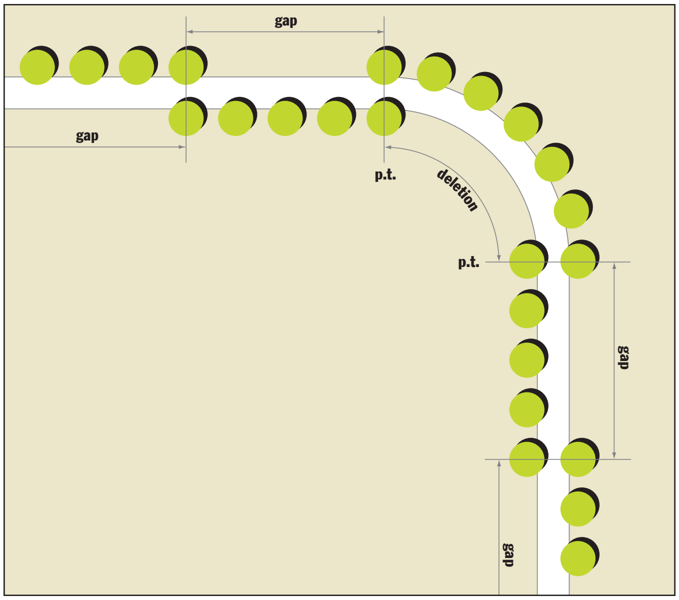


Figure 7.16. Corrective adjustments on curves.

quate rooting space and water reservoir for a tree with a crown spread of approximately 8-9 feet (crown projection of 54 square feet). It is evident that such a tree will need to be a columnar shaped species or a relatively youthful form of a larger growing tree that will require periodic replacement.

The decision to use planters requires that careful consideration be given to the selection of tree species that will tolerate the harsh and demanding conditions associated with planters, the design of the planters, and the quality and composition of the soil mixture. Above ground planter construction can be pre-cast or cast-in-place reinforced concrete or mortared brick or concrete modular units. Artificial or engineered soil mixtures (e.g., Amsterdam Tree Soil and Cornell University Structural Soil™) have been formulated for use as a load-bearing base and favorable rooting material under sidewalk pavements in conjunction with below ground tree pits.

Krizek (1987) recommends that candidate tree species for planters and pits have wide shallow highly branched roots, a slow rate of growth and tolerate air pollution, deicing salt, extreme cold, drought and waterlogging. Generally, raised planters have different structural and planting medium requirements than grade-level planters (e.g. insulation, automatic monitored irrigation, wick system, drainpipe, drainage material, surface grates, root barriers).

Positioning decisions will vary depending on factors such as the width of the street, width of the boulevard, locations of intrusive elements, proximity of adjacent buildings and design stratagem.

The following standards are recommendations and their use is discretionary. Lesser or greater requirements might be warranted by special circumstances. The recommended standards are based on the projected mature dimensions (e.g., crown spread and trunk diameter) of the various suitable tree species. If proven-adapted species are matched to their planting sites, and are not critically damaged nor attacked, they should attain a mature size, as did many street side American elms prior to their devastation by Dutch elm disease. However, shortened longevity probably will be the rule for street trees planted in above ground planters or in ground vaults in downtown or neighborhood retail areas.

Opposite vs. Alternate Configuration and Width of Street

The most common positioning practice involves the repetition of a single species in parallel rows with the trees on one side of the street positioned opposite or at right angles to the companion trees on the other side of the street (see Figure 7.10). When streets are relatively narrow (20 to 30 feet wide) and there is limited tangential space for crown development, trees might be placed in an alternate position or diagonally from their companion trees on the opposite side of the street (see Figure 7.11). The drawback to alternate positioning is that it produces a configuration of trees at the intersection which dismantles the visual balance and order needed at intersections (see Figure 7.12 and 7.13).

Uniform Spacing and Intrusive Elements

Generally trees in a row planting are positioned at a uniform spacing (equal distance apart) that is directly related to the typical mature crown spread of the subject species (see Table 7.2). Ideally, the crowns of adjacent or opposite trees will not or, at most, barely touch when they reach maturity. Frequently, the presence of intrusive elements or obstacles such as light standards, utility poles, hydrants, gate valves, driveways, crosswalks, underground utility connections, and remnant trees can disrupt the desired or assigned uniform spacing. In response, the standardized distance between some trees may have to be subtly increased or decreased or heights

Table 7.2. Spacing relationships.

Mature Crown Spread*	Recommended Spacing**	Example Species
Very Narrow >20'	10'-20'	Amur Maple, Columnar Norway Maple, Crabapple (var.)
Narrow 20'-35'	15'-35'	Celebration Maple, American Hornbeam, Crabapple (var.), Ohio Buckeye
Intermediate 35'-50'	30'-50'	River Birch, Kentucky Coffeetree, Black Ash, Green Ash, Ginkgo
Wide 50'-75'	45'-75'	Red Maple, Sugar Maple, Thornless Honeylocust, White Ash, Hackberry, Swamp White Oak, Pin Oak, American Linden
Very wide >75'	60' – >75'	White Oak, Northern Red Oak, Bur Oak.

* *Source: Hightshoe, G.L. 1988. Native Trees, Shrubs and Vines for Urban and Rural America. A Planting Design Manual for Environmental Designers. Van Nostrand Reinhold, New York, NY.*

** *The recommended spacing reflects natural crown development, unaltered by containment pruning.*

Table 7.3. Offsets from intrusive elements.

Intrusion	Recommended Minimum Offsets	Comments
Light standard	18’	Variable based on luminaire mounting height, overhang from curb and angle of light distribution. Trees should not be in conflict with line of light.
Utility pole	10’-18’ dependant on cross arm size.	Generally trees should not be in the same alignment as utility poles.
Hydrant	15’	Allows for repair excavations in accordance with O.S.H.A. standards.
Gate valve	15’	Allows for repair excavations in accordance with O.S.H.A. standards.
Driveway	10’	
Cross walk	5’	
Transformer, connection box,	6’	
Underground utility connection	15’	Allows for repair excavations in accordance with O.S.H.A standards.
Street sign	6’	Allows for trunk/root flare and typical width of walk-behind mower. Signposts could be relocated forward of proposed tree location.

of tree canopies adjusted to accomodate the function of the element (e.g. lights) accordingly (see Table 7.3). The occasion may also arise when an individual tree should be deleted in order to maintain the overall visual integrity of the row planting. Although it would be an equitable decision to locate a street tree in front of each adjacent residence or business, it might not be practical, in some instances, if adequate area is not available and the uniform spacing standard is to be maintained.

It should be noted that on curved road alignments, it is very likely that the designated configuration (e.g., opposite or alternate) and/or the spacing between trees in a row planting will have to be modified to accommodate the geometric effect of the difference between the radii of the inside and outside edges of such curves. The need for such modification is a function of the length of curve and corresponding degree of curve. The lesser the degree of curve, the greater its radius and length of the arc. Obviously, the longer or flatter the general curve (centerline of road), the closer it is to a straight alignment, and thereby less adjustment to the positions of affected trees will be required. Corrective adjustments would involve:

1. maintaining the selected configuration on both sides of the street, but adjusting the spacing between trees accordingly on one side of the street. Either increase the spacing on the outside curve or decrease the spacing on the inside curve (see Figure 7.14 and 7.15) or

2. deletion of trees on one side of the street through the length of the curve (from tangent point to tangent point). Such deletions could be fit into a modular repeat pattern on the subject street (see Figures 7.16).

Proximity of Adjacent Buildings

Regardless of where street trees are placed within the corridor, the expected mature crown spread or overhang should not exceed one-half the distance between the trunk or axis of the tree and the adjacent building in order to minimize encroachment and avoid tree/building conflicts (see Figure 7.17).

Table 7.4. Setbacks from curbs and sidewalks.

Mature Trunk Diameter	Recommended Minimum Setback	Minimum Boulevard Width*	Example Species
<12”	2 1/2’	5’	Japanese Tree Lilac, Crabapple (sp.)
12”+	4’	8’	Ohio Buckeye, River Birch, Red Maple
24”+	5’	10’	White Ash, Thornless Honeylocust, Pin Oak, Black Ash
36”+	6’	12’	Red Oak, White Oak, Hackberry, Green Ash, Kentucky Coffeetree, Sugar Maple
48”+	7’	14’	American Linden, Bur Oak

** Based on positioning tree in center of boulevard strip.*

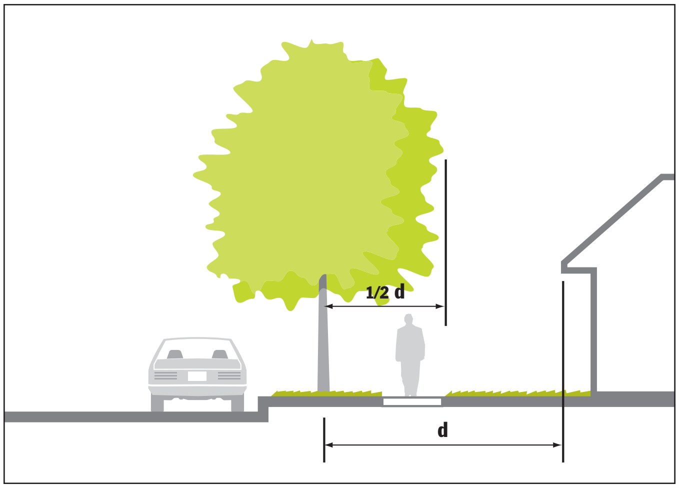


Figure 7.17. Proximity to adjacent buildings.

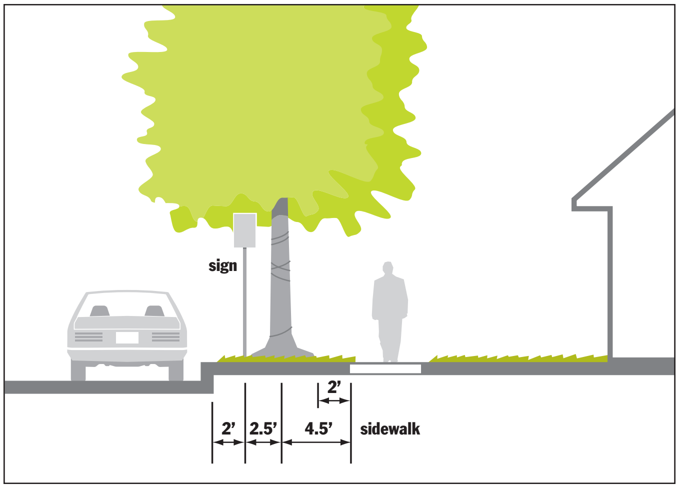


Figure 7.18. Setback from curb.

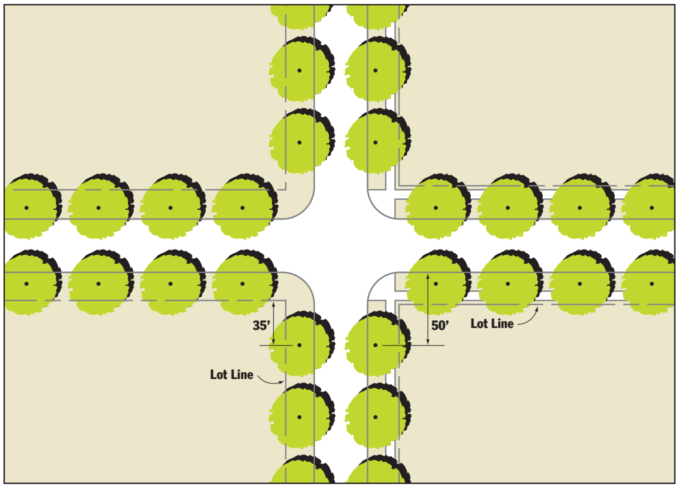


Figure 7.19. Clear-view triangle or setback at intersections.

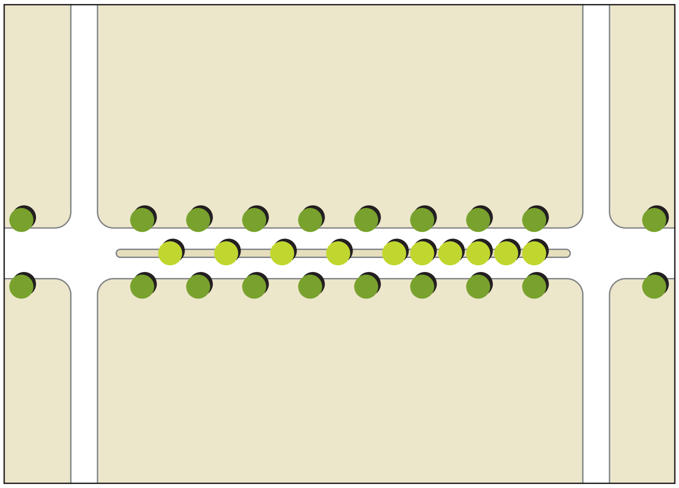


Figure 7.20. Spacing reduction to create an illusion at intersection.

Proximity to Curb-line and Sidewalk

Due to potential conflicts, street trees should be subject to the following setbacks in relation to adjacent curbing and sidewalks (see Table 7.4). Each setback includes an allowance of two feet streetward for street signage, and the typical space occupied by trunk/root flares (see Figure 7.18). Some units of government might have a policy requiring that all trees planted in the right-of-way must be at least six feet from the back of curb for purposes of snow removal and storage, and traffic safety.

Proximity to Intersection

It is imperative that sight lines remain unobstructed at roadway intersections for the purpose of traffic safety. Consequently, no tree should be placed closer than 50 feet to the nearest perpendicular curb line nor closer than 35 feet to the nearest perpendicular lot line in order to provide sufficient sight distance that respects the area of a "clear view triangle". Maximum vehicle speed limits and intersection controls can influence such minimum setbacks. (See Figure 7.19).

Note: Consult with the responsible, local road ahthority engineer for exact safety clear zone setback requirements.

Design Stratagem

There are certain situations where deviation from the recommended standard spacings are appropriate. Generally such modifications are intended to achieve a creative design strategy. A pattern of significant breaks or gaps can be introduced into a uniform row planting to add visual interest by creating a different sequential rhythm (see Figure 7.20). A significant reduction in the spacing between the last few trees toward the end of a row planting in a long median can encourage deceleration near an intersection by creating the illusion that a vehicle's speed is too fast since trees are passing by more quickly (see Figure 7.20). Changing the species of the last few trees (e.g., shorter height, columnar form, finer texture, grayer foliage color) will strengthen this intended effect. The repetitive rhythm of a row planting can be changed by graduated sequencing where the spacing between trees decreases or increases every few trees in a series of gradual steps leading respectively to an important destination or exit from an area.

The payoff for following a thorough planning process is seeing the related sound decisions represented in a thoughtful street tree master plan document. The payoff for following a thoughtful street tree master plan will be an established flourishing street tree population in the subject community.

Literature Cited

Krizek, D.T. and S.P. Dubik. 1987. *Influence of Water Stress and Restricted Root Volume On Growth and Development of Urban Trees*. J. Arboriculture 13:47-55.

ISSUE NO. 8

What Information Should be Included in the Master Plan Document?

This issue addresses the preparation of the street tree master plan document. The typical format for such a document is an 8.5" x 11" stapled or bound booklet. Generally, there will be two versions of the document. The draft copy or preliminary version is submitted to the elected officials (e.g., city council, town board), appointed officials (e.g., planning commission, park board), affected departments (e.g., road authority, park authority), and local residents (e.g., property owners, business owners) for review and comment. (Note: Prior to the start of the planning process it was determined that the community is street tree receptive and a street tree master plan should be prepared [see ISSUE NO. 1]). The final copy or adopted version will duplicate the preliminary version except that it will include revisions (e.g., deletions and additions) imposed by the approval authority following prescribed or established procedures.

Typically, public input (e.g., concerns, criticisms, objections, suggestions, requests) will be in the form of verbal remarks at public meetings and/or written comments relative to particular issues. Following the public input process, the approval authority probably will adopt the document contingent on certain modifications and amendments in response to public input and its own judgments. (Note: If the approval authority did not support the idea of a street tree planting program, the planning process would not have been initiated [see ISSUE NO. 1]). The adopted version is the official document that will guide future street tree planting efforts in the community. Since the master plan, in most cases, represents a multi-year strategy and effort, it should remain a dynamic rather than static guide, subject to amendment, as needed, to adjust for changing factors.

The typical components of a street tree master plan document and their sequence are outlined below.

MASTER PLAN DOCUMENT FORMAT
Cover Letter (draft version-separate from document)
Cover
Title Page
Credits
Table of Contents
Cover Letter (adopted version - included in document).
Introduction
    Background
    Intentions
    Vision
    Scope of Planting Program
    Benefits of Urban Trees
    Planning Process
    Street Settings
    Tree Species List
    Composition of Proposed Tree Population
    Tree Characteristics
    Planning Area Index Map
    Species Assignment Maps
    Bibliography
    Appendix

Often, the generic content of a master plan will include "implementation priorities," "time schedules," and "budgets." However, due to the instability (e.g., postponements and availabilities) of several elements such as local funding, cost share grants, supply of certain tree species, timing of road improvement projects, timing of overhead wire removals (e.g., burying of wires), neighborhood politics and public services equitability, it might be prudent to sidestep such published commitments.

Cover Letter

In keeping with the two versions of the master plan document, two cover letters will need to be prepared. Since the draft version of the master plan was probably prepared by a department staff person or an appointed planning group, the accompanying letter should be signed by the director of the responsible department or chairperson of the advocacy committee. The letter that will accompany the adopted official version of the master plan should be signed by the community's chief executive official (e.g., mayor, town board chairperson). In most cases, the content of the second letter will duplicate much of what was stated in the first letter. Usually such letters are prepared by a person directly involved in the planning process. Typically, the cover letter that accompanies the draft version is a separate document, whereas the cover letter that accompanies the adopted version can either stand alone or be incorporated into the pages of the document.

The cover letter should be a one or two page letter of transmittal on official letterhead stationary that presents the draft master plan document to elected officials and interested property owners, and the approved master plan document to the citizens of the community.

The letter should address the following points:

- importance of the planting or replanting program (e.g., community beautification, enhance quality of life, reforestation after devastation of tree population by disease or insect epidemic).
- scope of tree planting program (e.g., number of trees to be planted and general time frame).
- purpose and benefit of a thoughtful master plan (e.g., planting program guide, promote species diversity and selection of tree species that are suitable for existing site conditions).

The letter accompanying the approved document might include a request that adjacent property owners help with aftercare watering and scout for disorders that could affect the health and survival of street trees.

Cover

Since the cover identifies the document, it should catch-the-eye and inform the reader of its content. To readily attract attention and remain durable, the cover should be printed on colored card stock or cover paper. Generally a cover will include the title of the document in large bold letters (e.g., STREET TREE MASTER PLAN or BOULEVARD REFORESTATION PLAN), name of the community, date of completion, adoption or printing (e.g., month and year), and a graphic rendering of a tree or trees (a photograph is a suitable substitute for rendered graphics).

The words “draft copy” might be stamped or printed on the cover of the preliminary version of the document to suggest that the plan is open to amendment and has not been cast-in-stone. Different colored covers and dates on the respective covers of the two versions will also help to avoid confusion when both documents are in the hands of the same reader.

If the document has been prepared under contract by a consultant, it is appropriate to include the name and address of the consultant on the cover.

Although the layout is often original and distinctive, some communities may require the use of a standardized cover format on all of their official documents.

Title Page

The title page is the first page of the document (discounting an inserted cover letter). It generally duplicates the information (minus the graphics) contained on the cover such as title (e.g., STREET TREE MASTER PLAN FOR CITY OF WOODALE), who it was prepared for (e.g., city council, department or commission), who it was prepared by (e.g., department, task force, consultant) including a contact address (postal and e-mail) and telephone number, and date of completion, approval or printing (month and year). The layout can be either typical and stylized or somewhat unconventional.

Credits or Acknowledgments

The credits page recognizes the individuals and groups that have participated in and contributed to the effort to prepare the master plan. Generally, the listing will include their names, affiliations (e.g., department, agency, organization) and specific role, contribution or job title. It is usually politically expedient to also list the names of the approval body (e.g., elected officials) in the adopted version of the plan.

Table of Contents

The Table of Contents lists the components of the document in an outline format in their order of appearance so the reader can quickly locate particular sections of interest. Each component or divisional topic is identified by the respective heading or topic title accompanied by the corresponding page number.

Introduction

The Introduction provides the reader with information that may be necessary to understand and appreciate the content of the document and the associated planning process. The introduction restates, in greater detail, some of the information contained in the cover letter. The introduction often includes a discussion of the following elements.

Typical examples of talking points are listed for reference and, if applicable, can be used to develop an outline to fit the subject community. It is not uncommon to present one or more of the following elements as separate components in the body of the document.

- Background—statement that chronologically recounts facts, events, and prior actions that have led up to the decision to establish a street tree planting program. (Talking points – e.g., citizens petition, prior community renewal projects, existing street tree population, prior street tree planting projects, impact of tree disease epidemic.)
- Intentions—statement that explains the intended purpose and use of the document. (Talking points – e.g., provide a planning and implementation tool, define planning goals and objectives, determine tree species selection, establish arrangement and placement criteria, inform elected officials and citizens, establish planting priorities, describe elements of planning process, guide implementation and maintenance authorities.)
- Vision—generalized statement that champions the benefits of the urban forest especially the contribution of a

street tree infrastructure. (Talking points – e.g., improve appearance of neighborhoods and community, enhance quality of life, build community pride and spirit, improve environment, contribute to redevelopment efforts.)

- Scope of Planting Program—statement that describes the nature and extent of the tree planting program. (Talking points – e.g., character of the community, number of trees to be planted, miles of streets with number of trees per mile, planting schedule, overall cost of program, funding source breakdown.)

Benefits of Urban Trees

A qualitative and quantitative description of the environmental, aesthetic, social and economic benefits provided by urban trees will demonstrate how street trees can improve a community's image, the quality of life of its residents and revenues of its businesses. As the backbone of the sales pitch, this component must establish the reasons for initiating a street tree planting program, reinforce the fact that street trees should be an integral part of a community's infrastructure and justify program costs relative to benefits received.

References and Resources:

Coder, K.D. 1996. *Identified Benefits of Community Trees and Forests*, University of Georgia Cooperative Extension Service - Forest Resources Publication FOR96-39.

Dwyer, J.F., McPherson, E.G., Schroeder, H.W. and Roundtree, R. 1992. *Assessing the Benefits and Costs of the Urban Forest*. Journal of Arboriculture. 18 (5): 227-234.

McPherson, E.G., Simpson, J.R., Peper, P.J., Maco, S.E., Gardner, S.C., Cozad, S.K. and Xiao, Q. 2005. *Midwest Community Tree Guide, Benefits, Costs and Strategic Planning*. U.S. Department of Agriculture – Forest Service; Newtown Square, PA.

Robinette, G. 1972. *Plants/People/And Environmental Quality*. U.S. Department of the Interior - National Park Service, Washington D.C.

Planning Process

A description of the process used to develop the proposed street tree master plan will provide the disclosure that readers need to be reassured that the plan will be equitable and is the result of an objective, responsible and thoughtful process. A typical outline for the narrative would include a chronologic summary of the following actions:

- Determination of local support of tree planting program (e.g., public meetings and survey) (see ISSUE NO. 1)
- Determination of tree species preferences (e.g., survey) (see ISSUE NO. 2)
- Determination of existing street corridor conditions (e.g., inventory) (see ISSUE NO. 2)
- Determination of street tree functions (see ISSUE NO. 3)
- Determination of species diversity goals (see ISSUE NO. 4)
- Determination of arrangement patterns (see ISSUE NO. 5)
- Determination of street and tree pairings (see ISSUE NO. 6)
- Determination of placement settings (see ISSUE NO. 7)

Street Settings

Street setting or placement options (see ISSUE NO. 6) should be illustrated by model elevation and plan views that show the various streetscapes or tree placement settings given certain corridor situations as affected by the type of street, width of the street, width of border areas, presence and location of sidewalks, presence of medians, and presence of overhead utility lines (see Figure 7.1 thru Figure 7.9 and Figure 8.1). The diagrams should also include an elevation that labels the elements of the typical street corridor (e.g., street, boulevard, sidewalk, border area, right-of-way). (See Figure 8.2). It would be helpful to the readers if each street or section of a street were listed under the model diagram that represents the tree placement setting appropriate for that street.

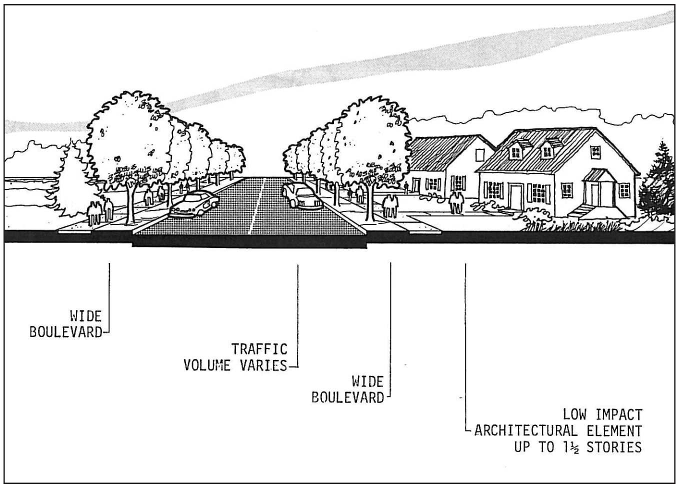


Figure 8.1. Example illustration of street setting.

** Source: City of St. Paul Street Tree Master Plan 1978*

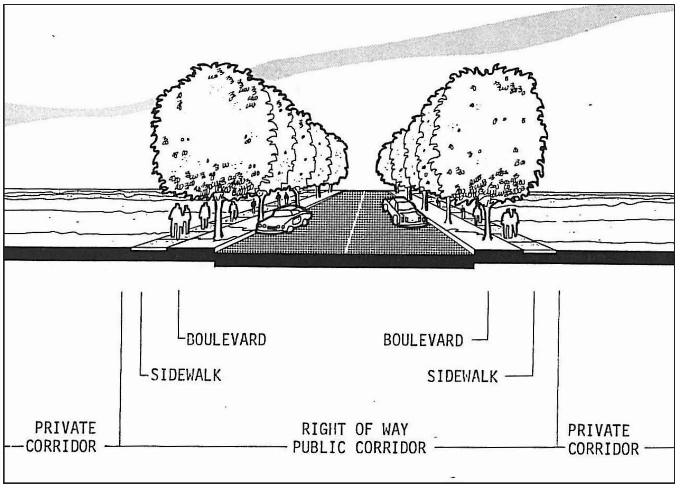


Figure 8.2. Example of graphic streetscape definitions.

** Source: City of St. Paul Street Tree Master Plan 1978*

Tree Species List

The tree species list or palette provides a listing of all of the tree species or kinds of trees (genera) that have been assigned to and will be planted on streets in the subject community (see ISSUE NO. 6). Although the selected tree species can be listed or arranged in several different sequences, the most common and effective system organizes them in alphabetical order of scientific or botanical nomenclature but identifies them by their more commonly recognized and widely spoken common name.

Example

Listing Order Common Name	**Organization Order Scientific Name (Genus/species)**
Amur Maple (tree form)	*Acer ginnala*
Deborah Maple	*Acer platanoides* 'Deborah'
Emerald Queen Maple	*Acer platanoides* 'Emerald Queen'
Red Maple	*Acer rubrum*
Autumn Spire Maple	*Acer rubrum* 'Autumn Spire'
Northwood Maple	*Acer rubrum* 'Northwood'
Sugar Maple	*Acer saccharum*
Green Mountain Maple	*Acer saccharum* 'Green Mountain'
Autumn Blaze Maple	*Acer x freemanii* 'Jeffersred'
Ohio Buckeye	*Aesculus glabra*
Common Hackberry	*Celtis occidentalis*
Thornless Cockspur Hawthorn	*Crataegus crusgalli inermis*
Autumn Blaze White Ash	*Fraxinus americana* 'Autumn Blaze'
Fallgold Ash	*Fraxinus nigra* 'Fallgold'
Marshall's Seedless Ash	*Fraxinus pennsylvanica* 'Marshall's'
Patmore Green Ash	*Fraxinus pennsylvanica* 'Patmore'

This list can serve as the legend or key for the Species Assignment Maps described below. If the list will serve this function, each tree species should be assigned a graphic symbol or letter-number symbol that corresponds to and will identify the tree species assigned to a particular street on the neighborhood or planning district base maps. If the addition of these legend symbols or codes will cause page congestion and disorder, a separate Species Legend Page should be prepared following the same order of succession described above.

The number of listed species will influence the type of symbols selected to represent the respective species. Obviously, the greater the number, the greater the variety of symbols needed. Although there are only 26 letters, each letter can be combined with other letters or numbers, making the possibilities endless (e.g., AB, A2). However, graphic symbols will be limited by the number of patterns available as a rub-on charting tape or computer graphic. Since the document, particularly the tree species assignment maps might be photocopied, the symbols used to denote the species must be distinguishable when the pages are printed in black-and-white.

The following examples demonstrate two effective letter/number coding systems for identifying the different tree species on Species Assignment Maps.

Example 1. Street Tree Species List

Coded for Reference

A	Amur Maple	
B1	Deborah Maple	*Both are Norway Maple varieties.*
B2	Emerald Queen Maple	
C	Red Maple	*Includes Red Maple and two varieties*
C1	Autumn Spire Maple	
C2	Northwood Maple	

Example 2. Street Tree Species List

Coded for Reference

A Maple
- A1 Amur Maple
- A2 Deborah Maple
- A3 Emerald Queen Maple
- A4 Red Maple
- A5 Autumn Spire Maple
- A6 Northwood Maple

B Ohio Buckeye
C Common Hackberry
D Thornless Cockspur Hawthorn
E Ash
  E1 Autumn Blaze White Ash
  E2 Fallgold Ash

Generally, the letter/number codes displayed in the two examples have been assigned based on the order of the respective tree species or genus groups on the tree species list and do not relate to the primary letters in the common or scientific names. (See Example Box 20: Neighborhood Tree Species Composition Map Legend). However, another commonly used system does assign letters to represent the abbreviations of the common or scientific names (e.g., SM - sugar maple, AS - *Acer saccharum*, ASG - *Acer saccharum* 'Green Mountain'). If it happens that two or more species initially share the same abbreviation, adjustments should be made accordingly (e.g., SIM - silver maple, SUM - superform maple, ASI - *Acer saccharinum*).

Composition of Proposed Street Tree Population (Tree Species Composition List)

Since species diversity is one of the principle goals of a street tree planting initiative, the inclusion of a list by columns and a related pie chart that shows the resultant composition of the proposed street tree population will demonstrate actual attainment of diversity objectives. (See Example Box 21: Neighborhood Tree Species Population List). The Tree Species Composition List should provide a numerical breakdown of the projected street tree population that reflects the number of trees by genus group and/or species, and their respective percentages of the total population. It might also be helpful to include individual pie charts that depict the genus and species composition percentages for each neighborhood or planning district.

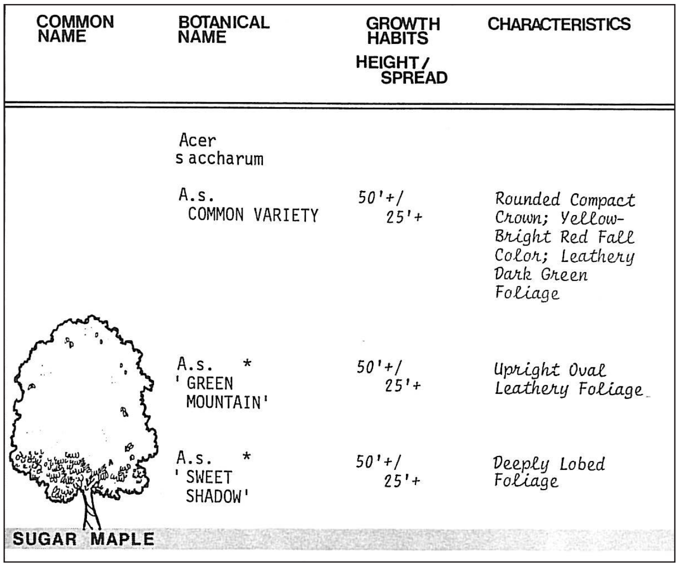
If the subject community has remaining remnants of an existing street tree population, columns should be added to the list that provide an inventory of the existing species, and the combined totals by species of the proposed plantings and the existing trees.

Tree Characteristics

A descriptive listing of the characteristics (e.g., concise description or table) of each tree species enrolled on the Tree Species List, accompanied by a silhouetted sketch of their respective forms will help the reader of the document to visualize and compare the various species selections (see Figure 8.3). The display should follow the order represented on the Tree Species List. Relevant

Symbol	**Species Common Name**
A1	Flame Amur Maple
A2	Autumn Spire Red Maple
A3	Red Sunset Maple
A4	Silver Queen Maple
A5	Unity Sugar Maple
A6	Celebration Maple
B	River Birch
C	Common Hackberry
D1	Autumn Blaze White Ash
D2	Fallgold Ash
D3	Northern Treasure Ash
E1	Northern Acclaim Honeylocust
E2	Shademaster Honeylocust
F	Ironwood
G	His Majesty Corktree
H1	Swamp White Oak
H2	Pin Oak
I	Ivory Silk Lilac
J1	American Sentry Linden
J2	Greenspire Linden
J3	Harvest Gold Linden
K	Discovery Elm

Example Box 20: Neighborhood Tree Species Composition Map Legend



COMMON NAME	BOTANICAL NAME	GROWTH HABITS HEIGHT/ SPREAD	CHARACTERISTICS
	Acer saccharum		
	A.s. COMMON VARIETY	50'+/ 25'+	Rounded Compact Crown; Yellow-Bright Red Fall Color; Leathery Dark Green Foliage
	A.s. * 'GREEN MOUNTAIN'	50'+/ 25'+	Upright Oval Leathery Foliage
SUGAR MAPLE	A.s. * 'SWEET SHADOW'	50'+/ 25'+	Deeply Lobed Foliage

Figure 8.3 Example of species illustration and listing of characteristics.

** Source: City of St. Paul Street Tree Master Plan 1978*

Tower Park Neighborhood

Genus Group	Species	*Neigh. Species Total	*Neigh. Genus Total	*Neigh. Species %	*Neigh. Genus %
Maple	Flame Amur Maple Autumn Spire Red Maple Red Sunset Red Maple Silver Queen Maple Unity Sugar Maple Celebration Maple	51 10 65 40 76 60	302	5 1 6 4 7 5	28
Birch	River Birch	10	10	1	1
Hackberry	Common Hackberry	68	68	6	6
Ash	Autumn Blaze White Ash Fallgold Ash Northern Treasure Ash	40 72 60	172	4 7 5	16
Thornless Honeylocust	Northern Acclaim Honeylocust Shademaster Honeylocust	80 34	114	7 3	10
Ironwood	Ironwood	48	48	4	4
Corktree	His Majesty Corktree	39	39	4	4
Japanese Tree Lilac	Ivory Silk Lilac	36	36	3	3
Oak	Swamp White Oak Pin Oak	60 12	72	6 1	7
Linden	American Sentry Linden Greenspire Linden Harvest Gold Linden	36 48 76	160	3 4 7	14
Elm	Discovery Elm	80	80	7	5
Totals		**1101**	**1101**	**100**	**100**

*Note: *The heading "City-wide" would be substituted for "Neighborhood" in a listing of all trees planted and to be planted along community streets in accordance with the comprehensive community street tree master plan document.*

Example Box 21: Neighborhood Street Tree Population List

characteristics should include growth habits (height and spread), form, summer and fall foliage colors, flowering habit, preferred soil conditions, and tolerances.

Species characteristics can be extracted from reference books, web sites, nursery catalogs and species recommendation guides published by universities and state departments of natural resources.

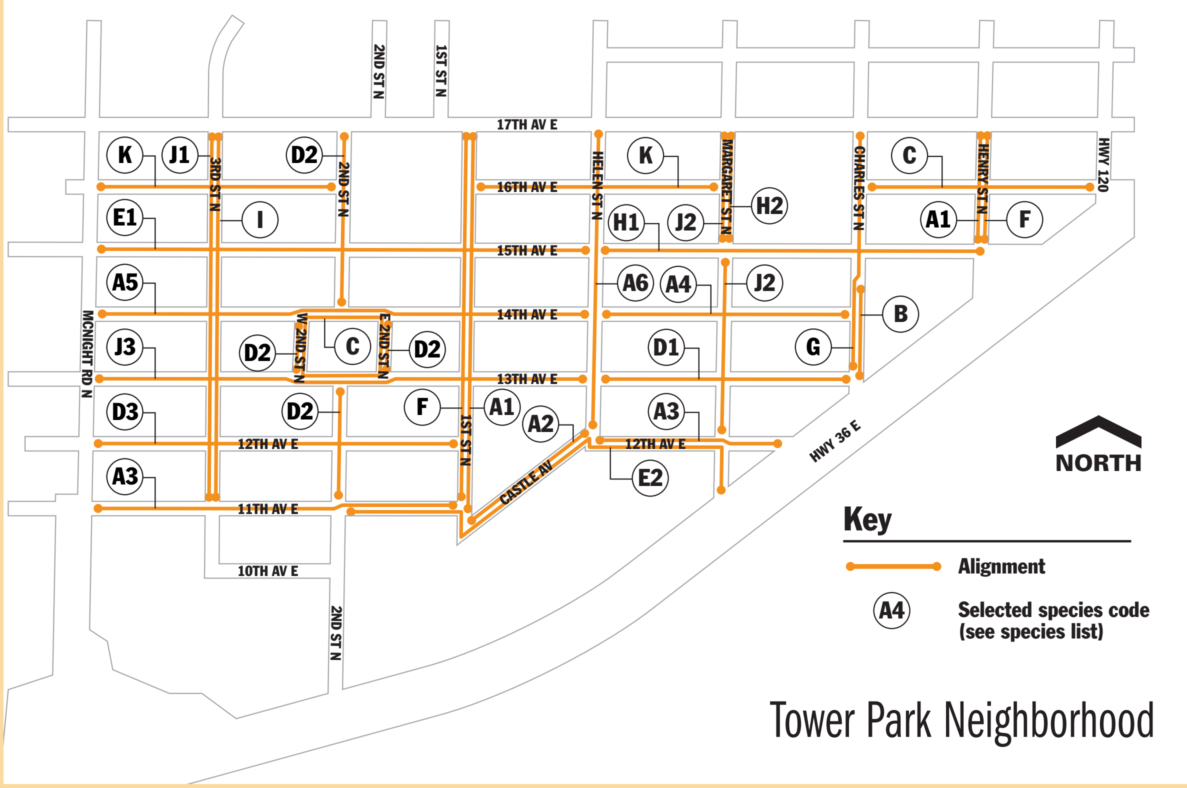
Planning Area Index Map

If the subject community is of a size that warrants a series of tree species assignment maps based on neighborhoods or planning districts, a map of the entire community with the respective areas outlined and labeled should be prepared as a reference index (see ISSUE NO. 6, Step 1).

Species Assignment Maps

The species assignment maps constitute the conventional diagrammatic plan component of the document. This series of maps indicates the conclusive pairing of each tree friendly street or section of a street with a designated tree species or combination of species. The assignment maps can be equated to the conclusion and recommendation components of other reports or documents.

The selection and assignment of a particular tree species is represented by a graphic symbol or letter/number code imposed on a basic street map of the respective neighborhood or planning district. (See Example Box 22: Neighborhood Species Assignment Map). Each area map should be identified by the traditional name of the neighborhood or planning district as indicated on the planning area index map.



Example Box 22: Neighborhood Species Assignment Map

Note: See Example Box 20 for Species Legend

Code	Species Common Name
A1	Flame Amur Maple
A2	Autumn Spire Red Maple
A3	Red Sunset Maple
A4	Silver Queen Maple
A5	Unity Sugar Maple
A6	Celebration Maple
B	River Birch
C	Common Hackberry
D1	Autumn Blaze White Ash
D2	Fallgold Ash
D3	Northern Treasure Ash
E1	Northern Acclaim Honeylocust
E2	Shademaster Honeylocust
F	Ironwood
G	His Majesty Corktree
H1	Swamp White Oak
H2	Pin Oak
I	Ivory Silk Lilac
J1	American Sentry Linden
J2	Greenspire Linden
J3	Harvest Gold Linden
K	Discovery Elm

Bibliography

A bibliography should be included as a component if publications (e.g., books, pamphlets, articles) were used as a source for some of the information presented in the body of the document (e.g., benefits of trees, species characteristics). The bibliography can also serve as a reference list of publications a reader can consult for additional information on certain issues.

Appendix

The Appendix is a separate section that follows the body of the document. Usually the appendix provides supportive information that is not critical to an understanding of the issue or issues being addressed by the document (e.g., resolution adopting the master plan, community tree ordinance or regulations). All too often, authors of master plan documents incorporate supplementary information that might be relevant to an overall discussion of the issue (e.g., planting details, pruning practices, sustainability) but these can remain separate stand-alone documents and be available if needed.

ISSUE NO. 9

What Circumstances Often Influence the Materialization of Thoughtful Street Tree Master Plans?

This issue addresses some of the realities that can arise to challenge the otherwise orderly and goal-oriented decision making and implementation process. Although one of the goals of the master plan is to provide uniform street-side row plantings of trees (see ISSUE NO. 5), it is likely that social, political, and environmental factors will impact the good intentions of the plan, especially the continuity of the row plantings.

Public Meetings

In communities that have neighborhoods or planning districts with strong identities, it is beneficial to organize and schedule one or more meetings in each area so that interested residents can be informed about the planning process and proposed tree species assignments. The objective of these meetings is to garner neighborhood support of the street tree planting program and form a general consensus relative to tree species assignments prior to the public hearing. The number of attendees will range from a handful to several dozen, and include both naysayers and proponents of the proposed plan. Interaction in these smaller gatherings will be more focused, simpler, and less confrontational, and personal feedback will be less inhibited than at an all-encompassing public hearing. Many issues may surface during these meetings, including some outside the scope of the street tree master plan. Usually, one of the most common concerns relates to the kind of tree to be planted on a particular block or in front of certain attendee's property. It is likely that the list of tree species in the master plan will include personal favorites and others that are generally disliked. A marketable master plan will be able to incorporate reasonable area concerns, without compromising the general intent of the plan.

Personal Preferences

It is generally accepted that, to be effective, a street-side row planting of trees must convey a sense of unity and continuity. As previously discussed (see ISSUE NO. 5), repetition of the same species or combination of species, size and spacing will produce the desired uniformity. However, based on the law of averages, it is predictable that, at any public meeting some property owners will request that no tree be planted or that a favorite species different than the one assigned in the draft master plan be planted in front of their property (see Table 9.1). If such species changes and resulting gaps are limited, the disruption will only impact their immediate locations and points-of-viewing, and may not have a noticeable effect on the integrity of the entire row planting on the subject street.

Although elected officials may appreciate the need to match a tree species to existing site conditions, it is unlikely, when confronted at a public hearing, that adherence to certain cultural and design principles will be a persuasive point. By their nature, elected officials are responsive to the wishes and pressures from the electorate, and will probably approve the master plan subject to requested deletions and substitutions. Although it would be appropriate to offer objective advisory comments or counter-arguments at a public meeting or in a written recommendation, the risk may outweigh the gain and could jeopardize approval of the master plan. It would be inept to belabor the issue. "It is better to lose an occasional battle, but win the war."

Problems with trees
Trees are a problem in cities because they cause allergies.
Trees should not be used in business districts because they block store signs.
Trees should be removed from cities because they can fall across power lines.
Trees should not be used in cities because they make it difficult to detect criminal behavior.
Trees should not be planted along streets because they drip sap or sticky residue on parked cars.
Trees should not be planted in cities because they are ugly when they are not maintained.
Trees should not be planted in cities because they cost the city too much.

Table 9.1. Potential problems that might cause some property owners to oppose the planting of street trees (Lohr, Mims, Tarnai and Dillman 2004)

Disparities and Irregularities

Overtime, it is not uncommon for the uniformity of a street-side row of trees planted at the same time to be challenged by the loss of trees within the row due to errant vehicles, disease, stressful site conditions, lightning, strong winds, and snow and ice loading. If the damaged trees are removed and not replaced, the resulting vacancies or gaps can affect the visual rhythm of the planting. A policy of no net loss of trees would signal the timely planting of replacement trees. Normally, replacement trees should be the same species as those that were damaged and are being replaced. A warranted exception would be in those cases where the loss was the result of stressful site conditions or insect/disease pressures that plague a particular species. In such cases, replacement trees should be a different, more tolerant species, and if possible, have visual qualities similar to the original species (e.g., mature size, form, texture and foliage color) to minimize the impact on the continuity of the row planting.

There are many examples in communities that have an established maturing tree population where several dissimilar tree species have been planted as haphazard replacements in an existing street-side row planting. These replacement trees have filled-in the gaps, but they might violate design principles and create visual disharmony. Irregularity can also occur when replacement trees are the same species as the existing remaining trees. It is likely that there will be a noticeable difference in size and form between recently planted replacement trees and the more mature existing trees. Although these differences will prevail for many years and consequently affect the continuity of the row planting, the resulting situation is an uncontrollable reality associated with biologic elements and the passage of time.

Size or growth disparity between trees of the same species planted at the same time can occur, over time, due to causal factors such as genetics, micro site conditions, girdling roots, and climatic stresses. This stunting or abnormal retardation of the growth rate will have the same effect on the uniformity of the row planting as the irregularities discussed above. If growth abnormalities are detected early on, and the cause can be and is corrected in a timely manner, the size difference should be positively resolved in a relatively short time. If the causes are not correctable, the stunted trees should be removed and replaced as soon as possible. However, this probably will not happen due to other planting priorities and funding limitations.

Literature Cited

Lohr, V. and C.H. Pearson-Mims, J. Tarnai, and D. Dillman. 2004. *How Urban Residents Rate and Rank the Benefits and Problems Associated with Trees in Cities*. J. Arboriculture 30:28-35.

What Other Actions are Required to Establish a Successful Street Tree Population?

This issue acknowledges the related activities that must follow, if a successful street tree population is to be realized. The master plan is only the first step in a series of steps toward accomplishing the initial vision. The mission that follows is like a chain, each subsequent step or required action is linked to and dependant on the action before and after it.

The successful establishment and sustainment of a street tree population involves not only a thoughtful master plan, but also the adoption and enforcement of a comprehensive tree ordinance, purchase of quality stock, adherence to proper planting procedures, conscientious performance of establishment care, ongoing individual tree maintenance and street tree population management. Together, these aims constitute the components of a community street tree program. However, by itself, the "best laid plan" remains just that, a plan of "good intentions". Although community streets may be planted with trees in accordance with the master plan, it is likely that, over time, the resulting tree population will suffer if any of the "links" are broken or missing. Unsuccessful plantings will be noticeable and can jeopardize public confidence and support.

Since this guide focuses on the recognition of a communal vision and preparation of a document (master plan) that will provide the foundation for its implementation, the subsequent actions associated with the street side planting of trees and sustainability of the resulting street tree population are only briefly discussed as they are authoritatively addressed in other publications. Those authoritative references are listed at the end of each of the following discussions.

Any person involved in establishing and overseeing a community's street tree infrastructure should have a full set of reference materials in their personal library. It is also advisable to maintain a collection of exemplary master plans, ordinances, specifications, maintenance and management programs from other communities.

Tree Ordinance

A comprehensive community tree ordinance should be "on the books" prior to the adoption of a street tree master plan. The ordinance will establish the community's authority to regulate and control the planting, maintenance, removal and preservation of trees within the community, and its jurisdiction over and ownership of trees within road rights-of-way. Without such control and assignment of responsibility, the planting (e.g. species selection and placement), care and protection of street trees would be subject to the whims of adjacent property owners and abuse by the general public.

References:

Bedker, P. and K. Himanga. 2001. *TREEORD: A Tool For Tree Ordinance Development*. Tree Trust, St. Paul, MN.

Deneke, F.J. and G.W. Grey 1978. *Urban Forestry*. John Wiley and Sons, New York, NY. Miller, R.W. 1997. *Urban Forestry: Planning and Managing Urban Greenspaces* (2nd ed.). Prentice Hall, Upper Saddle River, NJ.

Phillips Jr., L.E. 1993 *Urban Trees*. McGraw-Hill, New York, NY.

Quality of Planting Stock

High quality planting stock has the best chance of surviving transplanting from the nursery to the street side environment. Since high quality trees will experience less shock and quicker establishment, they will require less after care than unthrifty planting stock.

Regardless of their source (e.g. municipal or commercial nursery), trees destined for planting along street corridors should exhibit suitable development due to proper production practices. Each tree should conform to quality standards established by the American Association of Nurserymen (e.g. American Standard for Nursery Stock, ANSI Z60.1) and the quality provisions of a bidding specification commonly associated with plant material purchasing contracts. Generally, such quality standards and specifications require the trees to be hardy, undamaged, healthy and vigorous first-class representatives of their species. In particular, they should have a straight trunk with a dominant central leader, good form with sufficient properly spaced branches starting 6 to 8 feet above ground line, ample roots at proper depths and in balance with top growth, and be free from insects and diseases. Hardy stock is that which is obtainable from sources located within the limits of an "acceptable growing range" or respective plant hardiness zone. Compliant stock would include trees continually cultivated and grown within the boundaries of a designated growing range (same hardiness zone as subject community) for at least two years, or trees grown outside the acceptable growing range provided the seed source or root or graft stock originated within the acceptable range. (Minnesota Department of Transportation 2005).

Dependant on the size of the planting project (number of trees to be planted) and location of the grower or source of the stock, it would be advantageous to inspect and select (tag) the actual trees in the field, prior to digging. It is also advisable to inspect and approve the purchased stock upon or soon after delivery during temporary storage in a holding area, to verify that the trees are those that were tagged and continue to satisfy quality standards. Such action is a time management measure that will facilitate the timely delivery of substitutions for rejected trees. It will be advantageous to tag more trees than are being ordered in anticipation of some trees being rejected. If it is impractical or inconvenient to select trees at the source, and there will be a period of time between delivery and planting, inspection at the holding area is recommended. In any case, the trees should be inspected and/or reinspected at the planting sites prior to planting. Trees that do not conform to the applicable quality standards and specifications should be rejected.

A label should be attached to each shipped tree that identifies its common and/or scientific name. With the ever increasing threat of invasion by certain destructive insects and diseases, it is mandatory that lots or shipments of stock be accompanied by a "Certificate of Nursery Inspection" issued by the Department of Agriculture of the state of origin.

Since the grower is also responsible for the digging, handling and shipping of planting stock, purchase contract specifications should also include provisions that define these related operational procedures.

References:

American Association of Nurserymen (AAN). 1997. *American Standard For Nursery Stock: ANSI Z60.1* American Nursery & Landscape Association. Washington D.C.

Himleck, E.B. and G.W. Watson. 1997. *Principles and Practice of Planting Trees and Shrubs*. International Society of Arboriculture, Savoy, IL.

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Minnesota Department of Transportation: (MN/Dot). 2002. *Inspection and Contract Administration Guidelines for MN/Dot Landscape Projects*. Minnesota Department of Transportation, St. Paul, MN.

Treepeople. 1990. *The Simple Act of Planting a Tree: Healing Your Neighborhood, Your City and Your World*. Jeremy P Tarches, Los Angeles, CA.

Miller, R.W. 1997. *Urban Forestry: Planning and Managing Urban Greenspaces* (2nd ed.). Prentice Hall, Upper Saddle River, NJ.

Proper Planting Practices

Two common adages, "getting off to a good start" and "by the book" are apropos to the planting task. Like a bank deposit, the act of planting street trees represents a community's investment in its future with the hope that, over time, their continued growth and good health will yield desired benefits.

The actual planting of trees is the first visible physical act to implement the species selections and arrangement assignments proposed by the street tree master plan. The proper planting of trees in accordance with recommended techniques and "best planting practices" will eliminate losses during the establishment period and promote vigorous growth and good health. Typical planting operations include excavation of tree pits, preparation of backfill soil, setting trees in pits, removal of root ball wrapping, disruption of circling roots, backfilling, formation of basin collars, mulching and watering.

Contracted plantings should be done by skilled workers subject to the technical provisions of a comprehensive contract specification. Municipal crews and volunteer groups should receive specialized training prior to planting, and professional supervision during planting.

References:

Himelick, E.B. and G.W. Watson. 1997. *Principles and Practices of Planting Trees and Shrubs*. International Society of Arboriculture, Savoy, IL.

Tree Trust. 2001. *Community Planting Guide* (2nd ed.). Tree Trust, St. Paul, MN.

Establishment Care

The after-care that needs to be given to new plantings should begin immediately after planting and in effect, is a continuation of the planting process. By all standards, the planting process is not finished until the transplanted trees are established in their streetside locations. A tree is "established" when it has adapted to its new surroundings, resumed normal growth, replaced the lost roots and is able to persevere under normal conditions without assistance. It is during the establishment period that trees will experience transplanting shock due to the resulting reduction of the root mass. Under normal conditions, the recovery time for a transplanted tree is approximately one year for each inch of trunk caliper. The establishment period should be regarded as a period requiring regular inspections and intensive care to reduce or prevent stress related problems.

The primary cause of post-planting stress is too little or too much water. Judicious watering during the establishment period in accordance with recommended practices (e.g. proper amounts and frequency) will promote successful recovery and desired performance.

Other stress related factors can include competition for root space, insect pests and pathogens, weed growth, nutrient deficiencies and unnecessary wounding. Besides watering, maintenance measures such as fertilization, replenishing mulch, trunk protection (e.g. seasonal wraps and rodent barriers), pest and weed control and pruning might also be required during the establishment period.

Typically, contracted plantings are to be watered by the contractor during a specified one or two year maintenance or warranty period. Frequently, contractors slight or dismiss this critical requirement. This negligence is often due to a willingness to gamble that most of the trees will survive without adequate watering during the relatively short warranty period. Such waterings are difficult for an inspector to monitor, and being incidental to the bid price for planting, time/cost incentive favors omission rather than adherence to a judicious schedule.

An effective means to promote conscientious watering on a regular basis is to separate the watering task from the unit price for planting, and provide compensation for it as a separate pay item with payment to be made for each verified time that trees are actually watered.

If watering is to be the responsibility of the community, the task should be assigned to the same individual(s) for the duration of the growing season. Inherently, this person will develop a familiarity with micro-situations, "take ownership" of the project, be prideful of the level of survival and perform all related duties in a responsible manner.

Although volunteer efforts are laudable and promote advocacy, independent watering done by adjacent property owners tends to be unreliable, locationally spotty and difficult to monitor.

References:

Himelick, E.B. and G.W. Watson. 1997. *Principles and Practices of Planting Trees and Shrubs*. International Society of Arboriculture, Savoy, IL.

Ongoing Maintenance

The successful establishment of new plantings should not suggest that after-care can be concluded. In fact, the recovery and endurance of these transplants should signal the need to commit to an on-going maintenance program to ensure their continued survival. The intense, relatively short term watering program associated with establishment periods should transition to a combination of maintenance practices focused on the growth, structural development, appearance, good health and longevity of each tree. Such measures can be proactive (e.g. to prevent anticipated negative effects) and/or reactive (e.g. to correct occurring negative effects). An effective maintenance program will be based on a balance of both strategies.

The maintenance or long term care of trees until their eventual removal involves the execution of routine tasks directed at the trees as individuals. The maintenance given to each tree, in turn, contributes to the sustainability of the overall street tree population. Typically, tree maintenance tasks include pruning, fertilization, integrated pest management, wound treatment, bracing and cabling and hazard inspections. The type, level, frequency and priority of maintenance measures will vary with the species, size and maturity of the subject tree. Generally, maintenance during the early or formative years (trunk diameter 12 inches or less) should focus on development of a sound scaffold branch structure, natural form and pest management. Maintenance during the later or maturing years (trunk diameter larger than 12 inches) should focus on health, extending longevity, pest management, safety and removal.

Ideally, tree maintenance programs are adapted to a systematic and cyclic scheduling of the maintenance tasks based on cultural requirements and climatic patterns. However, crisis situations such as disease epidemics, insect infestation, snow and ice loading, wind storms and droughts often create a need for sporadic interventions.

Maintenance tasks are usually performed by responsible community department personnel or contractors. Contracted maintenance should be done by skilled technicians in accordance with the technical provisions of a comprehensive contract specification. In-house crews should receive specialized training prior to pruning and professional supervision during pruning operations.

References:

American National Standards Institute (ANSI A-300, Part 1). 2001. *American National Standard For Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance Standard Practices (Pruning)*. American National Standards Institute, New York, NY.

American National Standards Institute (ANSI A-300, Part 2). 1998. *American National Standard For Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance Standard Practices (Fertilization)*. American National Standards Institute, New York, NY.

Miller, R.W. 1998. *Urban Forestry: Planning and Managing Urban Greenspaces* (2nd ed.). Prentice Hall, Upper Saddle River, NJ.

Pirone, P.P., J.R. Hartman, and M.A. Sall, 1988. *Tree Maintenance* (6th ed.). Oxford University Press, New York, NY.

Street Tree Management Program

Street trees often comprise up to 25% - 30% of a community's tree population. As a significant component of the urban forest or green infrastructure of a community, the street tree population must be managed for its present and potential contribution to the physiological, sociological and economic well being of the community. Street trees are a vulnerable vegetative resource that can provide many benefits if the street side tree population can be sustained. Sustainability should be the underlying long-term goal of a street tree management program. Such programs focus on street trees as a population and their collective interactive relationship with the environment and society. Ensuring sustainability of the street tree population will ensure achievement of related long-term environmental, economic and social goals.

An effective street tree management program incorporates planning, organization, coordination and execution of component programs. Miller (1997) describes a successful street tree management program as one that involves enactment of a comprehensive ordinance, development of a street tree master plan, subsequent planting of trees, tree maintenance, tree removal and replacement, task scheduling, project funding and public participation. Miller (1997) further concludes that "good management involves the setting of goals and objectives, prioritizing them and developing specific strategies to achieve them".

Individual street trees will "come and go", but the street tree population must endure.

References:

American Forestry Association. 1989. *Shading Our Cities: A Resource Guide For Urban and Community Forests*. Island Press, Washington, D.C.

Clark, J.R., N.P. Mathney, G. Cross and V. Wake. 1997. *A Model of Urban Forest Sustainability*. J. Arboric 23:17-30.

Deneke, F.J. and D.W. Grey. 1978. *Urban Forestry*. John Wiley & Sons, New York, NY.

Miller, R.W. 1997. *Urban Forestry*, (2nd ed.). Prentice Hall, Upper Saddle River, NJ.

Phillips Jr., L.E. 1993. *Urban Trees*. McGraw Hill, New York, NY.

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Epilogue

Although this manual has focused on the organized street-side row planting of trees, it is not the intent to prescribe the paradigm that "an effective streetscape requires traditional row plantings" nor to disregard the contribution of bordering areas to the streetscape. To the contrary, decision makers in their role as planners, when addressing streetscape issues, are encouraged to "keep an open mind" and think beyond the bounds of the public right-of-way.

For the purpose of this discussion, the term "streetscape" refers to the vegetative or "green" elements of roadway landscapes, excluding non-vegetative elements such as pavement, lighting and furniture. Centered on the axis of the road, the streetscape incorporates street side row plantings as well as adjacent public and private border areas which can include residential front yards, office building frontages, parking lot enclosures, property delineations and miscellaneous land use screens and buffers. A panoramic streetscape contributes to the visual experience enjoyed by pedestrians, vehicle operators and passengers passing through a roadway corridor. Given the wide range of situations and conditions that exist within and along roadway corridors, it should be expected that by plan, default or happenstance, community streetscapes will take many forms.

Although it is likely that street-side row plantings will remain the most common directed landscape within roadway corridors, departure from the norm can be reasonable and feasible when medians and boulevard strips have abundant widths, and sight distances and pedestrian cross-circulation can be interrupted. Where appropriate, traditional street tree plantings could be supplemented or replaced by multi-tiered plantings featuring compositions of trees, shrubs and herbaceous perennials. Obviously, such plantings will require additional maintenance.

It should be remembered that it is not essential that streets be lined with trees. Even the patchwork collection of front yard landscapes of suburban neighborhoods without street trees can provide a pleasing streetscape. Interestingly, by choice or accident, possibly influenced by a sense of conformity, city code setback restrictions or mortgage requirements, front yard trees of different species often come to be in rows creating a semblance of street trees.

Plantings in public and private border areas or on properties adjacent to road rights-of-way such as a cemetery, school campus, townhouse complex, strip mall or park can do much to enhance the streetscape experience. Also remnant, vacant or forfeit parcels "filled" with plantings will expand the "green" dimension of a streetscape.

Streetscapes may begin with a row planting of trees, but the visual experience should not end street side. The possibilities and opportunities are limited only by the interest, imagination, cooperation and coordination of decision makers, developers, property owners and the general public. The identity and quality of a community and its neighborhoods will be reflected by the quality of its/their streetscapes.

Appendix

APPENDIX 1

Forms

This section of the Appendix contains the following full-size versions of the forms that were referenced in the discussion of a particular issue.

ISSUE 2	Form 2.1	Inventory Checklist
ISSUE 2	Form 2.2	Species Selection Matrix
ISSUE 3	Form 3.1	Function Assignments
ISSUE 6	Form 6.1	Species Selection Options

INVENTORY CHECKLIST

Street____

(Name)

Segment From ____________________ To ____________________

(Address or Cross Street)

Orientation ____

(e.g. North-South, East-West, etc.)

Urban Section ____________ Suburban Section ____________ Rural Section ____________

Width of Street ____________ Width of Right of Way ____________ Width of Boulevard ____________

Building Setback ____________ Character of Adjacent Buildings ____________________

____

Type of Street ____________ Traffic Volume ____________ Traffic Composition ____________

____

Type & Height of Overhead Utilities ____________________

____

Type & Height of Illumination Standards ____________________

Type & Location of Underground Utilities ____________________

Adjacent Land Use ____________________

____________________ Lot Widths ____________

Existing Street Tree Species ____________________

Existing Private Tree Species ____________________

____

Existing Soil Conditions ____________________

Salting Pattern & Practices ____________ Air Pollutants ____________

Sun/Shade Patterns ____________________

____

Prevalent Tree Pests, Diseases, Damage ____________________

Remarks ____________________

____

Species Selection Matrix Form

Neighborhood ____________ **Street** ____________ **From** ____________ **To** ____________

Hardiness								Natural Range		Height					Crown Spread					Trunk Diameter				Trunk Flare			Form									Mass			Branching Habit					Root Pattern			Foliage Duration	
Zone 2	Zone 3a	Zone 3b	Zone 4a	Zone 4b	Zone 5a	Zone 5b	Zone 6	Native	Non-Native	Very Short < 20'	Short 20' – 35'	Intermediate 35' – 50'	Tall 50' – 75'	Very Tall > 75'	Very Narrow < 20'	Narrow 20' – 35'	Intermediate 35' – 50'	Wide 50' – 75'	Very Wide > 75'	Small < 12"	Intermediate 12" – 24"	Large 24" – 36"	Very Large > 36"	Slight	Moderate	Buttress	Columnar	Conical	Globular	Irregular	Pyramidal	Rounded	Spreading	Upright	Oval	Open	Moderate	Dense	Upright	Ascending	Horizontal	Recurving	Descending	Shallow Lateral	Deep Lateral	Taproot	Deciduous	Evergreen

Foliage Texture			Summer Foliage Color										Autumn Foliage Color												Flower Color												Fruit Structure													
Fine	Medium	Coarse	Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Bronze	Purple	Maroon	Dark Green	Green	Light Green	Yellow Green	Yellow	Gray	Red	Orange	Brown	Bronze	Purple	Maroon	White	Gray	Yellow	Green	Pink	Red	Red-Purple	Purple	Orange	Brown	Blue	Inconspicuous	Seedless	Berry	Pome	Drupe	Multiple	Nut	Cone	Pod	Samara	Capsule	Strobile	Follicle	Achene	Aril

Allergen			Plant Sex			Soil Texture												Soil Drainage			Soil Moisture			Soil Reaction					Soil Compaction			Shade Tolerance			Artificial Lighting			Spray Salt			Soil Salt			Atmospheric Pollutants						
Low	Moderate	High	Perfect	Monoecious	Dioecious	Sand	Loamy Sand	Sandy Loam	Loam	Silty Loam	Silt	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay	Excessive	Moderate	Poor	Dry	Moderate	Wet	Strongly Acid 4.0 – 5.0	Moderately Acid 5.1 – 6.0	Slightly Acid 6.1 – 6.5	Neutral 6.6 – 7.5	Alkaline 7.6 – 8.5	Sensitive	Moderate	Tolerant	Intolerant	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sensitive	Intermediate	Tolerant	Sulphur Dioxide	Ozone	Oxides of Nitrogen	Peroxyacetyl Nitrate	Hydrogen Fluoride	Hydrogen Chloride	Ethylene

FUNCTION ASSIGNMENTS

Neighborhood

Street

Desired Functions	Priority	Desired Functions	Priority
A.		F.	
B.		G.	
C.		H.	
D.		I.	
E.		J.	

Comments

Street

Desired Functions	Priority	Desired Functions	Priority
A.		F.	
B.		G.	
C.		H.	
D.		I.	
E.		J.	

Comments

Street

Desired Functions	Priority	Desired Functions	Priority
A.		F.	
B.		G.	
C.		H.	
D.		I.	
E.		J.	

Comments

Street

SPECIES SELECTION OPTIONS

Neighborhood

Street

Suitable Species	Ranking	Selection
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		
J.		

Comments

Street

Suitable Species	Ranking	Selection
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		
J.		

Comments

APPENDIX 2

Footnotes – Inventory Checklist Factors

This section of the Appendix contains the designated footnotes to Table 2.1 in ISSUE NO.2 that expand the associated explanation of each identity factor.

1. If curbs are not in place, measurement is from edge of pavement to edge of pavement. If medians are present, measurement is from face of outer curb to face of opposite median curb.
2. The right-of-way can consist of both fee title ownership and permanent easements. The primary purpose of rights-of-way is to provide for vehicular travel including public transit, with the ancillary purpose of serving pedestrian and bicycle traffic. The right-of-way can include the street, boulevards, shoulders, drainage swales, sidewalks, and unused border areas. Unused portions of rights-of-way are often intended for future improvements or road widening and placement of public utilities.
3. Also referred to as "treelawn," "tree belt" or "curb lawn." Often the location of signage, streetlights, and underground utilities such as electric, gas, cable, and telephone lines.

   The width of tree-friendly boulevards should comply with the minimum standards established in Table 7.4, page –. The recommended trunk diameter/setback relationships reflect a clear zone setback of at least 2 feet to provide for the unobstructed viewing of street signage (e.g., parking regulations, traffic control, speed limits), unrestricted development of the maturing tree trunks and root flares and safe nondisruptive setbacks from sidewalks (e.g., existing or pending).

   The width of the boulevard also becomes a factor in estimating the adequacy of soil root zones to hold sufficient water to meet the transpirational demands of the selected trees. Lindsey and Bassuk (1991) affirm that 2 cubic feet of quality soil (e.g., proper infiltration and drainage, oxygen diffusion, water-holding capacity, fertility) for each square foot of crown projection (e.g., total ground area under dripline of a canopy) will provide soil volumes that promote and support tree growth and longevity. If it is postulated that a street tree's root zone is generally contained within the boulevard, the available volume of soil can be calculated by multiplying the width of the boulevard (ft.) by the spacing between trees in the row planting (ft.) by the optimum depth (3 ft.).

   For reference purposes, according to the rule of thumb, a tree having a mature crown spread of 20 feet and crown projection of 314 square feet (e.g., cockspur hawthorn, Japanese tree lilac, prairie fire crabapple) requires 628 cubic feet of soil volume which would be satisfied by a boulevard width of 10 feet and a spacing between trees of at least 21 feet (e.g., 10' x 21 x 3' = 630 cu. ft.). However, the roots of street trees typically extend under sidewalks into the front yards of the adjacent property and share root space with adjacent trees in the row planting, thereby increasing the available soil volume accordingly.
4. Typical minimum building setbacks required by city codes: Residential District = 30 ft., Commercial District = 25 ft., Industrial District = 50 ft.
5. Descriptive terms include: one story, two story, high rise, colonial, ranch, Tudor, single family, townhouse, condominium, apartment, office building, factory, warehouse, strip mall, shopping center, school, church.
6. Generally, streets are grouped into three categories: arterial, collector and local. Principal arterials such as freeways, expressways or interstate highways are not conducive to typical street-side row plantings. However, groupings, clusters or massings of trees, and compositions of trees with shrubs, that have adequate setbacks from traffic ways, and can be focused upon from fast moving vehicles do provide acceptable landscapes within high-speed highway rights-of-way.

   Minor arterial streets connect major centers within the community with access points to principal arterials, and serve less concentrated traffic generating areas. They serve as boundaries to neighborhoods, distribute traffic from collector streets and provide for movement of through-traffic. Traffic volumes are moderate and design speeds are relatively high, often requiring broad clear zones. These streets are usually spaced at 1-3 mile intervals.

   Collector streets provide direct service to residential neighborhoods and commercial and industrial areas, connect local streets with arterials, and provide local through routes. Traffic volumes are low to moderate and the minimum design speed is 30 mph. These streets are usually spaced at half-mile intervals.

   Local streets provide direct access to abutting land and through traffic is discouraged. Convenience of the motorist is secondary with overriding consideration directed toward fostering a safe and pleasant environment. Traffic volumes are low and design speeds are 20-30 mph.
7. Vehicle size (e.g., cars, buses, delivery trucks, tractor-trailers) will establish the minimum clearance height.

Typical vehicle dimensions are described in American Institute of Architects: 1981. *Architectural Graphic Standards*. John Wiley & Sons, New York, NY.

Generally, streets have a minimum clearance requirement of 14-16 feet.

8. Average daily traffic counts (ADT) reflect the total volume of vehicular traffic during a given time period (in whole days). Such data does not pinpoint the variations in traffic that typically occur during the monitoring period. The volume of traffic, by itself, is not significant. Instead, it is the potential by-products that can affect tree health and consequently influence tree species selection.

The potential for tree damage from deicing or anti-icing salt applications increases proportionally as traffic volumes increase. Generally, deicing salts are applied to the high-volume, high-speed roads (e.g., collectors and arterials). Air contaminants (e.g., ozone, nitrogen oxides and peroxyacetyl nitrates) from vehicle exhaust emissions also increase along roadways as traffic volumes increase.

9. Trees with a mature height greater than 18 feet should not be located under overhead utility lines nor be planted closer to the utility lines than their respective height at maturity. Allowance should also be made for a clear zone around utility poles.

Generally, in new subdivisions, utility lines are being placed underground. Some progressive communities are requesting that, over time, existing overhead distribution lines, circuits, and systems within road rights-of-way be relocated underground. Such underground utilities can also obstruct or preclude placement of street trees.

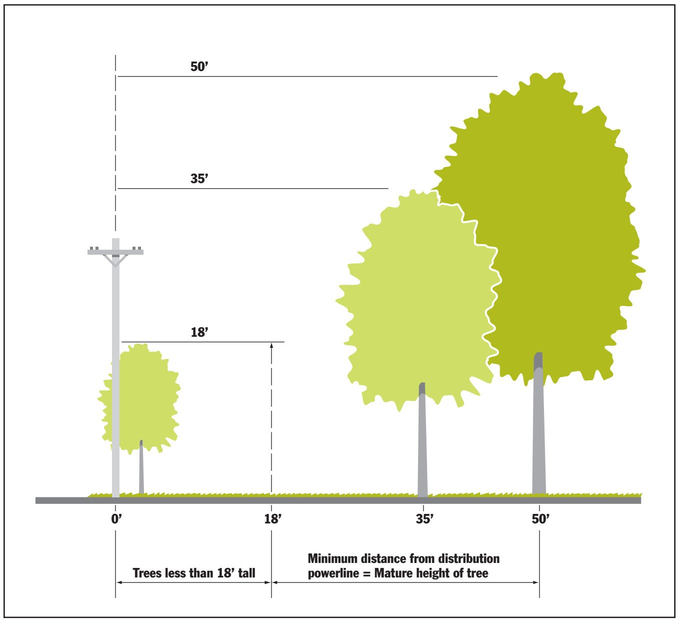

Figure A 2.1 Distance from power lines

10. Nighttime lighting can produce extended vegetative growth and delayed dormancy when natural conditions are otherwise prompting the slowing and stopping of seasonal growth (Cathy et al. 1975). Research indicates that such lighting in excess of 1 ft. - c influences the photoperiod and can have an unfavorable impact on the resulting unhardened growth when subjected to early frosts. Similarly, winter dieback will be more severe on photo-responsive or photoperiodically sensitive trees exposed to all-night artificial light (Hightshoe 1988).

High-intensity-discharge (HID) lamps such as mercury vapor (Hg), metal-halide (MH), and high-pressure sodium vapor (HPS) are replacing the less efficient incandescent (INC) filament lamps. When compared, the order of photoperiod response influence (high-low) is INC>HPS>MH>Hg (Andresen 1976). Incandescent light sources emit the greatest amount of far red light, the wavelength which promotes shoot elongation.

Although street trees can be intentionally placed to intercept (e.g., block or filter) nighttime glare from streetlights, their height, spread, and foliage density can also interfere with intended light distribution due to improper placement. The mounting height and overhang of the luminaire and the vertical angle of light distribution will establish the proper offset for each type of tree as related to its mature size and form or eventual pruning heights to mitigate safety issues.

11. The existing types of underground utility service and relative locations within the rights-of-way should be identified. If sidewalks are present, it is likely that underground utilities are located within the boulevard area. If there is no existing sidewalk, it is likely that the utilities are located within the border area 10-15 feet from back-of-curb. Underground utilities can include gas, electric, telephone, and cable, and are typically buried at depths of approximately 1 - 3? feet below grade. Burying utilities in boulevards or border areas without sidewalks has been a common practice for 35 – 40 years. Although this measure eliminates the potential for conflicts between street trees and overhead utility services, for all practical purposes, it has replaced one problem with another. The excavation of planting pits can be dangerously close to the existing burial depth. Typically, excavators are required to maintain a minimum horizontal (side-to-side) clearance of 2 feet between the buried facility and the cutting edge of any power-operated excavating

equipment. Careful hand digging with hand tools or vacuum excavation is permitted, provided there is no unauthorized relocation or undermining of lateral support. The alignment of such utilities can be located and marked, but due to liability issues it is unlikely that specific depth readings would be noted. Facility depths may vary due to installation practices, changes in grade, frost, erosion, and other variables. It is not unusual to discover cable and telephone lines less than 12 inches below grade.

The location of existing underground utilities (e.g., alignment and depth) might rightly preempt the planting of street trees in some roadside areas. Otherwise, it might be feasible to adjust the normal placement of trees in such situations if the boulevard is of adequate width and the buried lines are deeper than 4 feet.

Just as broken branches from street trees can down overhead wires during a storm, windthrown or uprooted street trees can disrupt buried facilities entangled in uplifted root systems.

Overtime, the root systems of existing street trees may be damaged (severed) by underground utility repair operations and/or the installation of such lines.

Water and sanitary sewer mains are in the street, and service lines running to buildings are at a depth of at least eight feet. Storm sewers can be installed at varying depths and usually are below and parallel to the overlying curb and gutter, except where they run to a nearby storm water treatment pond.

12. Adjacent land use can have a marked influence on available boulevard space and growing site conditions. Typical land use categories include: single family residential, multiple family residential, manufactured housing, commercial, office, light or heavy industrial, mixed use, institutional (e.g., school, church, library, civic building), park, open space, railway.

13. Minimum lot widths for single and multiple family residential dwellings are based on municipal code standards and can vary with the age of the subdivision, time of platting, and age of the community. Early platting might have required single-family residential lots to be 45 feet wide, whereas contemporary provisions require single-family lots to be at least 80 feet wide and multiple-family lots to be at least 60 feet wide. Whether a lot is 45 or 80 feet wide, with allowances for driveways, walks, utility poles, and luminaires, there is probably adequate space for only one tree per standard residential lot.

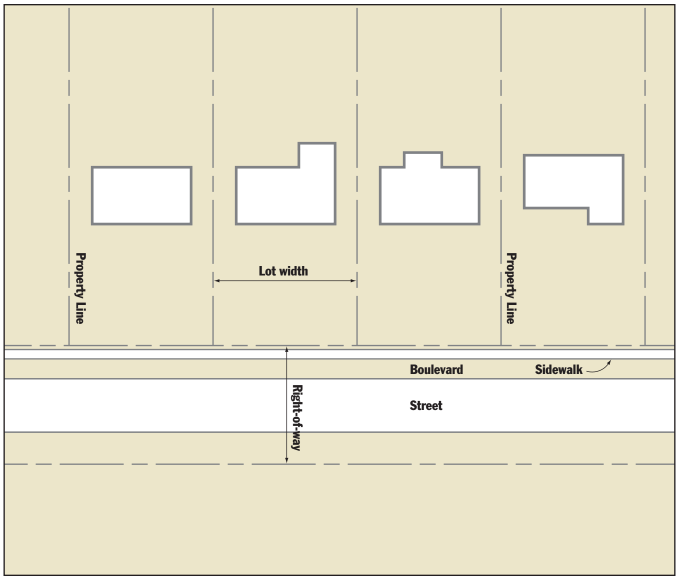

Figure A 2.2 Lot width dimensions

14. Information should include the location, species, size, and existing condition rating for each tree. Existing trees might be remaining remnants from a prior public planting initiative impacted by disease infection, insect infestation, ice storm, strong winds, or adverse site conditions, especially if they are the same species or reflect a design pattern within the same block. If remaining trees within the same block include several different species and do not reflect any design pattern, the subject trees might have been planted by adjacent property owners or may be overlooked naturally established pioneers.

If the existing trees are remnants of a prior planting, it would be advisable to determine the cause of the demise of the absent trees. If the cause was a biotic problem or intolerance of existing site conditions, it would be advisable not to in-fill with trees of the same species. However, if the existing trees are the same species, thriving, and not threatened by a particular problem, it might be advisable to plant the same species in vacant spaces. Existing trees planted by adjacent property owners might be an indication of their species preference. If existing trees do not match the species selected for planting on the respective street, the question arises as to what action, if any, should be taken to maintain the continuity of the plan. Also, it is likely that existing trees will be larger than the trees to be planted, and as such, may compromise the continuity of the plan as influenced by size uniformity (see ISSUE NO. 9).

15. Information should include the location, species, and size of existing trees. Evaluate the impact that existing trees will have on street trees and vice versa, especially competition for growing space and shading (irradiance levels).

16. Random or directed samplings can determine general soil type (e.g., sandy, silty, clayey, loamy, gravelly, peaty) and conditions such as moisture content, soil reaction, compaction, and fertility. Hand-held instruments or testing kits that will directly determine several of these factors are available through catalogs. Soil survey maps that provide a general overview of soil types within a particular county are available from the US Department of Agriculture Soil Conservation Service.

Existing soil conditions (e.g., quality and quantity) at planting sites have a critical influence on survivalibility and establishment of transplants and their extended health, growth, and longevity. The importance of soil quality increases as the required volume of soil is decreased.

The condition of roadside soils will range from suitable (good) to unsuitable (poor) due to prior site disturbance such as grading (cuts and fills), road and building construction, installation of underground utilities). In fact, existing soil conditions on the same segment of a given street may be a montage of soil types and properties. Boulevards can be listed among the most highly disturbed urban planting sites.

Poor quality soil limits the list of tree species suitable for such roadside plantings, and in turn will reduce overall species diversity within the street tree population. Conversely, modifications that improve soil conditions will greatly increase the selection of proven-adapted species. Generally, such modifications involve either removing and replacing the existing soil or adding amendments that will improve the structure, water-holding capacity, drainage, aeration, fertility, and soil reaction.

Soil modification in boulevards is expensive and difficult due to the sanctity of existing turf and spatial confinement by in-place curbs, sidewalks, and underground utilities. The simplest corrective measure involves digging larger planting holes and backfilling with improved soil at the time of planting. Otherwise, the most opportune time to improve existing soil conditions is in conjunction with a road improvement project that involves removal and relocation of curbs, relocation of utilities, and grade changes.

17. Injury from exposure to salt spray or drift and accumulation of salt from plowed snow storage or spring runoff and subsequent contamination of soil can result from winter use of certain deicers. No tree species is completely tolerant of salt injury, even reportedly salt-tolerant trees have limits on the amount of salt they can accept before they weaken and become vulnerable to other problems (Johnson 1995).

18. Exposure to high concentrations of certain gaseous pollutants (e.g., sulfur dioxide, fluoride, ozone, peroxyacetyl nitrates) and particulate pollutants (e.g., kiln dust, fluoride dusts, soot, sulfuric acid mist, metal processing dust) can cause injury to susceptible trees. Tolerant species can be used to abate gaseous, particulate, and odoriferous air pollution (Robinette 1972).

Pollutant	**Source**
Sulfur dioxide	Combustion of fossil fuels, ore smelting, manufacture of sulfuric acid and sulfur.
Ozone	Combustion of automobile and industrial fuels.
Peroxyacetyl nitrate	Automobile exhaust.
Flourides	Smelting of nonferrous ores; combustion of coal, manufac ture of brick, ceramics, cement, glass & phosphate fertilizers, hydrofluoric acid.

19. Existing elements such as other trees and buildings that produce an *urban canyon effect* can impact seasonal irradiance levels, thereby causing undesirable shade acclimation responses (Kjelgren 1995).

20. It would be irresponsible to plant tree species that are experiencing or have the potential to experience species population devastation (based on occurring pest distribution and avancement patterns) due to susceptibility or vulnerability to certain disease infection or insect infestation (e.g., Dutch elm disease, oak wilt, emerald ash borer).

21. If street tree plantings are to be phased over several years; it would be advisable to coordinate such phases with any street improvement projects scheduled for the same general time frame. Such tree planting might be considered a related improvement item and thereby qualify for funding through the construction project budget.

22. Driveways are a measurable interruption of the boulevard strip and can disrupt the predetermined uniform spacing of street trees. Also, trees located within the boulevard strip can constitute sight obstructions for drivers maneuvering onto a street from the adjoining property.

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APPENDIX 3

Determinants

This section of the Appendix contains a glossary that is intended to instill an understanding of the significance of each determinant and its relationship to the tree species selection process (see Table A.3). Generally, the determinants can be categorized into four groups: (1) provenance, (2) physical characteristics (features), (3) required soil properties, and (4) tolerance to injurious conditions.

Provenance	Physical characteristics	Soil properties	Tolerances
Hardiness	Height	Soil texture	Soil compaction
Natural range	Crown spread	Soil drainage	Shade
	Trunk diameter	Soil moisture retention	Artificial lighting
	Trunk flare	Soil reaction	Salt (spray salt and soil salt)
	Form		Atmospheric pollution
	Mass		
	Branching habit		
	Root pattern		
	Foliage duration		
	Foliage texture		
	Summer foliage color		
	Autumn foliage color		
	Flower color		
	Fruit structure		
	Plant sex-allergen relationships		

The composite created by each completed species selection matrix form (see Appendix 1, Form 2.2) will facilitate the efficient comparison of candidate tree species and their subsequent match-ups with the respective roadside planting sites.

Each determinant on the species selection matrix form is subdivided into a series of descriptive gradations. Collectively, the designation of applicable variables will characterize the desired species qualities and suitability for a given street. As determined in ISSUE NO. 2, Step 4, the identified variables will be recorded as highlighted or hachured cells on the respective species selection matrix form (see ISSUE NO. 2, Example Box 2: Completed Species Selection Matrix).

Most of the determinates and related gradations included on the species selection matrix form correspond to the search criteria (e.g., plant characteristics and site characteristics) featured in the Minnesota Department of Transportation (MnDOT) plant selection matrix, *Woody and Herbaceous Plants for Minnesota Landscapes and Roadsides*, available online at *http://www.plantselector.dot.state.mn.us/*. Some of the determinants on the matrix form that are overlooked in the MnDOT matrix such as “mass,” “branching habit,” and “artificial lighting tolerance” have been borrowed from the authoritative manual by Hightshoe (1988), *Native Trees, Shrubs and Vines for Urban and Rural America*. Determinants such as “trunk flare” and “trunk diameter” which are not addressed in typical references will require field verification or rely on personal knowledge.

Table A.3. Relationship priorities between species selection determinants and planning issues.

		Species Characteristics																Soil Properties				Tolerances				
		Hardiness	Height	Crown spread	Trunk diameter	Form	Mass	Branching habit	Trunk flare	Root pattern	Foliage texture	Foliage duration	Summer foliage color	Autumn foliage color	Flower color	Fruit structure	Plant sex-allergen	Soil texture	Soil drainage	Soil moisture	Soil reaction	Soil compaction	Shade tolerance	Salt tolerance	Artificial lighting	Air pollutants
Longevity	Establishment	H																H	M/H	H	M/H	L/H		L/H		
	Survivability	H																H	M/H	H	M/H	L/H	M	L/H		L/H
	Growth and development	H								M								H	M/H	H	M/H	L/H	M	L/H	L/M	L/H
Design decisions	Functions		H	H		H	M	M			L/H	L/H	L/H		M											
	Diversity																									
	Design objectives		H	H		H	M	M			L/H	L/H	L/H	L/M	L/H											
	Arrangement compatibility		H	H		M	M	L			L/H	L/H	L/H	L/M	L/M											
	Spatial compatibility		H	H	H	H		M	H	M/H																
	Placement		H	H	H	H			H	M						M/H										
	Positioning		H	H	H	M	L/M	L/M	H	M																
	Public opinion														H	H	L/H									

Key: H=high, M=medium, L=low

Artificial lighting tolerance—reflects the inherent level of susceptibility to deleterious effects caused by extended photoperiods due to night lighting.

Nighttime lighting coupled with favorable temperatures can produce extended vegetative growth and delayed dormancy when natural conditions are otherwise prompting the slowing and stopping of seasonal growth. Research indicates that nighttime lighting can have an unfavorable impact on the resulting undarkened growth when subjected to early frosts.

Influence: growth and development, positioning
Determination: inventory of type and location of light standards
Priority: Low to Medium

Atmospheric pollution tolerance—reflects the inherent level of susceptibility to the phytotoxic effect of gaseous air pollutants.

While trees have the ability to remove gaseous pollutants from the atmosphere, certain species can be injured by these same emissions. Gaseous air pollutants are the products of fossil fuel combustion and manufacturing processes and originate from "point" sources (stationary land-based locations) or "diffuse" sources (photochemical smogs–widespread accumulation of reactive chemical byproducts). Injury can range from chronic to acute depending on duration of exposure, concentration of pollutant, prevailing weather conditions, prior condition of tree and inherent sensitivity.

Influence: general health, growth and development, survivability, susceptibility to other problems
Determination: location of potential point sources, inspection of existing area trees (signs and symptoms), verification by soil test or foliar analysis (state university or private testing laboratory)
Priority: Low to High

Autumn foliage color—reflects the typical coloration of autumn foliage of a mature tree when grown in an open area under favorable conditions.

The primary colors of autumn coloration changes (e.g., yellow, orange, and red) each peak at different times. The first being yellow (early to mid-fall), followed by orange (mid-fall), and finally red (mid to late fall). Within a given area, each succeeding peak is separated from the prior peak by 7 to 16 days.

Influence: arrangement compatibility
Determination: design objectives, autumn coloration of nearby tree species
Priority: Low to Medium

Available soil moisture capacity—reflects the ability of a given soil to retain or store available soil water.

Water retention and availability are related to the size and distribution of soil particles (texture) and soil pores (micro and macro), and the attraction of soil solids for moisture (adhesion). Available moisture will be the amount of soil water held in micropores between "field capacity" and the "wilting point." Field capacity is the moisture content of a soil held in the micropores by surface tension after all "gravitational" or "free" water has drained from the macrospores immediately following saturation of the soil to its maximum retention capacity. The wilting point is the moisture content of a soil held in the smallest micropores by increased particle surface attraction and attraction between water molecules (cohesion) after additional soil moisture is lost due to direct evaporation from the soil surface and evapotranspiration from vegetation surfaces (point at which permanent wilting of a plant occurs). Although an adequate amount of water may remain in the soil at the wilting point, it is not readily available due to the tension of the attractive forces. (Buckman and Brady 1965)

Moisture held in macropores in excess of field capacity limits is "superfluous" water and of no benefit to trees. In fact, such water, if held too long, causes the soil to become anaerobic leading to the suffocation of roots, reduced bacterial activity, adverse biochemical changes, and leaching of nutrients.

Silty soils have the greatest capacity to hold water that will be available for use by trees.

Influence: establishment, survivability, growth and development
Determination: field analysis (soil moisture meter)
Priority: High

Branching habit—reflects the typical structural arrangement and directional pattern of growth from the main trunk of a mature tree when grown in an open area under favorable conditions (Hightshoe 1988)

Branching habit will influence the inherent crown spread and form of the tree.
Influence: functions, arrangement compatibility, spatial compatibility (encroachment conflicts)
Determination: function expectations, traffic and pedestrian clearance requirements
Priority: Low to Medium

Compaction tolerance—reflects the inherent level of susceptibility to the deleterious effects of compacted soil.

Compaction is the result of physical compression of the soil aggregates producing disaggregation into individual particles and disintegration of the soil structure. Common causes of soil compaction include pedestrian and vehicular traffic, site grading operations, and stockpiling of soil.

Compaction increases the density (weight per unit volume of dry soil) by filling macropores with soil particles. Soils of a uniform texture (regardless of particle size) are more resistant to compaction than complex soils consisting of a broad mix of different sized particles. Fine textured (clay) and wet soils are more vulnerable to compaction than coarser textured (sandy) and drier soils. Soils are most vulnerable to compaction when they are at "field capacity" and macropores filled with air. (Harris 1983).

Compaction creates an impervious soil surface (greatest density 0.75" below surface) and destroys permeability in the upper soil horizon (4" to 8" deep). The resulting soil condition impedes the infiltration and percolation of water and aeration (gas exchange capacity-oxygen for carbon dioxide). Compacted soil conditions impair root development.

Influence: establishment, growth and development, survivability, susceptibility to biotic and abiotic disorders.
Determination: bulk density test, compaction meter
Priority: Low to Medium (High if soil area is subjected to significant pedestrian traffic)

Crown spread—reflects the typical horizontal dimension or distance between the outer reaches of the branches at the widest section of the crown of a mature tree when grown in an open area under favorable conditions.

Crown spread or "dripline" width is the dimensional basis for deriving "crown projection", one of the factors used to calculate the adequacy of the soil volume incorporating the root zone of the subject tree.

Note: Crown spread, height, and trunk diameter constitute the "size" of a tree which can be impacted by environmental conditions and physical surroundings.

Influence: functions, arrangement compatibility, spatial compatibility (encroachment conflicts), placement, spacing, positioning
Determination: function expectations, design objectives, species combination criteria, spatial limitations, scale relationships
Priority: High

Foliage duration—reflects the typical leaf life span of a tree when grown in an open area under favorable conditions.

Deciduous–leaves are shed annually in early to mid-autumn
Evergreen–leaves (needles in most cases) remain on the tree throughout the entire year or longer. Some needles (2-10 years old) will be shed each year, dependant on the species.

Influence: functions, arrangement compatibility
Determination: function expectations, design objectives
Priority: Low to High

Foliage texture—reflects the typical aggregation of leaf forms as it relates to the size, shape, pattern, and proportion of the composite leaves of a mature tree when grown in an open area under favorable conditions.

Other factors that affect the appearance of leaves include the type of tip, margin, stiffness, veining, thickness, and surface quality. Foliage texture is one of the factors that contributes to "crown density" or "mass."

Influence: functions, arrangement compatibility
Determination: function expectations, design objectives
Priority: Low to Medium (High if required for design or arrangement purposes)

Flower color—reflects the typical hue or coloration of blossoms (female or perfect flowers) of a tree when grown in an open area under favorable conditions.

Although most species flower during spring, there are a few species that flower during later summer and autumn. Some species are dioecious and bear female (pistillate) flowers on one plant and male (staminate) flowers on another. Selection of species that have such male flowering plants will resolve fruit-related maintenance and nuisance issues. Also, some cultivars produce sterile flowers and thereby do not yield fruit (seedless). However, it should be noted that such male flowering dioecious species are producers of pollen that can trigger allergy and asthma attacks.

Influence: functions, arrangement compatibility
Determination: function expectations, design objectives, objections of adjacent property owners relative to resulting petal litter, and fruit production.
Priority: Low (High if flowering is required for design purposes, or if petal drop, eventual fruit debris and fruit projectiles are viewed as maintenance and nuisance issues or if pollen-induced allergies and asthma are a health concern)

Form—reflects the typical crown shape of a mature tree when grown in an open area under favorable conditions.

Form is a visual classification that describes the outline of the crown in geometric terms, and generally reflects the dimensional relationship between the horizontal and vertical axis of the crown. The typical form of most species changes, over time, as the tree matures.

Influence: functions, arrangement compatibility, spatial compatibility, placement, spacing, positioning
Determination: function expectations, species combination criteria, spatial limitations
Priority: Medium (High if a certain form is required for design purposes and spatial limitations)

Fruit structure—reflects the typical type of ripened seed vessel of a tree when grown in an open area under favorable conditions.

Some fruits have the potential to become nuisance ground litter, projectiles, and attract birds that produce an accumulation of offensive excrement.

Influence: placement
Determination: public acceptance, municipal maintenance (cleanup) commitment
Priority: Medium (High if there is negative public acceptance and no maintenance commitment by municipality)

Hardiness—reflects a cold-hardiness rating indicated by the code assigned to the northernmost zone (distinct geographic region delineated by isotherms) in which the species will tolerate the average annual minimum temperatures. (A species might not be completely winter hardy when subjected to local temperature regimes or prolonged periods of the coldest or abnormally low temperatures.) The respective zones are defined on a nationwide map published by the US Department of Agriculture (USDA). The outlined zones represent a 10° F incremental difference and are subdivided into an "a" and "b" area, with the "a" zone incorporating the lower minimum temperatures

Note: Although rated as winter hardy within a given zone, some species might be injured by winter temperatures when placed in aboveground planters.

Influence: establishment, survivability, growth and development, planting stock source
Determination: USDA Plant Hardiness Zone Map
Priority: High

Height—reflects the typical vertical dimension or distance from the ground line to the top of the crown of a mature tree when grown in an open area under favorable conditions.

Note: Height combined with crown spread and trunk diameter constitute the “size” of a tree which can be impacted by environmental conditions and physical surroundings.

Influence: functions, arrangement compatibility, spatial compatibility (encroachment conflicts), placement, function expectations, positioning
Determination: design objectives, spatial limitations, scale relationships
Priority: High (very high if under overhead wires)

Mass—reflects the typical density of the crown of a mature tree when grown in an open area under favorable conditions.

Crown density reflects the amount of branches, foliage and reproductive structures that block light visible through the crown (Tallent-Halsell 1994). Density can be measured as a ratio of positive to negative space within the outline of the crown and is defined by the degree of opacity, translucency or transparency (Hightshoe 1988).

Influence: functions, arrangement compatibility, positioning
Determination: function expectations, design objectives
Priority: Low (Medium if certain density is required for design purposes or artificial light distribution)

Natural Range—reflects the inherent growing range or geographic origin of a species based on its distribution prior to European settlement in the United States.

The designation of “native” can infer being indigenous to a particular region, state or more specifically to an area such as a county or community. Typically, the term is not applied to cultivars, even though the hybrid parents or parent cutting or seed source is/are indigenous to a given area.

Influence: selection policy
Determination: species geographic distribution maps (see references below)
Priority: Low to High (High if native species are required by community policy or cost share grant criteria)

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Plant sex-allergen relationship—reflects the inherent propensity of a species to produce pollen that will exacerbate allergy and asthma problems.

Pollen is an allergen produced by male flowers or flower parts that can trigger allergy and asthma attacks.

Generally, "monoecious" species that have separate male and female flowers on the same plant and especially male flowering dioecious species that have male and female flowers on separate plants are the worst offenders. Pollen produced by "perfectly" flowered species having bisexual flowers (flowers containing both male [stamens] and female [pistils] parts) is heavy, sticky, and normally not conducive to being windborne.

From an allergy point of view, female flowering dioecious species and pollen-free cultivars are the most suitable selections. The prevailing trend to select litter free or "clean" (e.g., seedless or fruitless) heavy pollen producing dioecious male species has worsened allergen levels.

Other factors that contribute to a tree's capacity to aggravate allergies and asthma are the duration of flowering, inherent weight and moisture level of pollen grains.

Influence: public opinion
Determination: neighborhood resident survey
Priority: Low (High if residents report chronic allergy or asthma problems and/or if fruit litter is considered a nuisance)

Root pattern—reflects the typical structural arrangement of the primary roots of the root system of a mature tree when grown in an open area under favorable conditions.

The inherent form of a root system can be altered by physical barriers, water table level, impermeable subsoil, and soil fertility.

Influence: spatial compatibility (encroachment conflicts), placement, positioning
Determination: existing planting site restrictions (hardscape infrastructure, underground utilities, building foundations)
Priority: Medium (High if there is limited below ground space or potential underground utility conflicts)

Salt tolerance—reflects the inherent level of susceptibility to the buildup of toxic levels of de-icing and anti-icing salt compounds.

Spray salt–accumulation of a toxic quantity of salt compounds deposited directly on aboveground parts (e.g., stems, branches, buds, and needles) by spray or drift as a mist or residue powder stirred by vehicles, traffic turbulence and/or winds.

Soil salt–accumulation of a toxic quantity of salt compounds carried by snow melt runoff and plowed snow, and deposited on soil overlying tree root systems.

Sodium chloride (Na Cl) is the most commonly used salt compound. Calcium chloride (Ca Cl) is also used, but typically reserved for the coldest temperatures. Sodium chloride is five times more toxic to trees than calcium chloride.

Reportedly, the greatest injury to trees occurs within 60 feet of treated roadways. Usually, salt applications for winter anti-icing and de-icing purposes are most commonly associated with high-speed, high-volume roads and intersections.

Trees can be predisposed to salt-related injury and decline by stress-causing climatic and environmental factors (e.g., drought and cold temperatures). The extent of injury will be influenced by the amount and concentration of salt deposited on trees and underlying soil, amount of rainfall, soil properties such as texture and permeability and age of affected trees.

Influence: establishment, survivability, growth and development
Determination: road authority (e.g., state and local) application records, inspection of existing trees for related symptoms, laboratory testing of soil and/or leaf samples
Priority: Low to Moderate (High if adjacent road is high-speed and high-volume arterial or collector street)

Shade tolerance—reflects the inherent level of susceptibility to the deleterious effects of shade.

Shade is the result of a reduction of available sunlight due to its interception or screening by buildings and other trees.

Sunlight is the energy source that is required for photosynthesis to take place. Any reduction of the normal photoperiod or amount and quality of sunlight that reaches a tree will affect physiological processes and growth related activities.

Influence: survivability, growth and development
Determination: inventory of existing trees and buildings
Priority: Medium

Soil drainage—reflects the frequency and duration of periods of saturation or partial saturation as influenced by soil permeability and percolation.

The downward movement of water through soil pores is controlled by the amount of precipitation, soil texture, and structure. Soils having a high content of coarse particles (e.g., sandy and gravelly soils) tend to be well drained, and soils having a high content of fine particles (e.g., clayey soils) tend to be poorly drained. A highly permeable soil may not be well drained if it overlays an impermeable soil layer (hardpan), bedrock, pavement, compacted aggregate base material or high water table, all of which will block the downward movement of water through the soil profile.

Influence: establishment, survivability, growth and development
Determination: field analysis (visual signs, e.g., poorly drained: wet and soggy surface, ponding, presence of moisture tolerant vegetation, blue or mottled color of subsoil), field analysis (perc test, infiltrometer)
Priority: High

Soil reaction—reflects the degree of acidity (low pH), neutrality or alkalinity (high pH) of a given soil (relative concentration of free or dissociated acid (H+) and alkaline (OH-) ions in the soil solution.

Most trees grow best on soils having a slightly acidic reaction (pH value between 5.5 and 7). Buried construction debris (e.g., concrete, plaster, and masonry products) can increase the alkalinity of a soil.

High acidity reduces activity of beneficial microorganisms (e.g., nitrogen-fixing bacteria) and induces toxic levels of certain elements. High alkalinity reduces absorption and availability of nutrients.

Influence: growth and development, winter hardiness, vulnerability to insect damage
Determination: field analysis (soil pH meter, indicator solution test kit), laboratory analysis (soil test: pH and nutrients)
Priority: Medium to High

Soil texture—refers to a permanent soil property that reflects the size of mineral particles (e.g., sand, silt, and clay) and the relative proportion of the various particle sizes found in a given soil.

Most soils consist of a mix of particle sizes which determines the soil type. The basis for naming the soil type is dependent on the textural composition of the surface layer of soil (A horizon). Favorable soils are usually medium to moderately fine in texture (e.g., loamy soils). Particle size and surface-to-volume ratio influences permeability, workability, aeration, water and nutrient holding capability, and supplying ability.

Influence: establishment, survivability, growth and development
Determination: field analysis (by feel) or mechanical (laboratory) analysis, USDA Soil Conservation Service County Soil Survey Report
Priority: High

Summer foliage color—reflects the typical coloration of summer foliage of a mature tree when grown in an open area under favorable conditions.

The different values and intensities of green are the predominating plant color in nature. Foliage colors are greatly affected by foliage texture which influences light absorption and reflection. Consideration should be based on the color of the foliage when viewed against the sky, against existing buildings, and against the foliage of other tree species.

Influence: functions, arrangement compatibility
Determination: function expectations, design objectives, colors of existing buildings and foliage of other nearby tree species
Priority: Low to Medium (High if required for design or arrangement purposes)

Trunk diameter—reflects the typical width of the trunk of a mature tree when grown in an open area under favorable conditions.

Generally, the diameter would be the linear measurement through the center of the trunk from one side to the opposite side at 4.5 feet above ground line.

Influence: spatial compatibility (encroachment conflicts), placement, positioning
Determination: existing planting site restrictions (width of boulevard)
Priority: High

Trunk flare—reflects the extent of the typical basal swelling of the trunk at or near the ground line for a mature tree when grown in an open area under favorable conditions.

Trunk flare is a result of the trunk/root interface (root collar: zone of differentiation of stem and root tissues) where primary or first order lateral roots originate and radiate downward into the soil.

The normal uniform taper of the trunk can be accentuated producing buttress-like flares due to a high water table or underlying hardpan subsoil.

Influence: spatial compatibility (hardscape encroachment conflicts), placement, position
Determination: existing planting site restrictions (width of boulevard), proximity of hardscape infrastructure
Priority: High

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APPENDIX 4

List of Tree Species

This section of the Appendix contains the regional list of tree species that served as the list of potential candidates for use as street trees in the example community/neighborhood case study (See ISSUE NO.6).

Scientific Name	Common Name
Acer ginnala	Amur Maple (Tree Form)
Acer ginnala 'Embers'	Embers Amur Maple (Tree Form)
Acer ginnala 'Flame'	Flame Amur Maple (Tree Form)
Acer platanoides	Norway Maple
Acer platanoides 'Columnare'	Columnar Norway Maple
Acer platanoides 'Crimson King'	Crimson King Maple
Acer platanoides 'Deborah'	Deborah Maple
Acer platanoides 'Pond'	Emerald Luster® Maple
Acer platanoides 'Emerald Queen'	Emerald Queen Maple
Acer platanoides 'Princeton Gold'	Princeton Gold® Maple
Acer platanoides 'Royal Red'	Royal Red Maple
Acer platanoides 'Variegatum'	Variegated Norway Maple
Acer rubrum	Red Maple
Acer rubrum 'Autumn Spire'	Autumn Spire Maple
Acer rubrum 'Magnificent Magenta'	Burgundy Belle® Maple
Acer rubrum 'Olson'	Northfire® Maple
Acer rubrum 'Northwood'	Northwood Maple
Acer rubrum 'Franksred'	Red Sunset® Maple
Acer rubrum 'Polara'	Rubyfrost™ Maple
Acer saccharinum 'Silver Cloud'	Silver Cloud™ Maple
Acer saccharinum 'Silver Queen'	Silver Queen Maple
Acer saccharum	Sugar Maple
Acer saccharum 'Bailsta'	Fall Fiesta® Sugar Maple
Acer saccharum 'Commemoration'	Commemoration Sugar Maple
Acer saccharum 'Green Mountain'	Green Mountain® Sugar Maple
Acer saccharum 'Flax Mill'	Majesty® Sugar Maple
Acer nigrum	Black Maple
Acer x freemanii 'Jeffersred'	Autumn Blaze® Maple
Acer x freemanii 'Celzam	Celebration® Maple
Acer x freemanii "Marmo'	Marmo Maple
Acer x freemanii 'Scarsen'	Scarlet Sentinel® Maple
Acer x freemanii 'Sienna'	Sienna Glen® Maple
Aesculus rubra	Ohio Buckeye
Aesculus x arnoldiana 'Autumn Splendor'	Autumn Splendor Buckeye
Aesculus x 'Homestead Buckeye'	Homestead Buckeye
Betula 'Crimson Frost'	Crimson Frost Birch
Betula nigra	River Birch
Betula nigra 'Cully'	Heritage® Birch
Carpinus caroliniana	Blue Beech
Celtis occidentalis	Common Hackberry
Crataegus crus-galli inermis	Thornless Cockspur Hawthorn
Fraxinus americana 'Autumn Applause'	Autumn Applause® White Ash
Fraxinus americana 'Autumn Blaze'	Autumn Blaze White Ash
Fraxinus americana 'Junginger'	Autumn Purple® Ash
Fraxinus americana 'Jefnor'	Northern Blaze® White Ash
Fraxinus mandshurica 'Mancana'	Mancana Ash
Fraxinus nigra 'Fallgold'	Fallgold Ash
Fraxinus 'Northern Treasure'	Northern Treasure Ash
Fraxinus pennsylvanica	Green Ash
Fraxinus pennsylvanica 'Bergeson'	Bergeson Ash
Fraxinus pennsylvanica 'Heuver'	Foothills™ Ash
Fraxinus pennsylvanica 'Marshall's Seedless'	Marshall's Seedless Ash
Fraxinus pennsylvanica 'Patmore'	Patmore Green Ash

Fraxinus pennsylvanica ‘Rugby’	Prairie Spire® Ash
Fraxinus pennsylvanica ‘Summit’	Summit Ash
Ginkgo biloba ‘Autumn Gold’	Autumn Gold Ginkgo
Ginkgo biloba ‘Magyar’	Magyar Ginkgo
Gleditsia triacanthos inermis ‘Impcole’	Imperial® Honeylocust
Gleditsia triacanthos inermis ‘Shademaster’	Shademaster® Honeylocust
Gleditsia triacanthos inermis ‘Skycole’	Skyline® Honeylocust
Gleditsia triacanthos inermis ‘Suncole’	Sunburst® Honeylocust
Gymnocladus dioicus	Kentucky Coffeetree
Maackia amurensis	Amur Maackia
Maackia amurensis ‘Summertime’	Summertime® Amur Maackia
Malus ‘Adams’	Adams Crabapple
Malus ‘Adirondack’	Adirondack Crabapple
Malus ‘Bobwhite’	Bob White Crabapple
Malus ‘Centzam’	Centurion® Crabapple
Malus ‘Coralcole’	Coralburst® Crabapple
Malus ‘David’	David Crabapple
Malus ‘Donald Wyman’	Donald Wyman Crabapple
Malus ‘Hargozam’	Harvest Gold® Crabapple
Malus ‘JFS-KW5’	Royal Raindrops Crabapple
Malus ‘Pink Spires’	Pink Spires Crabapple
Malus ‘Prairifire’	Prairifire Crabapple
Malus ‘Professor Springer’	Professor Springer Crabapple
Malus Profusion’	Profusion Crabapple
Malus ‘Red Barron’	Red Barron Crabapple
Malus ‘Sentinel’	Sentinel Crabapple
Malus ‘Spring Snow’	Spring Snow Crabapple
Malus ‘Snow Drift’	Snow Drift Crabapple
Malus ‘Sutyzam’	Sugar Tyme® Crabapple
Ostrya virginiana	Ironwood
Phellodendron sachalinense ‘His Majesty’	His Majesty Corktree
Pinus nigra	Austrian Pine
Pinus resinosa	Red Pine
Pinus strobus	Eastern White Pine
Prunus maackii	Amur Chokecherry
Pyrus ussuriensis ‘Bailfrost’	Mountain Frost® Pear
Pyrus ussuriensis ‘Mordak’	Prairie Gem® Pear
Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Quercus ellipsoidalis	Northern Pin Oak
Quercus macrocarpa	Bur Oak
Quercus palustris	Pin Oak
Quercus rubra	Northern Red Oak
Quercus x macdanielii ‘Clemons’	Heritage® Oak
Quercus x warei ‘Long’	Regal Prince Oak
Syringa reticulate	Japanese Tree Lilac
Syringa reticulata ‘Golden Eclipse’	Golden Eclipse Tree Lilac
Syringa reticulata ‘Ivory Silk’	Ivory Silk® Lilac
Tilia Americana	American Linden
Tilia americana ‘McKSentry’	American Sentry® Linden
Tilia americana ‘Boulevard’	Boulevard Linden
Tilia americana ‘Redmond’	Redmond Linden
Tilia cordata	Littleleaf Linden
Tilia cordata ‘Greenspire’	Greenspire® Linden
Tilia cordata ‘Baileyi’	Shamrock® Linden
Tilia x flavescens ‘Glenleven’	Glenleven Linden
Ulmus ‘Cathedral’	Cathedral Elm
Ulmus ‘Commendation’	Commendation Elm
Ulmus ‘Danada Charm’	Danada Charm Elm
Ulmus ‘Morton’	Accolade® Elm
Ulmus ‘Morton Plainsman’	Vanguard™ Elm
Ulmus ‘Morton Glossy’	Triumph™ Elm