Street Trees, Overhead Utlitly Distribution, and Physical Infrastructure: Design Implictions, Maintenance Costs and Proposed Alternatives

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Chapter One

Introduction-
The Project, The Purpose and The Process

Background

The intent of this project was to examine the problems associated with street tree plantings as they relate to utility lines and urban infrastructure, and to develop recommendations for new plantings which will mitigate these problems. The use of overhead lines for electric transmission to the customer is common in most communities, and is most likely to occur in the older parts of these cities and towns. Although the newest subdivisions and neighborhoods, as well as the urban core of larger cities have developed underground burial methods for the distribution of electricity, overhead wiring is still the most common form of electrical power distribution. In addition to problems associated with overhead wiring, the use of the street tree as a streetscape element presents serious problems to the physical infrastructure of many communities.

The impact of overhead wiring and utility poles on the landscape is both physical and aesthetic. Viewsheds that otherwise would be unobstructed are interrupted by the siting of transmission lines. Design of streetscapes is influenced by the location and complexity of utility lines and overhead wiring further limits the development of design alternatives. The aesthetic quality of the streetscape is often shaped by the location of utility lines, and design responses, in many instances, are patterned after the utility infrastructure. One of the most commonly used elements of streetscape design are trees, which are used for a variety of reasons, but ultimately act as a screen against the view of unsightly overhead wiring. The widespread use of trees along streets and roads presents problems to the electrical distribution network, since ultimately most trees come in contact with the overhead wiring which can cause interruption in the delivery of electricity. Costs associated with the prevention of contact between trees and electric lines can be enormous. The lessening of the likelihood of such instances should be paramount in the development of streetscape designs which utilize trees as a design element.

In many instances, tree plantings along streets have included the use of varieties which, ultimately, encounter conflict with overhead utility lines and must be cut back to reduce the physical contact between the tree and the transmission lines to insure reliability and safety. Even the practice of proper arboricultural techniques has, in many instances, led to a degradation of the form of street trees and had encouraged the development of misshaped and aesthetically unpleasing trees along streets. In most cases the trees which result are ineffective as components of streetscape design, draw attention to overhead wires, and present a continual maintenance cost to the utility company and electricity user.

Additionally the use of the street tree as a design element often times presents serious maintenance problems in regard to repair of damage to the physical infrastructure of the the streetscape, resulting in substantial expense to the municipality.

The Purpose

Species selection, planting location, and cultural practices all have an impact on the ultimate visual quality, health, and cost of maintaining a street tree. The use of appropriate species, the proper location of plantings, and the implementation of a program of preventative maintenance for the street tree, will allow for a cost effective tree management system. Reducing the conflict between utility wires and tree plantings will lead to a less costly procedure for maintenance of overhead utility lines. The appropriate use of trees along streets can also benefit other components of the upkeep of the urban infrastructure, including reducing the amount of damage by tree roots to streets and sidewalks. The development of an aesthetically pleasing streetscape and successful design implementation will benefit from the development of a program which addresses the type, location, and upkeep of trees along streets and roadways. Ensuring that design considerations include the relationship between overhead utility lines and trees be understood. This should be paramount during the early stages of the design process, as well as in the areas of vegetation replacement and the siting or upgrading of electrical distribution networks. The obvious conflict between tree branches and electrical lines must be addressed throughout any design, maintenance or replacement process. Damage to private and municipal infrastructure must also be examined and addressed as part of the development of an integrated street tree program, and the costs of improper tree selection, placement and maintenance be calculated. The tree plays an important part of the design, function, and aesthetic success of the streetscape, and the implications of the use of this element must be considered when it is incorporated into the landscape.

The Study: Process and Procedure

Introduction

In response to the relationship between trees, overhead utilities, and municipal infrastructure a careful and thorough study of the problems which are inherit must be undertaken and proposed solutions be examined. Through the examination of the existing examples of tree and overhead wiring interface and infrastructure damage, the identification of inappropriate species selection, unsuccessful planting location, or poor cultural practices can be undertaken. The study of existing street tree plantings can be used as a point of departure for the development of a set of criteria that can lead to more successful and less costly street tree development and maintenance program. The examination of existing street tree plantings should include the study of the aesthetic quality, identification of the design concept, and a careful review of maintenance and cultural practices. The study of existing examples of street tree plantings will allow for the development of a set of recommendations for appropriate species types that will tolerate roadside conditions, give the aesthetic quality desired, achieve the design intent, reduce municipal infrastructure damage and limit the interface between utility wires and the individual trees.

Since it would be inefficient to examine every street tree that interfaces with a utility line in a municipality, it appears that an examination of various individual situations, that are typical of other instances throughout the city, be examined. The development of street tree planting types based on street type, street width, size of planting strips and treebelts, design intent, and location of physical infrastructure will allow for concentration on a selected number of streets that are typical of other situations that might occur in the community or in other service areas. A careful and focused study on these sampled streets will allow for the development of a set of criteria and guidelines that can be applied used by the tree warden, professional arborist, homeowner, and utility company to ensure that the proper species has been chosen, that it is planted in the appropriate location, and that its care is appropriate for a street tree situation. The use of a standard set of criteria will ensure that a street tree will be able to develop to its desired shape, fulfil its design intent, and will be aesthetically appropriate. Although standardized, the developed guidelines will allow for the flexibility necessary to choose species that will achieve the desired intent of the planting such as screening, ornament, shade, or other intent. The guidelines that will be developed can be used by the designer to choose the right tree for the right spot, so as not to interfere with overhead utilities, damage the municipal infrastructure, or cause unnecessary maintenance costs over the life of the tree.

The Methods

The preliminary step in this process was to identify typical street and utility line interfaces that present the most problem for the electric provider and for the municipal arborist or that showed the most potential for implementation of a proposed street tree planting program. The identification of streets which contain a large number of interfaces between trees and utility lines are one type of streets to be examined. Primary arterial roads with large amounts of traffic should also be identified and studied, since they are visually experienced by many people regularly. Residential streets in urban and suburban neighborhoods are another area that should be looked at, because the street tree plays an important role in defining the character of these areas. Streets currently containing none or very few street trees should be targeted, since they are potential areas for immediate impact. Streets with older, mature, and declining trees also be examined due to the fact that they will require care or replacement in the foreseeable future. Streets that vary in width of roadway, planting strip, treebelt, and right of way should also be examined since they can give a sampling of the various street types throughout the sample area. Streets that contain physical infrastructure damage to roadways, curbs, sidewalks or other utility systems, should be studied.

The Target Communities

In this particular study, there were three communities that were targeted for study. Springfield, Longmeadow, and Agawam Massachusetts were examined in relationship between street trees, overhead utility transmission lines, and physical infrastructure. These communities have been chosen because they represent a relatively complete inventory of street types that can be found in this area of New England, ranging from urban centers to rural roads. Each of the study communities are serviced by the same electric provider, Western Massachusetts Electric Company, a subsidy of Northeast Utilities, who maintains the transmission lines, and is responsible for the pruning of most street trees, when they encounter transmission line interface. The care of the trees on city or town roads is the responsibility of the tree warden in the particular community, but quite often the utility company ends up being the primary maintainer of the trees. Because trees are usually pruned back from utility lines every four years, they are in a position to recommend the direction of a tree maintenance program in a community due to the fact that they are in regular contact with the street trees and the persons responsible for their care. It is the intent of this study to present to Western Massachusetts Electric Company/Northeast Utilities and to interested communities a set of criteria and recommendations for the care and replacement of street trees under their care, based on the proper species selection, informed planting location and improved maintenance techniques. The development of the criteria and recommendations is based on the results of the study of the sampled streets and will emphasize design considerations, physiological factors, and informed arboriculture principles.

Findings and Recommendations

The results of the research project will be assembled in the form of a report which will be provided to Northeast Utilities to develop a policy for the management of street trees that interface with their utility lines. This information can also be utilized by municipalities to improve their street tree planting programs. The ultimate reduction in tree maintenance costs, lessening of infrastructure damage, and more successful design implementation are the hoped for results of the study and the development of more coordinated street tree policies by utilities and cities and towns is the goal and purpose of the study.

Through the development of a series of designs for street types, recommendations can be presented in an easily understood manner, thereby encouraging implementation of the proposed changes to the street tree maintenance and planting programs. The development of recommendations for proposed practices will be examined graphically, so as to be more fully understood, allowing for a more informed policy regarding what the realistic alternatives might be.

History of the City

A Perspective

A brief examination of the development of American cities allows for a basic understanding how the cities and towns which we see today came about, thereby putting this study in perspective with the development of the American city. This is important, since the recommendations which this study proposes must maintain and embellish the integrity of the streetscape environments which have shaped the form of our country. The layout of the cities and towns which are part of the American landscape today have their roots in the the history of the development of the unsettled territory. The character, pattern, and form of today's cities is a result of a series of changes that the American landscape has experienced over the past three centuries. It is important that future changes acknowledge this background and draw upon it to implement design decisions that will complement the special tradition of the American city.

Miller (1988) proposes that, "transportation is the key to both the location of cities and spatial patterns of land within cities. At the time of settlement in the United States the primary mode of transportation was water. Towns were located in natural ports and along navigable rivers. Cities were small and residents had easy access to the surrounding countryside." (Miller, 1988) This early American city layout is illustrated in the following drawing (FIGURE 1) showing a colonial city, on on waterway, which was compact to accommodate foot and horse travel.

FIGURE 1 - Early American city located near water transportation. *Source Miller 1988.*

Miller (1988) continues, "the coming of the Industrial Revolution in the mid-nineteenth century, brought about the same problems of overcrowding and pollution to American cities as was found in European cities. Railroads and trolleys linked cites and provided the means for the newly emerging industrial elite classes to escape the industrial squalor and pollution for more amenable surroundings in the new suburbs. Suburban communities sprung up at stations along railroad lines and populated stands developed along trolley corridors." (Miller, 1988) This is expansion along transportation lines is illustrated in the following map (FIGURE 2), showing expansion of suburban and outlying districts.

FIGURE 2 - Expansion of American city along railroad system. *Source Miller 1988.*

In the 1920's the first wave of suburban sprawl took place as a result of the desire for open space and single-family dwellings. People lived within walking distance of trolley lines and train stations, resulting in a spatial pattern which included a densely populated urban core, surrounded by less populated suburban nodes and neighborhoods. Populated strands followed trolley lines and neighborhoods developed along these lines. Surrounding these neighborhoods and between them were countryside landscapes of forests and farms. By the end of World War II the automobile started to change the spatial layout of the city. New subdivisions spread rapidly, and no longer were fixed to the transportation corridors. The development of neighborhoods spread in a random pattern across the landscape and open space and farm land was filled in with housing, shopping centers, and new industrial uses. This growth from the 1920's through the early 1950's is illustrated in the following map (FIGURE 3), showing more suburban sprawl and envelopment of the open space.

FIGURE 3 - First suburban expansion out of the American city from 1920's through early 1950's. *Source Miller 1988.*

In the mid-1950's construction of the interstate highway system began which was intended to allow better access into central cities and connect metropolitan areas, however their construction resulted in further development of communities along the highway system and the increase of decentralization from the center of the urban core. According to Miller, "as the American population became more affluent, house lots in the suburbs grew larger. The shift from high-density housing in the cities to low-density housing in the suburbs resulted in unprecedented urban sprawl." (Miller1988) The Springfield Metropolitan Statistical Area (SMSA) grew in population from 1950 to 1965 by 18 percent. During the same period the amount of land used for urban purposes increased by 136 percent (Lindsay, 1972) The map below (FIGURE 4) illustrates how the interstate highway system has influenced the layout of today's American city, including the communities examined in this study.

FIGURE 4 - Low density suburban sprawl and decentralization from urban core. *Source Miller 1988.*

As mass housing became the rule from the 1930's on, smaller lots were subdivided, and, to accommodate construction, existing trees were removed and not replaced (Zube,1971) The suburban neighborhoods lacked the vegetation that had been part of the streetscape of some of the older urban neighborhoods and public parks. The trend did not reverse itself until the late 1960's when wooded lots commanded a higher selling price.

Although most suburban communities did not recognize the importance of street tree plantings, in the early 1900's " most large cities and many medium-sized communities initiated city forestry programs to plant and care for street and park trees." (Miller,1988) This initial effort at planting the tree belts in the cities, has resulted in tree lined streets in many older American communities.

History and The Study Communities

Many of the streets that were examined in this study were designed and constructed in the period after 1920 and most were in place prior to World War Two. Most of the streets examined in this study contain 3-phase wiring, that usually occur on older streets. This type of wiring serves as the backbone for the surrounding neighborhoods, and these streets contain trees planted as part of a formal forestry program. Several examples are seen on newer streets containing overhead wiring, that were constructed in the 1960's. These have a different street pattern than do the other examples which come from older parts of the community. Much of the early layout of cities and towns was designed by engineers who set up city blocks in ordered fashion, or set out neighborhoods in areas which lay between larger arterial streets and trolley lines. This pattern has resulted in fairly uniform neighborhoods that are patterned in a block fashion. This is illustrated in the following drawing (FIGURE

5) showing a typical street arrangement of uniform lots, treebelts, and roadway width.

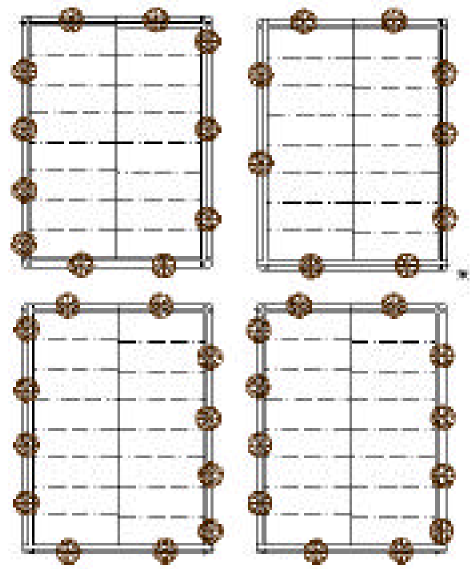


FIGURE 5 - Block arrangement of streets, lots, and street tree plantings.

This type of street alignment and layout is found in several of the communities looked at in this study, especially in the older neighborhoods. Although the grid pattern, including the perfectly straight curblines, are not the only type of streetscape occurring in the communities, it is one of the most interesting, since most of the trees are at mature sizes and are being removed with more occurrence than in other, newer neighborhoods. This presents a special challenge for the designer, tree warden, and utilities to develop methods that will ensure replacement of the the right tree in the right spot. Due to the linear nature of this street type, species selection and tree form are critical to creating the streetscape environment desired.

Other street patterns occur in the communities examined, and likely to occur in most other cities or towns. These include radial patterns, classic patterns, and linear systems, as classified by Harris and Dines (1988). The following illustrations (FIGURES 6,7) demonstrate how each of these patterns is different, resulting in a different streetscape environment where each occurs.

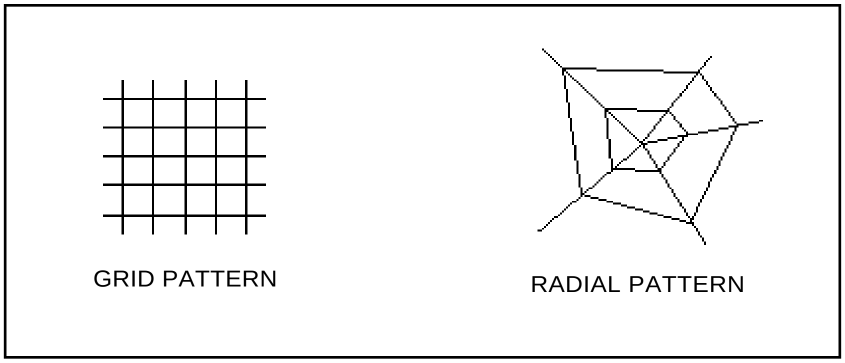


FIGURE 6 - Grid pattern and radial pattern roadway layouts. *Source Harris/Dines, 1988.*

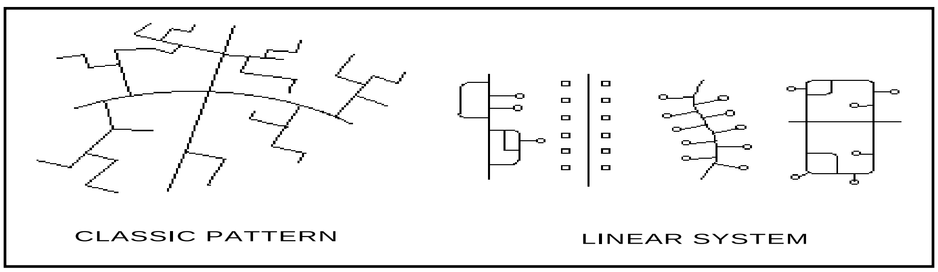


FIGURE 7 - Classic pattern and linear system of roadway layouts. *Source Harris/Dines, 1988.*

The Tree in The City

Miller (1989) describes the initial incorporation of the tree into American urban design following the Revolution when "Americans sought to create a new identity for themselves. Thomas Jefferson believed in a country governed by sturdy yeoman farmers and regarded the city dweller with a certain amount of suspicion. This attitude was embraced by the populace and influenced early attempts to incorporate nature in the urban design as well as identifying nature as a source of moral virtue." (Miller, 1988) This was followed in the mid-nineteenth century with the city beautiful movement, including, according to Miller (1989) "the introduction of trees on streets and construction of city park and civic centers. The city park movement, led by Frederick Law Olmsted, had as its goal the introduction of naturally landscaped parks into rapidly growing industrial cities. Olmsted, designer of New York's Central Park stated: "The park should, as far as possible, complement the town...what we want is a simple, broad, open space with sufficient play of surface and a sufficient number of trees about it to supply a variety of light and shade." (Miller, 1989)

During this same period, as cited by Ann Spirn (1984), a sanitary reform movement began which resulted in a large investment in municipal infrastructure. "During that period, most cities in the United States ripped down their streets to install new sewer and water lines. Large public parks were built in cities across North America and Europe, intended as "lungs of the city; part of a comprehensive effort to improve the health, safety, and welfare of city residents through the alteration of the physical environment."(Spirn, 1984) The incorporation of street trees as part of this new urban order was undertaken, but at the same time the emergence of suburban and greenbelt communities, resulting in the urbanizing of the rural outskirts of the major urban cores. There was an effort to continue the spirit of romanticism into these communities, through the use of tree lined streets and parks, however this was not to be the rule during the early twentieth century, when suburban sprawl began to preclude the emergence of romantic, greenbelt communities. The value of the tree as part of the community continued its cycle of moving from an important asset to becoming forgotten as the rapid pace of suburban sprawl continued.

It was not until the early twentieth century that existing urban centers started forestry programs to plant and maintain their street and park trees. While at the same time suburban expansion neglected to include trees as part of the new expansion of the American city. It has only been in the last twenty-five years that suburban communities have initiated programs that ensure the health of the trees in these less urbanized places.

Spirn (1984) states "city dwellers have demonstrated a sustained interest in nature throughout history. Today that interest has been heightened by a growing consciousness across society of the costs to health and welfare exacted by continued environmental degradation. It is time to expand what has been a romantic attachment to the ornaments of nature into a commitment to reshape the city in harmony with the workings of nature." (Spirn, 1984)

The commitment that Anne Spirn discusses is the reason for the research undertaken here. The ability to shape the future condition of the city is a special privilege, one that must be exercised with direction and purpose. The research findings and recommendations presented here will, hopefully, become part of this direction and purpose.

Conclusions

The use of trees as an element of the landscape is an important design concept that has been used throughout the world, and continues to shape the aesthetics and function of the streets and roads that connect cities and towns. The concurrent use of these roadways and paths by utility companies as right of ways for their overhead utility lines and cables presents an unfortunate conflict, in which the trees must adapt to the need to supply electric power to homes and businesses. The traditional cultural techniques of tree care have led to the development of street trees which are misshaped, irregular in form, or permanently disfigured, thereby defeating their original design intents. It is intended that through this study, the development of criteria and recommendations for the use of street trees which interface utility lines, will lead to a more effective and aesthetically successful use of trees as a design element along our streets and roads. The development of useful and complete information as a means to shape policy is important, and it is hoped that this study provides this information.

Chapter Two
The State of the Art -
Review of Current Street Tree Planting and Maintenance Practice.

Background

Street tree planting has traditionally been done by municipal forestry departments, under the direction of the city or town tree warden, following little or no consultation with the utility companies whose wires and cables run over, under or nearby the areas in which the trees are planted. This practice has resulted in street trees presenting severe maintenance problems for the utility and the city or town in future years. The necessity for pruning to eliminate safety hazards is increased, damage to underground and surface infrastructure can occur, and the health and aesthetic qualities of the street tree are likely to be diminished. The cost of a street tree planting program, which does not acknowledge the impact of overhead and underground utilities is great in both a financial and visual sense. The misshaped, unhealthy, or infrastructure damaging tree is likely to become the common street tree in communities which continue to implement traditional street tree planting programs which are more interested in the numbers of trees planted and do not engage in consultation and cooperation with utilities and municipal agencies which can assist in the development of successful street tree planting and management program. A pro-active approach which involves the co-operation of the tree warden, the utilities, citizen groups interested in the health and aesthetics of street trees, other municipal departments, and private property owners can improve the quality of the street tree planting and maintenance program in a community.

The establishment of a urban forestry program that addresses the needs of the municipality, the utilities, and the residents is critical to the health and quality of the street trees and to the visual and aesthetic appearance of the streetscape. Through a process involving all interested parties in the development of a tree planting and maintenance program addressing the needs of the trees, the utilities, the municipalities and the residents, the success of a street tree program can be realized. Kielbasa (1989) suggests that four components make up a successful urban forestry program, and ultimately ensure the health and vigor of the street trees. He states that this success can be developed when (1) an enlightened city is committed to urban forestry, (2) has in place a viable ordinance covering multiple aspects of the public/private forest, (3) a thorough inventory of the city trees and (4) a professional advocate such as a tree warden or arborist located in a forestry or tree-oriented division of city government. He suggests that with these components a successful street tree management program can be achieved. Additionally he cites the importance of the public role in an effective program and proposes that "a board representing the public should usually be legally constituted and take responsibility for policy and oversight of a comprehensive community tree program." (Kielbasa, 1989) The creation of such a board, along with increased public awareness of the role of the street trees, and the involvement of utility companies in the management process should ultimately encourage overall cost savings to both the municipality and to the utility companies.

Planting Procedures and Practices

Direction and mission

Several cities have developed programs designed to improve the quality of street trees through selection and planting practices benefitting the tree and the landscape at the same time. Cleveland, Ohio is one of the most successful cities to implement a program that attempts to choose the right tree for the right spot. Recent research by James Urban, et al (1989) reports that Cleveland has developed "checklists to help determine where a tree will fit... help prevent conflicts with existing buildings, utilities, driveways, and traffic signals, and allow the city forester to restrict planting to areas where the trees are likely to survive, thus conserving limited maintenance and tree planting budgets." The procedure used in Cleveland attempts to examine the tree on a long term basis, and considers the maintenance and care that the tree will need in the years following the initial planting. The cost of pruning, trimming, and other maintenance to keep the tree free from overhead utility lines and other influences is taken into account before the tree is planted, so that the most appropriate species can be planted. Through careful and appropriate investigation, the criteria for species selection and planting location can be determined and trees which require minimal care can be planted in the appropriate place, and still achieve the intended design or functional intent.

The Cleveland standards also require that trees not be planted within fifteen feet of a utility pole, within twenty-five feet of a street light, beneath overhead wires lower than twenty-five feet above the ground, or centered beneath the wires. This common sense approach allows for the development of a street tree inventory that can be maintained cost-effectively as well as adds to the aesthetic and visual quality of the community.

Other communities which have successful tree planting and maintenance programs in place are Milwaukee, Wisconsin, Seattle, Washington, Minneapolis, Minnesota, Cincinnati, Ohio, Highland Park, Illinois, and Austin, Texas. Other communities such as Atlanta, Georgia, San Francisco, California, Dallas and New York City all have non-profit groups in place which act as advocates for street trees and the urban forest, encouraging tree planting efforts which combine municipal, private, and citizen efforts.

Research and Responsibilities

The city forester or tree warden in each community ultimately has the responsibility for street tree selection and planting. In many instances, they are severely limited as to the space available for new tree planting. Often times, only narrow planting strips between the street and the sidewalk are available for the planting of shade or ornamental trees. There may be other restrictions which influence the location for tree plantings, resulting in a predictable street tree planting program, which is dictated by existing conditions rather than being the result of a planned effort. This results in a lessening of the quality of the urban forest, both aesthetically and ecologically. The tree warden must work to reduce the restrictions which he or she must work under, through innovative techniques, improved species selection, and encouraging involvement by those interested in the quality of the street trees in a community.

The tree warden or urban forester must be able to adopt new or revised planting and maintenance techniques in order to effectively manage the street trees under their jurisdiction. Research is currently underway to develop new techniques which will improve street tree health and vigor. Work at the Urban Horticulture Institute at Cornell University has been underway to examine urban street trees found around the country. One area of research, dealing with the soil requirements of street and urban trees has been undertaken. (Goldstein, et al 1991) Results of the soil needs study can be outlined by the following diagram. (FIGURE 8) (Moll and Urban,1989).

FIGURE 8 - Soil requirements of street and urban trees.
Source Goldstein et al 1991.

Results of one important study, determined the minimums for adequate soil volumes could be calculated based on calculations of crown projection, crown density and pan evaporation, thereby assisting in the development of specifications for soil quality and quantity for new plantings. The researchers calculated that a tree with a 20-foot canopy diameter and an average canopy density would use approximately 30 gallons of water a day in Ithaca, New York and therefore a total of more that 300 cubic feet of soil would be needed to support this tree through a 10 day rain-free period. This is important since it will allow for the application of this soil volume technique to actual design situations, including accurately estimating the required soil volume for a tree. Developing the ability to design from a horticulturally based position, rather than just relying merely on aesthetics, will allow for the ability to revise planting strategies which incorporate this new understanding of soils and tree growth. Recognition of the way in which a tree grows will result in more informed design decisions by landscape architects and others. Results from studies such as this must be used by the tree wardens to continually advance in street tree care and improvement.

Another example of improved cultural and planting technique can be seen in the work of Evans, et.al, (1990) whereby findings suggest improvements to physical infrastructure near street trees and encourage improved design and planting techniques to improve the likelihood of street tree survival. The following illustrations (FIGURE 9,10) show the researchers recommendations for improvements to paving and the physical environment near the street tree.

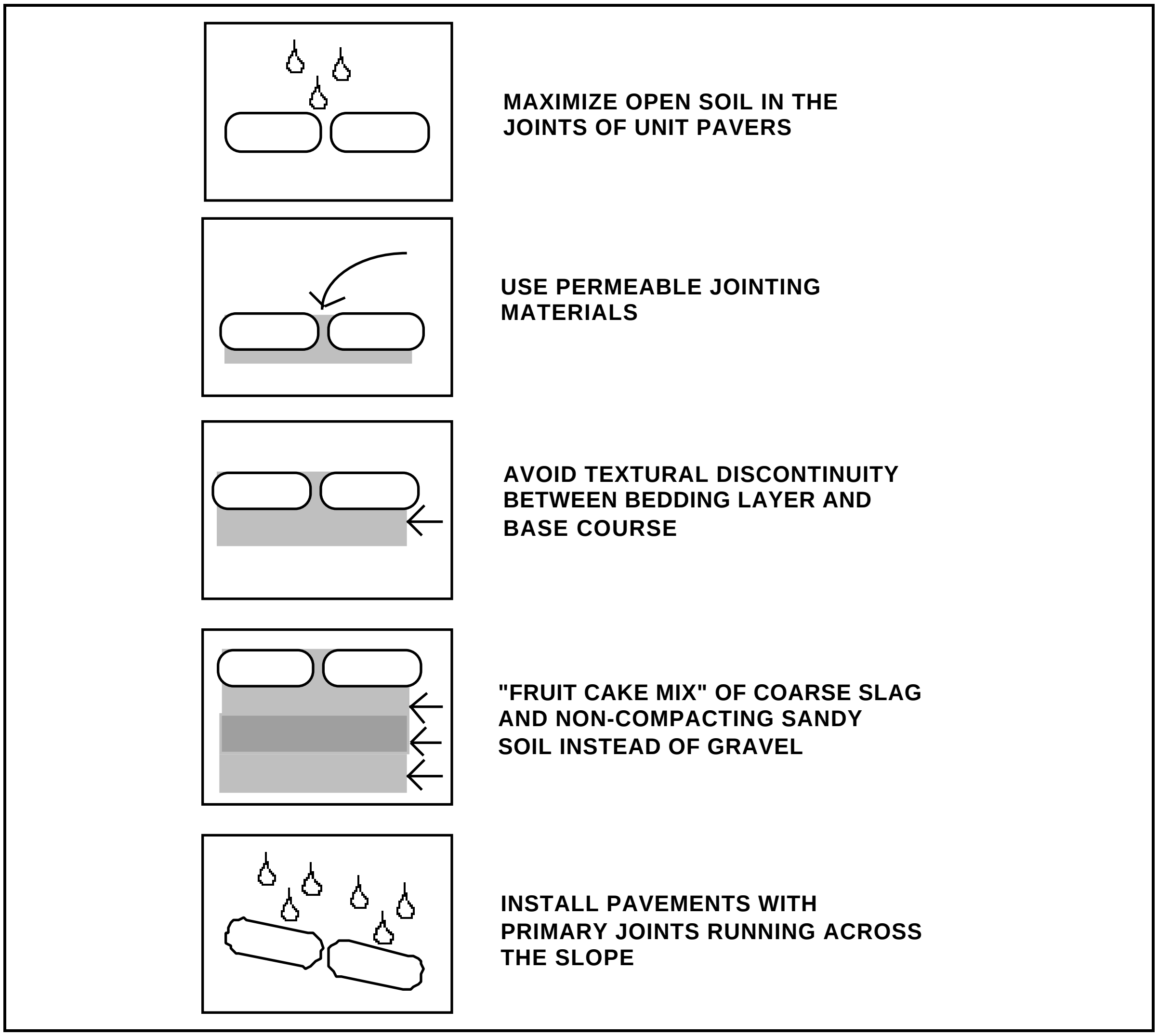


FIGURE 9 - Recommendations for sidewalk construction. *Source Evans et al, 1990.*

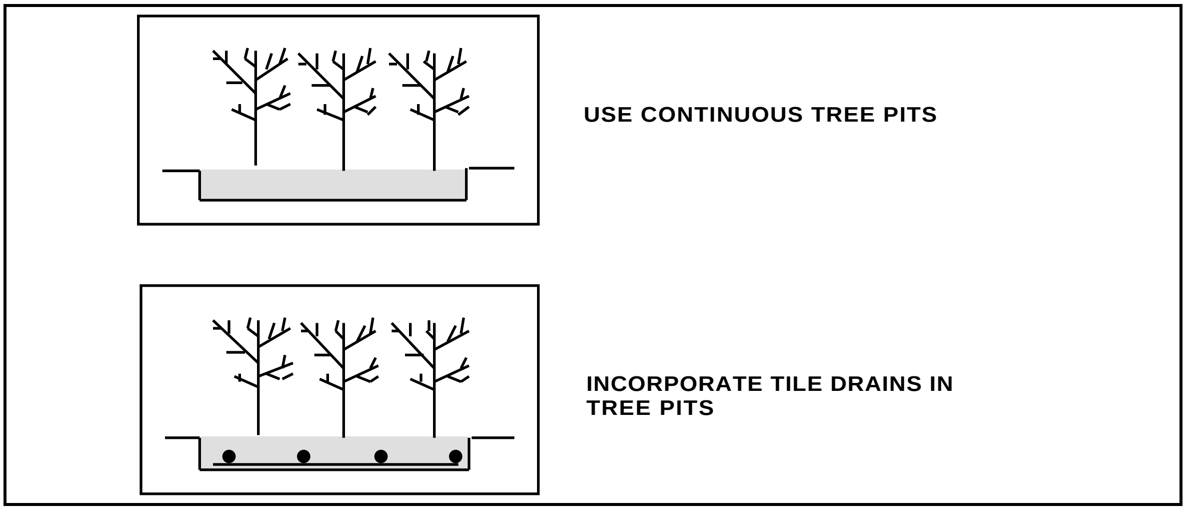


FIGURE 10 - Evans, et al. recommendations for tree planting. *Source Evans et al, 1990.*

Findings of research by Pittenger and Stamen (1990) suggest improvements in the treatment of soils around street trees and trees growing in the urban environment. The importance of maintaining adequate soil moisture around street trees is demonstrated providing the basis for changes to the way urban street trees are managed. The tree wardens and urban foresters must review their cultural and planting practices regularly, so as to update their programs to utilize the state of the art methods for planting and maintenance.

The need for additional research and development of innovative techniques for street tree planting and maintenance has been proposed by landscape architects, arborists, and scientists and review of current practices must be constantly undertaken. Urban, Arnold, and Hightshoe et al (1989) have outlined the importance of research as a tool to improve the quality of the street tree and the urban forest. Their recommendations include improvements to the technical expertise which is available to the tree wardens, foresters, and landscape architects, so that the quality of the trees can be maintained through sound species selection, planting methods and cultural practices.

Moll and Urban (1989) comment that "today almost none of these (planting specifications) recommendations are correct" (Moll and Urban, 1989) and that traditional planting specifications as documented in landscape journals, books and nursery catalogs are in need of research and revision. The following construction detail (FIGURE 11) is suggested by Moll and Urban (1989) as one of their recommendations for developing a better tree-planting specification.

FIGURE 11 - Moll and Urban's planting detail for urban street trees. *Source Moll and Urban, 1989.*

Design considerations

Arnold (1980) focuses on the use of trees as elements of urban design and presents numerous ideas and recommendations for their use in shaping the urban environment. Focusing on physical and abstract design principles, Arnold attempts to define the role of the tree in the urban environment, and closely examines the impact of street trees on the aesthetic make-up of the city. More specifically he presents concepts which develop the role of the tree as shaping spaces in the urban environment. Through examination of the geometry of the spaces, Urban shows how the tree can be effectively used as a design tool and an important landscape element. He develops themes which reflect on the street trees used to define space. The following diagrams (FIGURES 12,13) illustrate two of the design concepts that Arnold (1980) proposes. Comparison of the spatial effects created by the use of street trees is shown in FIGURE 12, while FIGURE 13 demonstrates how height plays a role in the effectiveness of the street tree as a design element.

FIGURE 12 - The use of trees to create space. *Source Arnold, 1980.*

FIGURE 13 - Trees and relation to height in the streetscape. *Source Arnold, 1980.*

Arnold (1980) proposes that "the largest and most important principle of urban design is spatial order" and "the most important function of trees is to define, reinforce, or create spaces...". (Arnold, 1980) The tree is used to define horizontal space by creating walls, and the vertical space is defined by the canopies. The physical design principles which Arnold suggests that street trees can reinforce are coherence, organization, enforcement of geometric patterns, and create transitions, define scale, and manipulate light and shadow.

Miller (1988) suggests that "as elements of design and aesthetics in the landscape, trees and other vegetation should be established following a specific plan that considers the principles of design." (Miller, 1988) He further proposes that "plantings on boulevards and streets should follow the principles of design constrained by the economics of management" The growth needs of the plant must also be considered in developing design and planting schemes. This concept begins to direct the focus for the use of street trees as a design element in the more urbanized setting. Miller also has outlined the critical role of selecting the proper species to be planted in a particular situation. Shown below (FIGURE 14) is Miller's Species Selection Model outlines a process for selecting tree species to be used in urban streetscape situations. (Miller1988)

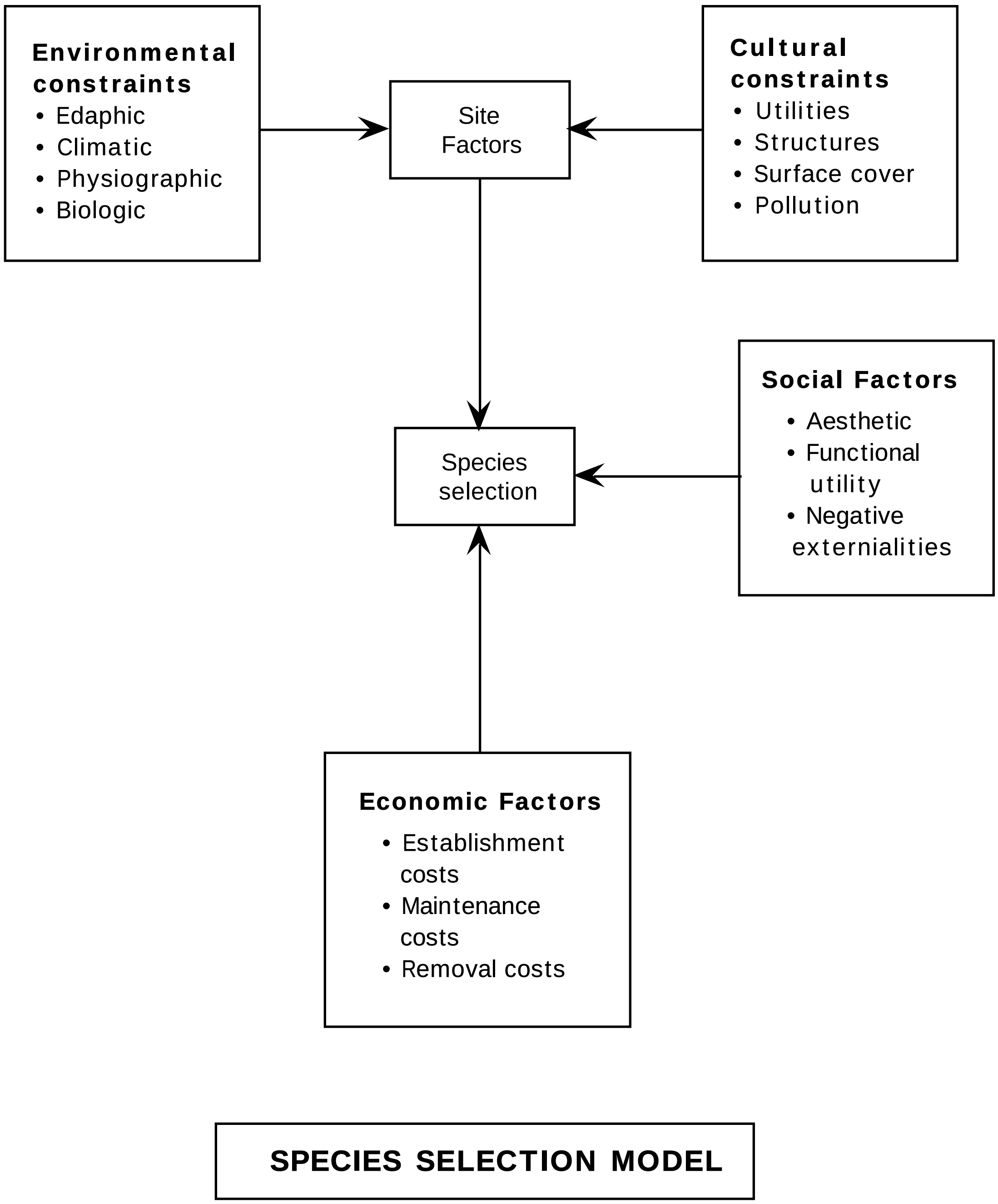


FIGURE 14 - Species Selection Model. *Source Miller, 1988.*

The role of the street tree in urban design is outlined in the research of Schroeder (1989) who presents an examination of the implications of utility arboriculture on the perceived visual quality of street trees and cites numerous examples of studies related to individual responses to vegetative growth in cities. Schroeder presents findings which indicate that street trees were the strongest positive influence on the street scenes that were examined. Demonstrating that environments with natural features such as trees are preferred to scenes lacking vegetation. Schroeder examines the implications of utility arboriculture on the visual quality of the street scene, and reflects on the implications to the overall aesthetic and design success of the streetscape. He recommends the use of trees which provide as much shade as possible, consistent with the requirements of line clearance.

Urban, et al reflects upon the use of the tree as a design component of the urban environment and encourages the incorporation of other design and scientific profession into the process of improving street trees and the urban forest. Urban (1989) further examines the role of landscape architects in the life of urban trees and describes in detail the importance of developing methods which can be implemented during the design phase that will allow for trees to be planted in manners that will encourage their survival. Urban suggests that the landscape architect is only a small player in the life of a tree, but the role is an important one, requiring improved technical expertise and comments that "urban environmental conditions have changed significantly and we must re-examine all of our standards".(Urban 1989) He reflects that the "profession is currently using the same details developed for planting trees in the suburban landscape or the great estates of a generation ago".(Urban, 1989)

In Europe there are innovative methods being employed to ensure the health of the urban street trees. According to Lueck (1989), there are several cities which have taken steps to ensure the quality of the street tree. In Zurich, for example, planting beds that extend into the street permit the planting of large-canopy trees along streets that were once considered too narrow for larger trees. According to Lueck, in Bern, Switzerland, "an average of $3,500 is spent for each tree planted in the downtown area, most of which goes to removal of existing soil, installation of perforated drainpipe, and erection of barriers and/or plantings to prevent compaction of soil in the root zone of the new tree." (Lueck,1989). The incorporation of perforated, flexible drainpipe during planting occurs in nearly every new planting throughout Europe, and appears to be greatly impacting the quality of the new plantings. Findings by Lueck state that, "excavation of trees planted ten years ago with this system show extensive root development all along the pipes." (Lucek,

1989) An specification drawing used by the Bern Parks Department, which employs a system of U-shaped pipes, the bottoms of which lie about a meter below the surface is shown below. (FIGURE 15)

FIGURE 15 - Street tree planting detail used in Bern, Switzerland. *Source Lucek, 1989.*

Urban et al (1989) states there are examples of cities using innovative design standards to improve the visual and ecological quality of street trees. Urban cites Portland, Oregon as a city which has used effective design standards to develop ten-foot wide median and buffer strips in redesigning roadways throughout the city. Portland's code requirements also require private investment in the streetscape plantings in the community. The urban forester is encouraged to become a forest planner rather than a supervisor of planting, facilitating the implementation of methods which encourage private sector commitment. This type of pro-active urban forestry is important to the success of street trees as an element of good urban design

Ecological Considerations

An important role of the street tree which must be acknowledged and strengthened, is its contribution to the "urban forest ecosystem" as defined by Grey and Deneke (1978), which includes all the ecological components of the city. According to Rowntree (1989) "without making too fine a point, the urban forest ecosystem can be apprehended and described -in spite of its heavy dose of anthropogenesis- using conventional ecological principles, and we (urban foresters) should not shy away from using them." (Rowntree,1989) He further proposes that incorporation of these ecological principles and ideas is paramount if the urban forester, landscape architect, or street tree manager is to be successful in ensuring the survivability of the urban forest. "As urban forestry is practiced today, the virtue of the ecological approach is more in using it to raise the right questions, to guide long-term planning, and to educate the public, than in using it to daily manage the trees." (Rowntree, 1989) It is important to consider applying the ecological principles to everyday practice in order to more fully address the importance of the city street tree. Rowntree suggests several ways for this to occur, including improving the way the structure and function of the urban forest is presented to the public, coupling of the urban forest ecosystem to adjacent ecosystems, and coupling the ecosystem to distant ecosystems. In these ways there will be the start of a method for quantifying the structure of the urban forest. It is critical to the success of the urban street tree that an ecological approach be mandated for the planning, planting, and care of our street trees.

Rowntree further explains that "since the late 1970's work in urban forest ecology has grown adequately to provide a sound base for our conception and application of the forest ecosystem, if only we were to put the parts together." (Rowntree, 1989) He proposes that there is currently an adequate foundation for scientists, designers, and practitioners to capitalize on the ecological approach to understanding and maintaining urban forest, which will allow for design decisions, planting procedures, maintenance practices, and management programs to increase the health and vigor of the urban ecosystem.

Others have examined the urban ecosystem and have developed methods and proposed changes that would allow for a more important acknowledgement of the role of the urban forest in the global ecosystem in which every city is contained. Moll (1989) comments about these efforts to focus on the importance of the urban forest ecosystem, and reflects on the work of the most influential of the ecological planners. "Innovative urban land planners and designers such as Ian McHarg, Michael Hough, and J. T. Lyle have seen a challenge in integrating the natural landscape as part of the design process, using existing natural conditions in a positive way. They suggest that urban designs that short-circuit a natural cycle or reduce diversity are negative elements. Working with the natural systems creates a solid foundation for building an ecological landscape, a landscape that fits the physical environment and is able not only to survive, but to thrive." (Moll, 1989) It is following these guidelines that the management of street trees must follow, so a to ensure the sustainablity of the urban forest ecosystem. The management of the streetscape must follow these principles if the health and vigor of the urban landscape is to be successful, and decisions regarding street trees must recognize this responsibility.

Budgeting and implementation

Kielbaso, et al (1988) have shown that the cost of municipal shade tree management in the United States is estimated at approximately $425 million annually. The research done by Kielbaso, et al have shown that the mean per capita cost of $1.48 for tree care compares to $1.63 in 1974 and $2.19 in 1980. They conclude that "it is a fact today that during budget preparation many cities view tree care as a nonessential activity...and under the economic restrictions placed on cities, it becomes more and more difficult to appropriate monies among departments." (Kielbaso,1988) A summary of their findings is shown in the following diagram. (FIGURE 16)

FIGURE 16 - Municipal tree care budgets. *Source Kilebaso,1988.*

Grey and Deneke (1978) have outlined the basic financing of street tree planting and maintenance programs, and conclude that " most municipal forestry programs are financed through general funds on the basis of a budget request made by the tree commission or the department under which the program operates." (Grey and Deneke, 1978) In addition to this type of typical budget request for financing, they cite capital funding, property assessment, block or street assessment, permit methods, and community and individual involvement as additional funding sources and methods.   This funding strategy is confirmed by Kielbaso, et al whose research has concluded that, the general fund provided 89% (weighted mean) of total tree care budget, in the communities that they surveyed. Further research indicates that an average of 61% of the total tree care budget of municipalities is devoted to street trees (Kielbaso, 1988). FIGURE 17, below presents the results of Kielbaso, et al's research on the sources of tree care funds.

FIGURE 17 - Municipal tree care budgets. *Source Kielbaso,1988.*

It has been proposed that an "appropriate funding target is the national average of $10.62 per street tree per year (median = $8.04) or $2.60 per capita." (Kielbaso, 1988) The establishment of a tree inventory program in each community "is the most effective and efficient way to determine what work needs to be done, what funding levels are adequate, and when the work must be done." (Kielbaso, 1988) The use of an accurate inventory will "provide convincing cases for budget appropriations" according to Kielbaso, et al's findings. (Kielbaso, 1988)

According to Miller (1988) "establishment of a street tree includes not only the cost of purchasing and planting, but must also include survival for a given establishment period...and an appropriate establishment period such as five years should be used to evaluate planting success." (Miller, 1988) He further suggests that "tree condition and growth rate as they influence tree value should also be considered."

Moll and Urban (1989) recommend that new methods be employed during the construction phase of a new roadway to ensure successful street tree establishment. The integration of tree planting with roadway construction is an idea that they propose will result in long-range benefits to the communities which develop this type of approach to street tree planting. They present an example of an integrated construction, developed by Bob Skiera, City Forester of Milwaukee, which includes "the cost of making space for trees" (Moll and Urban,1989), which is illustrated in FIGURE 18. As can be seen in the chart, 2 cents of each dollar spent on roadway construction should be aimed at new tree planting. This figure, as compared to the other elements of the construction project is minimal, yet the potential benefit is enormous. Moll and Urban suggest that this type of integrated approach to street tree planting can be successful, both economically and aesthetically.

FIGURE 18 - Integrated street tree planting plan.
Source Moll and Urban, 1989.

Miller (1988) has shown that, although it is expensive to plant new trees along municipal streets, the cost of planing is gained back through an increased net value of the tree population, raising property values resulting in enhanced real estate tax revenues. Using a computerized street tree management simulation that computed net tree values over a forty year period, Miller has shown that full stocking of the street trees produced the highest net value street tree population. The following diagram illustrates the Miller's findings. (FIGURE #19)

FIGURE 19 - Analysis of street tree stocking values.
Source Miller, 1988.

The involvement of the community, civic and private sources of funding are methods which must be considered to augment municipal budgeting for street tree planting programs. Citizen involvement must be encouraged, and participation in programs such as Tree City U.S.A, Global ReLeaf, and other such programs will allow for a more broad base to draw upon additonal or potential funding of programs to improve the quality of street trees around the country.

Maintenance Procedures

Trends and Practice

The maintenance and care of street trees has primarily been the responsibility of two entities. The municipality, usually under the direction of the tree warden attempts to maintain street trees so as to eliminate hazards, encourage healthy growth, and to develop trees that achieve aesthetic and functional success. The utility arborist is concerned with ensuring that adequate clearance between the tree branches and the overhead utility lines be maintained, as well as being concerned that tree roots do not cause problems with below ground equipment and delivery systems.

The amount of care to the trees that has been provided by each of these groups varies from city to city, but in many instances the only ongoing maintenance of public trees is done by the utility companies. The reduction in maintenance budgets that municipalities have allocated toward street tree care has resulted in many cities and towns relaying on the services provided by the utility. This has resulted in programs which are primarily concerned with seeing that line clearance be ensured, and little or no preventive cultural practices be included or little concern shown to the aesthetic quality of the street trees.

Studies (Kielbaso, 1989) concludes that the average municipality spends $2.60 per capita for tree care and of that figure aver 60 percent is spent on street trees. Of that amount it has been further estimated that 30 percent of the budget is used for trimming, 28 percent for removal and 14 percent for planting. These figures show the present average of conditions in the United States, and reflect the present direction that municipal tree care is moving. Keilsbaso suggests that it would be desirable to allocate 40 percent of the funding for trimming, 14 percent for removal, and 10 percent for planting. This would demonstrate the importance of how a preventive trimming program could aid in the development of an urban forest that requires fewer removals, thereby reducing the need for fewer replacements and allowing for that funding to be more effectively utilized.

Reduced funding for municipal tree care by most communities in recent years, has increased the need to efficiently manage the maintenance of the urban forest and requires that the financing of these programs be effective as possible. The reduction in money allocated for tree care has resulted in the reduction in many forestry departments, the elimination of maintenance programs, and a drastic cut in the number of new trees planted along municipal streets.

Local Practice

Western Massachusetts Electric Company's current schedule calls for the street trees in Springfield, Longmeadow, and Agawam, Massachusetts to be trimmed every four years to prevent growth into the overhead utility lines. This schedule is the result of a consultant study, which determined that this timetable would result in the most economical approach to the maintenance of the trees in these communities. Each street mile of overhead lines are reviewed every two years and spot pruning occurs in areas which excess growth has occurred and threatens to interfere with the wire. This method assures the utility that most of the lines are regularly serviced and street tree maintenance pruning occurs on a regular basis. John Morell (1988) recommends that an increase in the trimming cycle used by utility arborists will reduce the number of larger branches which must be removed from nearby the lines, thus reducing the cost and aesthetic impact of pruning operations.

The following table (FIGURE 20) examines the expenditures of Western Massachusetts Electric/Northeast Utilities in each of the three communities researched. Each town is identified and the total number of miles of streets which contain street trees are shown for each town. The average cost per mile for the most recent trimming cycle is identified, as well as the approximate total cost for the trimming cycle in each town, assuming all street miles were serviced. The final column in the table give the approximate budget for each town, as provided by the tree warden. Note the amount of expenditure by Western Massachusetts Electric/Northeast Utilities in each community as compared to the annual forestry budget.

Municipality	Street Miles with Trees and Utilities	Avg. Cost per Mile most recent trim cycle	Total Cost to trim all streets with utility lines	1991 Municipal Forestry Budget
Springfield	309	$ 2,794.00	$ 863,346.00	$ 463,000.00
Longmeadow	62	$ 1,295.00	$ 80,290.00	$ 119,444.00
Agawam	109	$ 1,702.00	$ 185,518.00	$ 24,000.00

FIGURE 20 - Expenditures by Northeast Utilities for street tree trimming to maintain safety clearance.

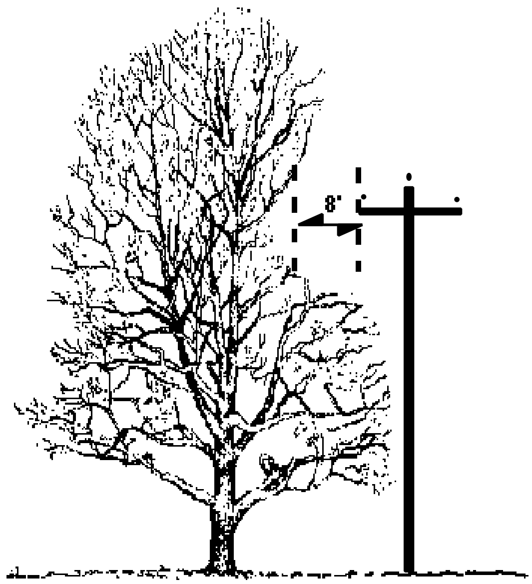
Assuming that the utility expenditure be averaged over four years due to the trimming cycle, and not take into consideration any trimming in the interim years, the following annual cost to Western Massachusetts Electric/Northeast Utilities for street tree trimming in the communities is compared to the annual municipal budgets. This is illustrated in FIGURE 21, shown below.

Municipality	Average yearly cost to NU for street tree trimming	1991 Municipal Forestry Budget
Springfield	$ 215,835.50	$ 463,000.00
Longmeadow	$ 20,072.50	$ 119,444.00
Agawam	$ 46,379.50	$ 24,000.00

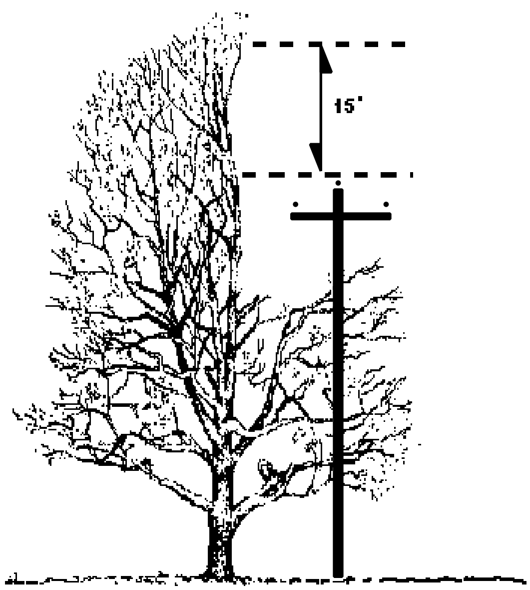
FIGURE 21 - Cost of tree trimming by NU as compared to annual municipal forestry budgets.

Conflicts with utilities and infrastructure

The intent of utility arboriculture practice is to provide adequate clearance between the overhead utility lines and the trees planted underneath them, as well as to provide that damage to the underground facilities from tree roots not occur. These missions present challenges to the utility arborist, who must follow strict guidelines so as to ensure protection of the public from electrical hazard which trees contacting utility lines present. The practice of trimming tree growth away from the overhead lines is an ongoing maintenance procedure and must be completed regularly for safe clearance to be obtained. The following figure shows an example of the minimum clearance distances which are required by Northeast Utilities. (FIGURE 22)



8' ON THE SIDE OF ELECTRIC LINES



15' OVER ELECTRIC LINES

FIGURE 22 - Clearance distances from electric lines as required by Northeast Utilities.

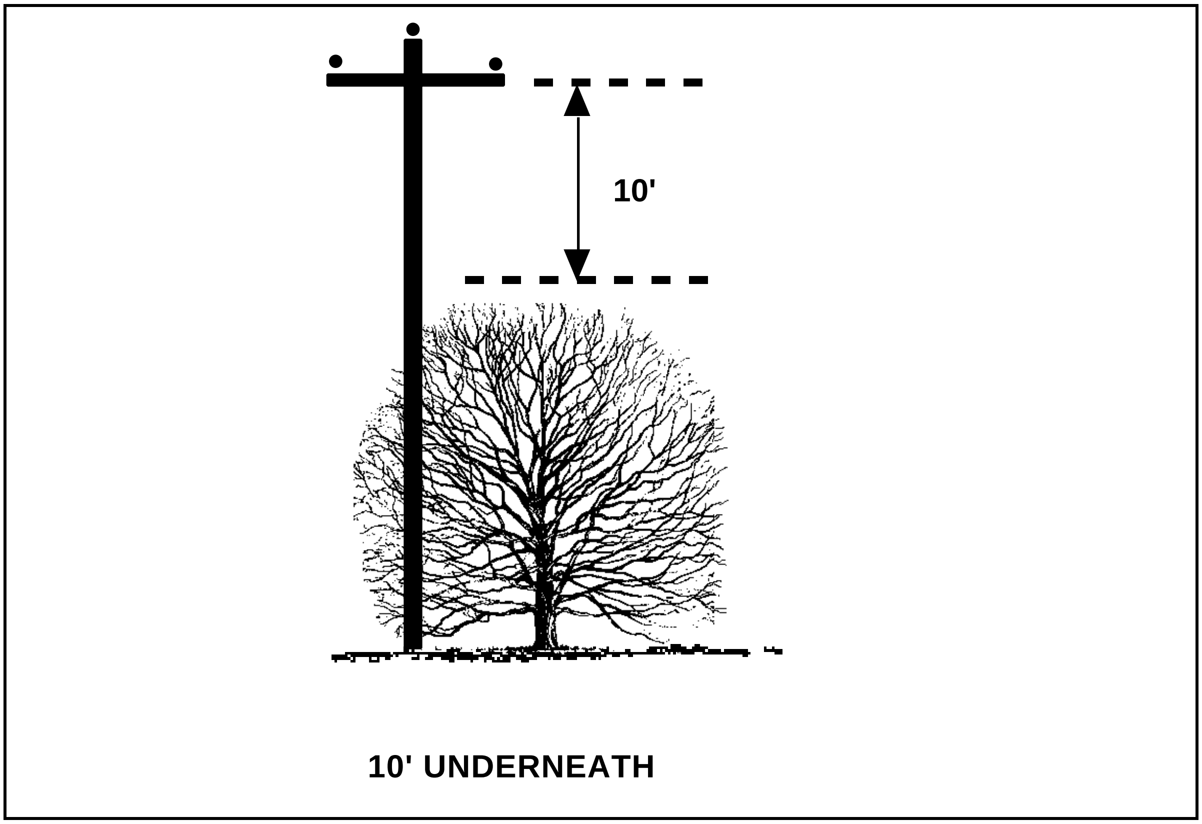


FIGURE 23 - Clearance distances from electric lines as required by Northeast Utilities.

Note that the distance which is required will present different challenges with the addition of a crossbar and additional primary distribution wires. In both of these examples a tree growing in the vicinity of the overhead lines would present a conflict with these clearances and require pruning.

The exact positioning of new utility lines can also change the character and aesthetic quality of the street tree. The following figures (FIGURE 24, 25) illustrate sample tree forms, before relocation of utility lines and clearance trimming, and after the changes are made. Note that various street trees are shown growing with ample clearance between the branches and the tree in the first illustration in each row, and the subsequent drawings show the trees after trimming operations have been employed. The examples illustrate various trimming techniques used by Northeast Utilities, and include Overhead Trimming, Side Trimming and Under Trimming. Note that in each type of trimming the form of the tree is changed and the integrity of the ultimate form threatened. These illustrations can also be used to demonstrate the importance of proper species selection and planting location when replacing street trees. The left trees, planted with adequate room for growth present a much more desirable situation, than do any of the other alternatives. The ongoing removal of branches which interfere with the overhead wires presents a continued financial cost to the utility as well as putting additional stress on the street trees, resulting in a less healthy urban forest.

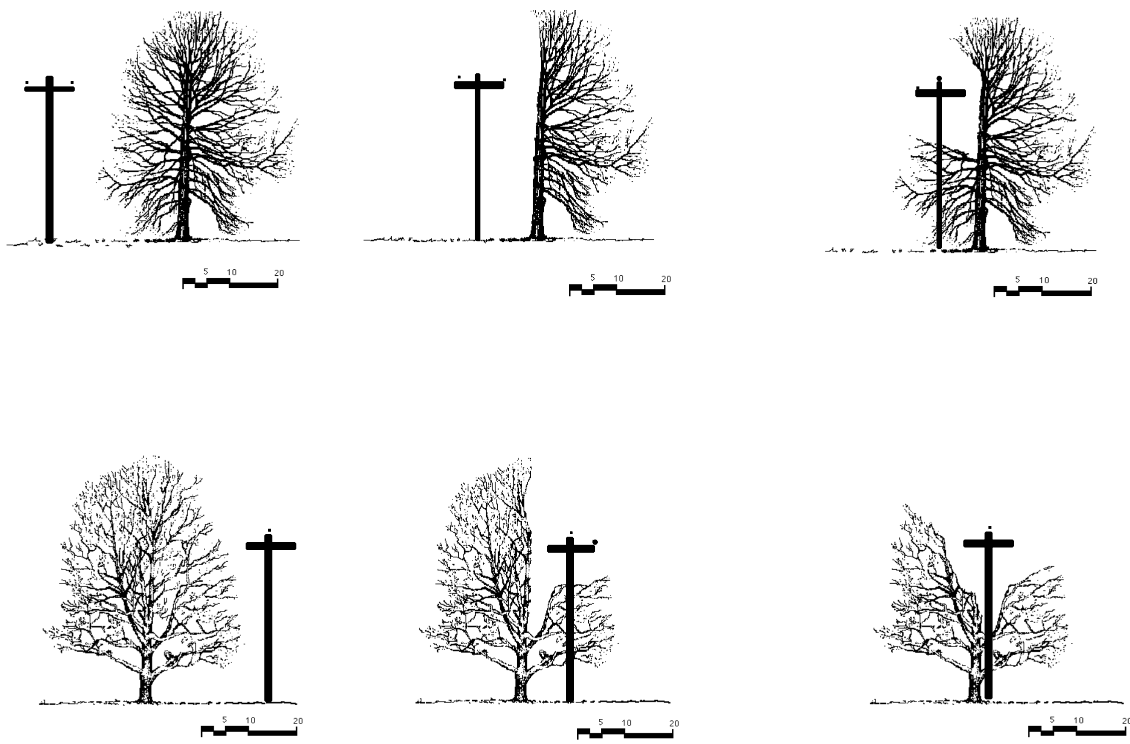


FIGURE 24 - Trees trimmed for clearance from utility lines.

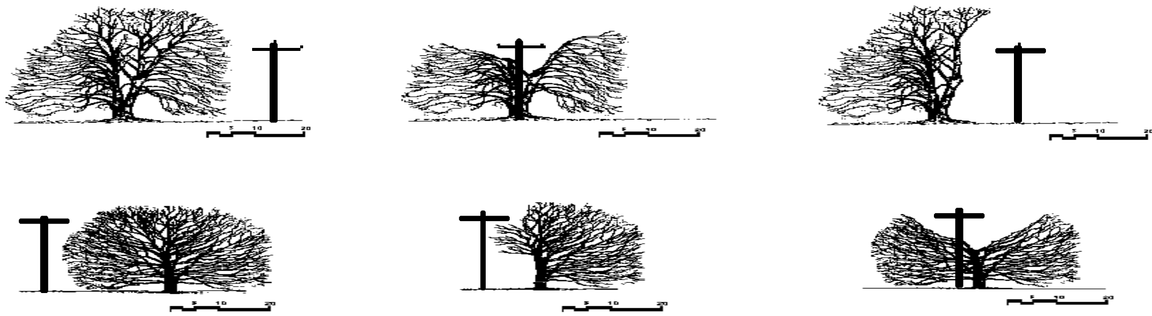


FIGURE 25 - Trees trimmed for clearance from utility lines.

As can be demonstrated in the following illustration, the tree planted along a street presents other problems for the utility and the municipality alike. (FIGURE 26) The diagram illustrates the potential for damage to the street, adjacent sidewalks and curbs, sewer, water, gas, telephone and electric distribution systems. Tree roots can cause cracking or heaving of asphalt in streets or concrete in pedestrian sidewalks. Concrete and granite street curbs can easily be displaced by tree roots which move laterally away from the tree trunk. Sewer lines are often disturbed by the intrusion of tree roots, and water, telephone, and natural gas lines are often moved and dislocated by expanding tree roots. This growth of roots in the vicinity of electric lines presents the possibility of disruption of service, although he main problem occurs when repairs or installation of new lines occurs. The clearance of branches away from the utility lines, pedestrian and vehicular pathways results in a tree that cannot maintain the design integrity that may be required along a streetscape.

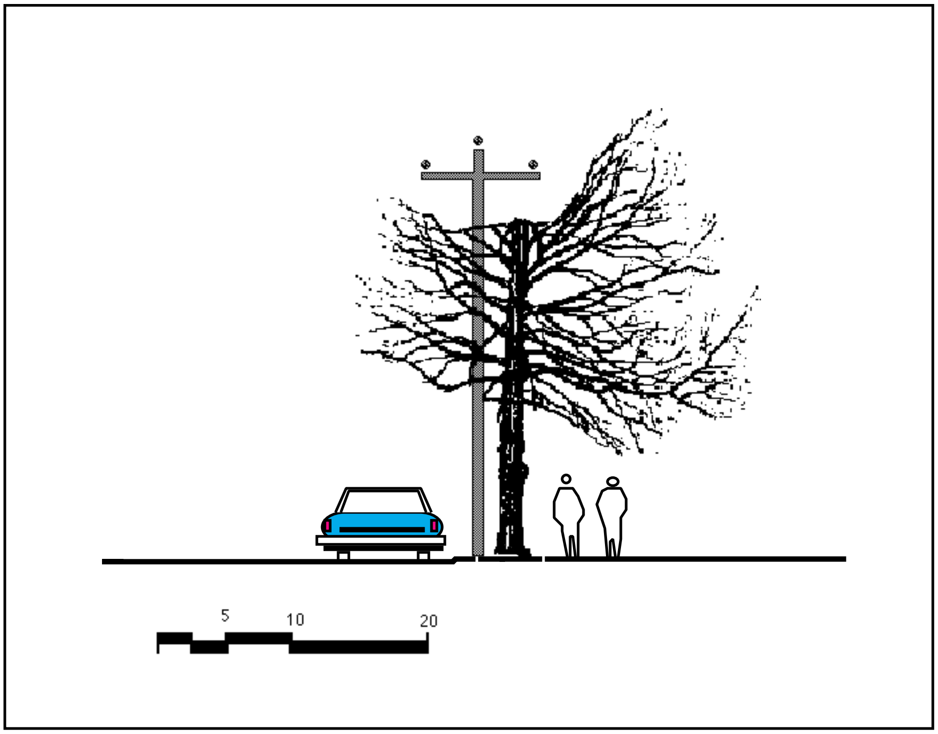


FIGURE 26 - Tree planting as part of the streetscape.

Barker, et al (1990) are currently studying the effects of urban trees and their roots on pavement surfaces at the USDA Forest Service's Pacific Southwest Forest and Range Experiment Station, in California. The development of shallow root systems is being studied and their relationship to infrastructure damage is being examined. In addition to this research, the use of micropropagation as a method for developing tree stock that will possess deeper rooting characteristics is being undertaken. The development of management strategies which reduce the potential for damage to pavement surfaces, curbings, and other infrastructure is the ultimate objective of current research. The improvement in the production capabilities of nurseries to produce more appropriate tree species is also being given careful consideration by these researchers.

Redwood City, California, as discussed by Moll (1986) has instituted a sidewalk repair program which is attempting to retain healthy and valuable street trees, while at the same time repairing damaged sidewalks which run near the trees. It is estimated that the cost of sidewalk repairs in the community will cost $24 million over the next forty years, or about $600,000 per year. This represents an average of

$10 per person annually. The goals of the program are to provide a safe walking surface, accommodate proper street drainage, and improve the health of the urban forest. To achieve these goals, Moll states, " some trees had to be removed, while others were saved by making changes in the sidewalk... and a system of operation needed to be established to insure that critical areas were serviced as soon as possible without causing other maintenance needs to suffer." (Moll, 1986) The development of a management program to identify the most important or crucial areas for repair has been undertaken by the community, with very good success thus far. Moll describes the repair sequence involved in the repair to the pavements and describes the processes of root pruning, aeration, and application of preventative herbicides to inhibit future root growth under the sidewalks.

Moll (1986) identifies the major sidewalk/tree conflicts found in Redwood City as shown in the following table, and can be used as the basis for examining potential sources of sidewalk/tree conflicts in any community.. (FIGURE 27)

• Trees were planted in an area too small to accommodate the mature size, resulting in sidewalk and curb lifting;
• Urban soils and lawn irrigation patterns encourage shallow root systems;
• Concrete was place right up to the trunk of the trees disrupting soil air balances and the concrete was physically lifted by the tree's root system;
• Homeowners feeling the best solution is to cut down the tree, whether the sidewalk repairs are scheduled or not;
• Where trees were removed, homeowners were reticent to having another tree planted fearing recurring damages;

FIGURE 27 - Potential sources of sidewalk/tree conflicts.

As is seen in Moll's list, most of the conflicts could be eliminated or reduced through programs which encourage proper planning, design, and maintenance of the trees and the nearby infrastructure. The implementation of a program, similar to Redwood City's allows for a reduction in the damage caused by trees, economic savings, and an increase in the health and quality of the streetscape forest. Moll estimates that the trees in Redwood City have a value of $23 million, and therefore the expenditure of maintenance costs can be easily justified. In other communities, it is important to consider whether the trees are worth the cost of the repair or replacement of the tree with an appropriate species would be the preferred option. Moll suggests that one way to determine whether improvements should be implemented is to "evaluate the cost of potential damage claims filed by those who may trip and fall on the uneven pavement... a payment that doesn't reduce conflicts or accomplish any repair." Moll suggests that the money paid out in damages, would be better off used for the proper care of the infrastructure, thereby benefitting the trees and the community.

The drawing below (FIGURE 28) illustrates damage to sidewalks, curbs and infrastructure resulting from tree roots growing near the surface. This situation is common in many communities, and can be used as the basis for examining solutions recommended by Moll.

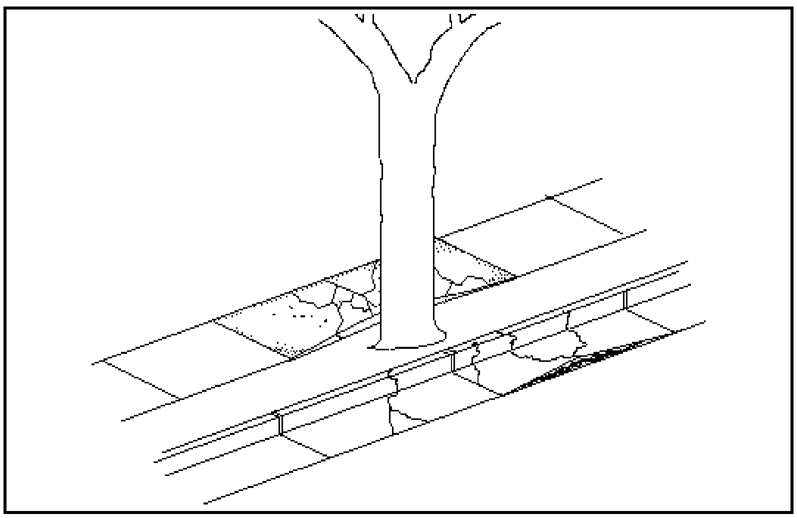


FIGURE 28 - Damage to sidewalk, curb, and storm drain due to tree roots. *Source Moll, 1986.*

The following illustrations (FIGURE 29) demonstrate how some of the techniques employed in the Redwood City example, and can be incorporated into management programs in any community which identifies potential conflict between trees and pavement surfaces. The repair and replacement of the sidewalk can allow for the growth of newly planted or existing trees while reducing the conflict between the roots and the physical infrastructure. The examples shown illustrate measures which improve the physical infrastructure and allow for expanded tree growth.

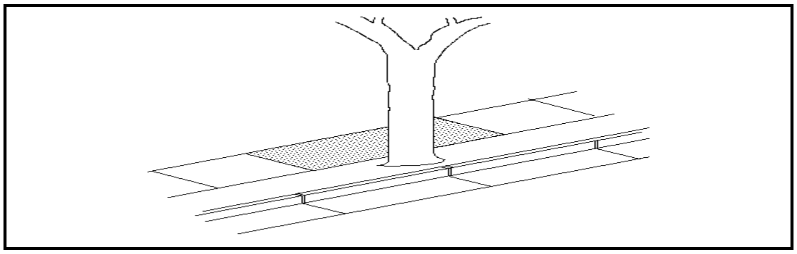


FIGURE 29 - Concrete sidewalk replaced with gravel or stone screenings. *Source Moll, 1986.*

In the illustration below (FIGURE 30) the sidewalk is redirected and ample room for trunk and root growth is provided along the planting strip.

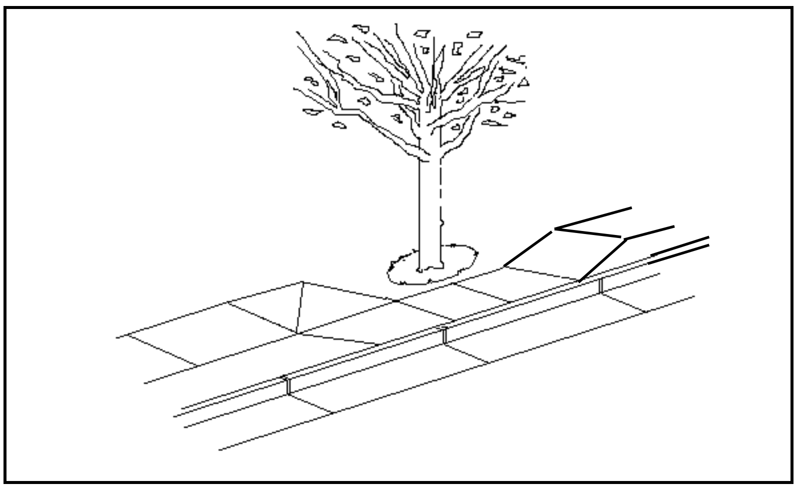


FIGURE 30 - Reconstruction of sidewalk allowing for increased root and trunk growth. *Source Moll, 1986.*

Other considerations include the following examination (FIGURE 31) of the condition of the street tree, as suggested by Moll (1986), to determine whether the tree should be replaced or infrastructure changes made.

• Tree species - does the tree respond well to root pruning?
• Size - how large will the tree grow in relation to the space available?
• Age - what is the trees projected lifespan?
• Space - has the tree encroached the sidewalk, curb and driveway so that root cutting is not possible without impairing the tree's health and stability?
• Condition - is the tree healthy and should it survive root pruning?
• Structure - is the tree structurally sound?

FIGURE 31 - Moll's criteria for determining need for tree replacement.

Damage to curbing and adjacent street paving can also occur when street trees are planted in areas where there is not ample room for root growth, or the species growing in a location is not suited to the site conditions. According to Miller (1988) the area where a tree is planted "provides size constraints on the species planted... and considerable damage to sidewalks and curbs results from fast-growing, shallow rooted species planted in narrow tree lawns." Wagar (1985) recommends planting slow-growing species with a smaller mature size in narrow treebelts in a effort to reduce the incidence of curb and paving damage.

Root pruning or other similar techniques to contain or restrict the development of tree roots is not currently undertaken by Western Massachusetts Electric Company or by the municipalities studied, although Hamilton (1988) has demonstrated that a reduction in damage to nearby infrastructure is possible by employing root severing techniques, however the use of such techniques requires analyzing the impact of root severance on the vigor of the tree and the ability of the remaining root to fully anchor the tree in the soil.

The combination of underground and overhead problems which result from street trees presents challenges and obstacles for the urban forester to overcome, including species selection, planting location, pruning methods, and other maintenance requirements. The systematic management and integrated approach to the care of street trees allows for the arborist to eliminate many of the problems associated with the trees and overcome the challenges which they face. Through the development of a program which address the needs of the municipality, the utility, and the community streets which contain healthy, safe, and aesthetically pleasing trees will be the norm.

Chapter Three
Developing the Method -
Improving the Quality of the Streetscape

Background

Through a careful and detailed examination of the street trees in Springfield, Agawam, and Longmeadow, Massachusetts, a series of street types has been developed giving a good overview of the various streets occurring in each community. By using these sampled typical streets, it is possible to examine the interrelationship between the street trees and the overhead wires and underground utility distribution networks. Typical examples of the various street types were selected based on the street width, character, and type of overhead utility line in place. The 'backbone streets" or streets with main distribution lines on them were the primary ones examined because they normally require the use of crossarms to hold the wires and therefore are most likely to interfere with the street trees.

The relationship of the street trees to the physical infrastructure was examined, based on examples in which obvious damage to streets, curbs, and sidewalks could be studied. Not all damage to the infrastructure can be seen from above ground, therefore underground implications of root growth will be looked at and damage to underground systems analyzed.

Each of the street types identified earlier are illustrated and overhead utility lines added to the street section. The images of a street type without the addition of overhead wiring are compared to the more desirable design schemes, which have no utility lines in them. The form of the pruned trees is based on typical examples currently found occurring on streets in any of the target communities. The impact of alternate species selection and planting location is examined, and demonstrated through additional drawings. This visual examination is intended to allow for discussion of these alternative management techniques which are designed to improve the health and appearance of the street trees, growing along municipal streets and near overhead utility lines.

The Target Communities

The subjects of the examination presented here are the western Massachusetts' City of Springfield, and the Towns of Longmeadow and Agawam. These municipalities were chosen because they include a variety of street types, as well as presenting a varied range of the scale of urban forestry operations. Street trees in each of the communities have their own characteristics and history, and can be used to reflect situations which occur in many other communities. The cross section of street types, condition of infrastructure, and street tree management programs in these three communities gives ample opportunity to reflect on the condition of street trees that are likely to be found in other cities and towns.

Community Location

The following map (FIGURE 32) shows the location of the three communities which served as the basis for this study. Included in the map are figures which indicate the population and the land area of each community.

Springfield, the largest of the communities is mostly urban in composition, and is the second largest city in Massachusetts. Most of the layout of the streets and neighborhoods was prior to the 1930's and has resulted in a community containing various neighborhoods. All of these neighborhoods form an overall urban pattern with a more dense urban core containing a downtown district.

Longmeadow, which is a bedroom community of Springfield is primarily suburban in character, with much of its growth having taken place since the 1950's. Although newer in neighborhood composition than Springfield, most of the streets contain overhead utilities, presenting problems for this community because of the trees lining most of its streets. The town has a tree lined town common where the early colonial village existed, and this served as the central point for radial development away from the old center.

Agawam, located across the Connecticut River from Springfield and Longmeadow was primarily a farming community until the 1960's and 70's when development pressure greatly increased the developed area of the town. Today, the town is primarily a bedroom community for Springfield, although a rural character can still be found in parts of the town. The street types vary in the town and overhead utility lines are found in all areas except for the newest subdivisions, where underground utilities are required. Most of the streets within the town are tree lined.

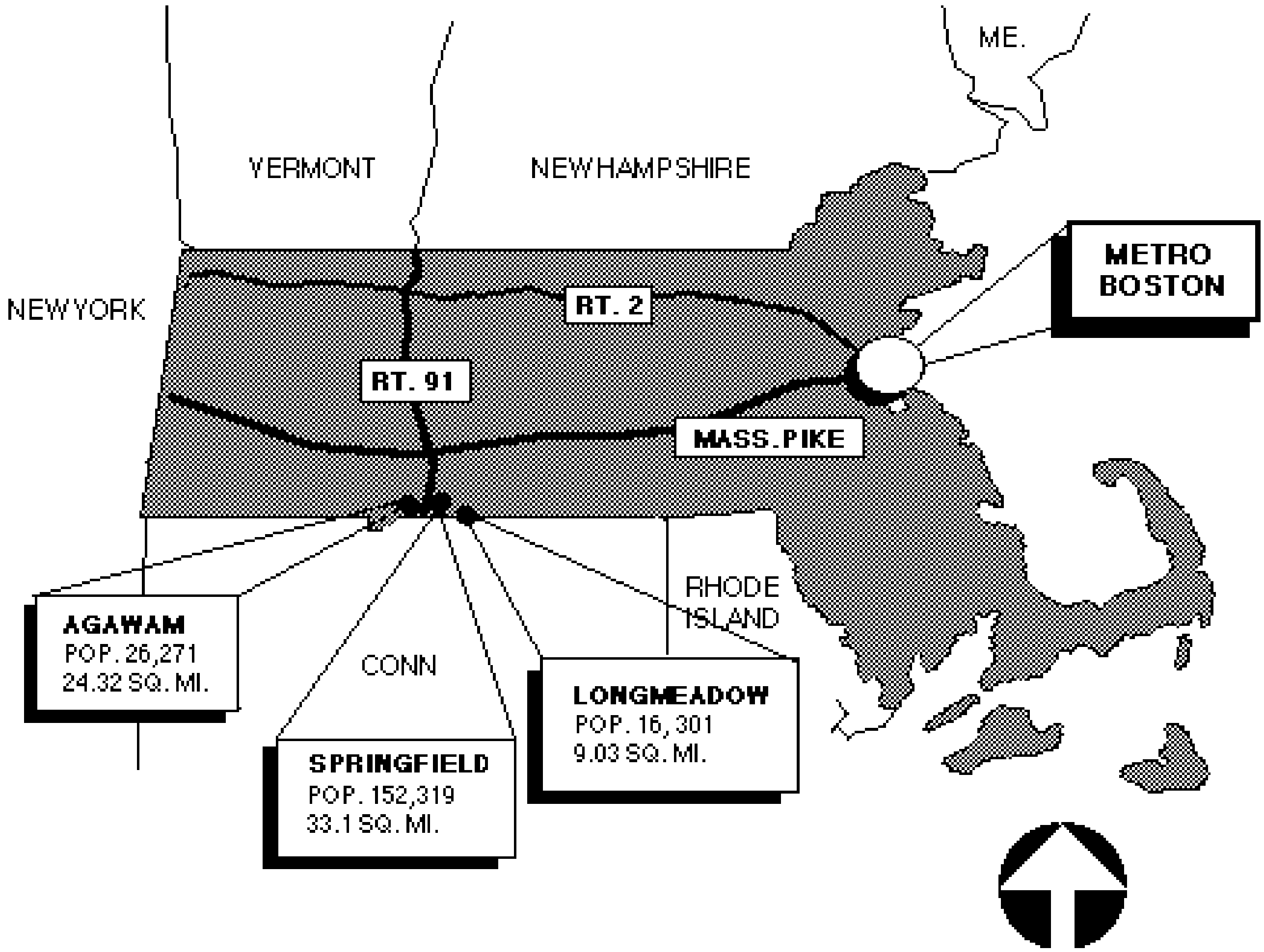


FIGURE 32 - Map of Massachusetts in New England context showing location of study communities.

The Procedure and Process

Purpose and Use

It is useful to note that the findings and recommendations found in this report are intended to be used by municipal tree wardens, urban foresters, utility arborists and citizen groups attempting to improve the condition of street trees. The intent of the research is to make the findings as useful as possible by all concerned parties, and to be as easily understood as possible. Therefore many of the recommendations and ideas that are presented are shown in graphic form, so that they can be easily reproduced and utilized by interested individuals. The primary intent of the information contained in this report is to assist in the implementation of policies which will encourage improved management of the street tree inventories in our cities and towns, thereby increasing the aesthetic and ecological quality of the streetscape.

Recommendations

A separate report is to be provided to the client which represents an executive summary of this research paper, so that the most pertinent components of the findings, which relate specifically to the utilities needs, can be most effectively used by the utility. The report in hand represents the most important findings of the research and contains information that can be utilized by audiences which include more than just utilities. The report is divided into several areas, each of which should be of interest to different target audiences. Portions of the report will be of value to some groups, such as researchers or scientists, while other areas will be important to tree wardens, arborists, or utility personnel. Landscape Architects and designers should find the information helpful in their work of creating space and developing the urban pattern and place. Each component of the report attempts to discuss topics in an easily understood manner, so that the materials, findings and recommendations can be most easily used by several groups. The findings and recommendations have been presented in a form which combines two aspects of the research; the use of the street tree as a design element and observations of the physical conditions affecting street tree growth. The findings have combined these two components of urban forestry to develop criteria and recommendations for species selection, planting location, maintenance procedures, and management policies. It is hoped that the findings and recommendations presented here will be utilized by the various professionals whose work determines the health and quality of our street trees.

Identification of various street types

In order to more effectively understand the how various street types affect the way in which street trees can be used, the street types are divided into several categories with common characteristics. Harris and Dines (1988) group roads and streets into four categories as shown in the table below. (FIGURE 33)

STREET TYPE	Number of traffic lanes	Width of travel lanes	Width of parking lane	Width of Right of Way
• **Major Arterial**	4+ lanes	12 feet	12 feet	120 + feet
• **Minor Arterial**	4-6 lanes	12 feet	10 feet	100-120 feet
• **Collector Streets**				
Single family residential	2 lanes	12 feet	10 feet	60 feet
Other collector streets	4 lanes	12 feet	10 feet	80 feet
• **Local Street**				
Single family residential	2 lanes	10 feet	8 feet	50-60 feet
Other Local Streets	2-4 lanes	11 feet	10 feet	60-80 feet

FIGURE 33 - Street types as identified by Harris and Dines.

In Figure 33 the width of the right of ways can vary from around 50 feet to over 120 on larger arterial roadways. The dimensional standards which Dines proposes are primarily guidelines for new roadway construction, and when examining existing streetscapes it is common to find variations in the dimensions. However, the street types listed above cover the basic range of street types found in most communities, therefore they will serve as the basis for identification of street types to be examined in this study.

Most of the streets which were examined in this study are minor arterial, collector, and local streets, with emphasis placed on streets that are the routes of 3-Phase overhead wiring and contain significant street tree plantings. The most common street types carrying this arrangement of transmission lines and containing street trees are the major arterial, minor arterial and single family residential collector streets. Several examples of of this type of street are included in this study.

Additionally, treebelt or planting strip width varies from street to street in most communities, thereby affecting available planting area, presenting design and planting implications. Most existing roadways do not have a standard width for the treebelt, therefore a great deal of variation occurs. Even on the same streets, sidewalks and their location play an additional role in determining the location of street trees. The location of the sidewalks ultimately affects the design which can be initiated on a particular roadway. The following drawings illustrate the different street types which are likely to occur in a community.

Major Arterial Roads

FIGURES 34 and 35 show a major arterial roadway with two lanes of traffic in each direction, with a 12 foot parking lane on both sides of the road. Note that these dimensions are the recommended minimums as proposed by Harris and Dines (1988). Most of the roadways examined in this study, had considerably less room for treebelts, because of a narrower right of way. The maximum size of the treebelt in this illustration is 24 feet, including the area necessary to construct a sidewalk and plant trees. The trees that are illustrated in this drawing are medium to large size deciduous shade trees, and serve as typical representations of the mature size of many trees along the street examined in this study. Sidewalks are found on both sides of this type of roadway, thereby reducing available space of tree planting. The drawing demonstrates the minimum design standards for a major arterial roadway, however many existing roadways studied fall below this minimum.

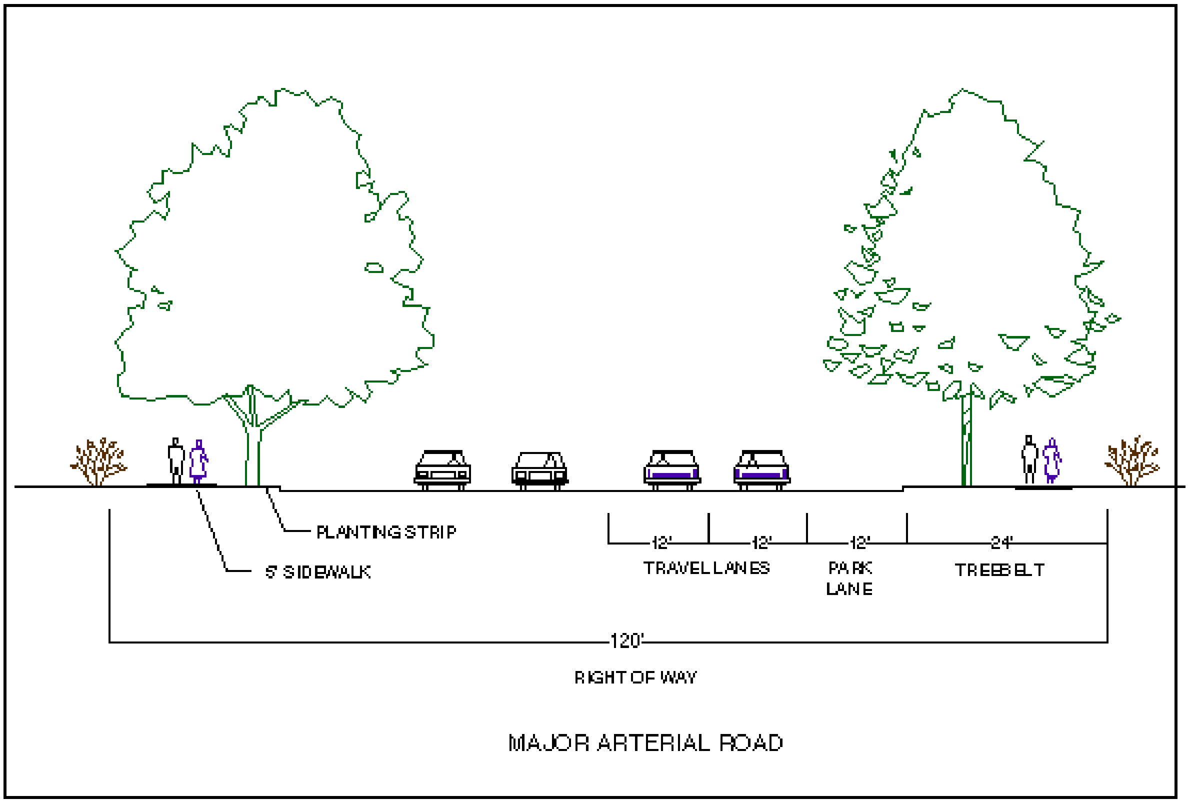


FIGURE 34 - Cross section of a major arterial road.

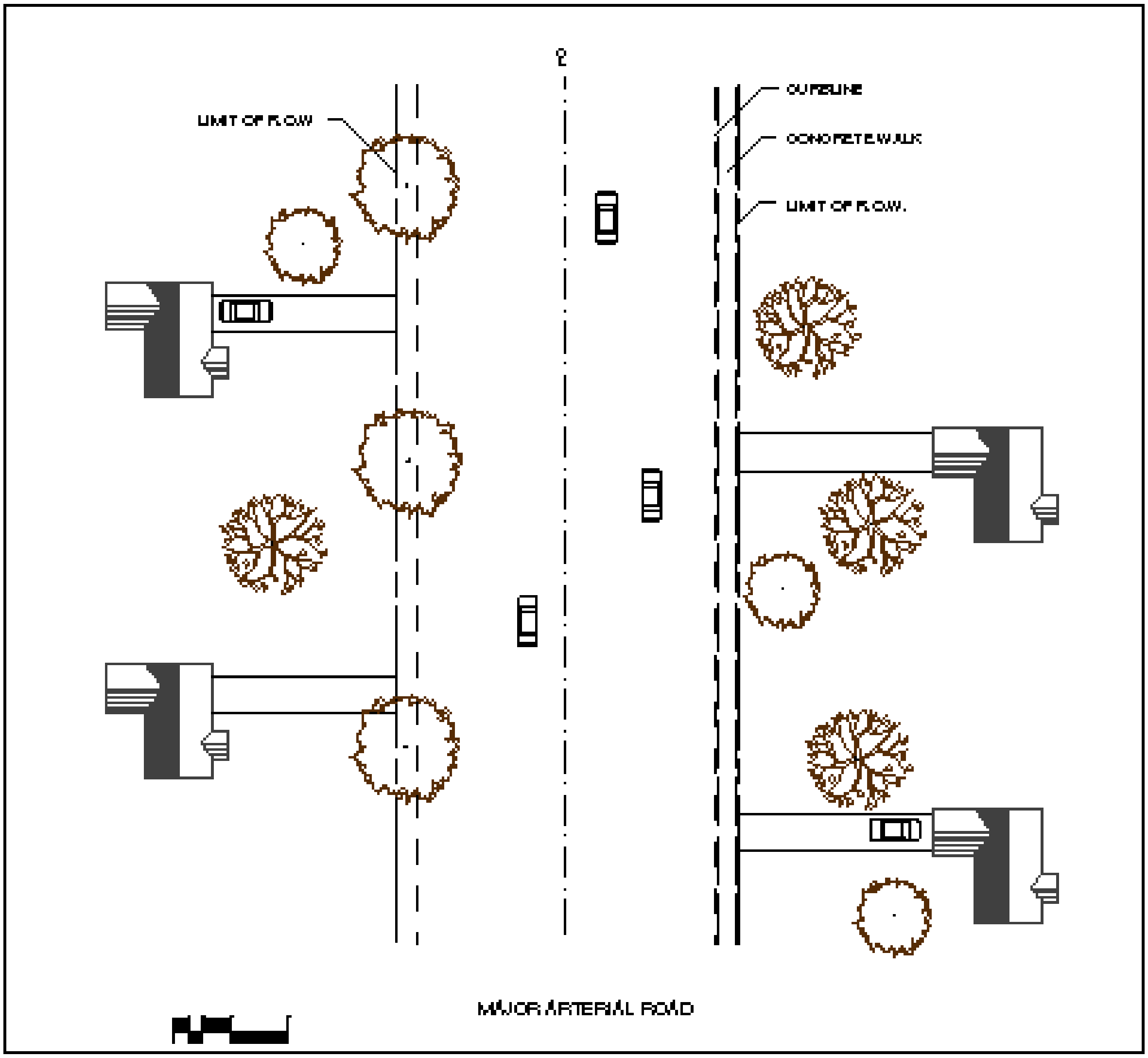


FIGURE 35 - Plan of a major arterial road.

Minor Arterial Roads

FIGURE 36, below, shows the minimum design standards for a minor arterial roadway, with similar limitations as the above roadway type, on the area available to plant street trees. This situation is the more common type of arterial roadway found in the communities studied, resulting in a decrease in planting space, as compared to the wider major arterial road. In the situation illustrated below, there is less space for tree planting. This location will not allow for trees to be set back from the roadway sufficiently to allow for vehicular travel beneath the trees. The tree will be unable to achieve its true form as a result. Also there is the increased likelihood of damage by roots to the sidewalk, curbs and other infrastructure due to the reduced distance from roots to the physical components of the streetscape.

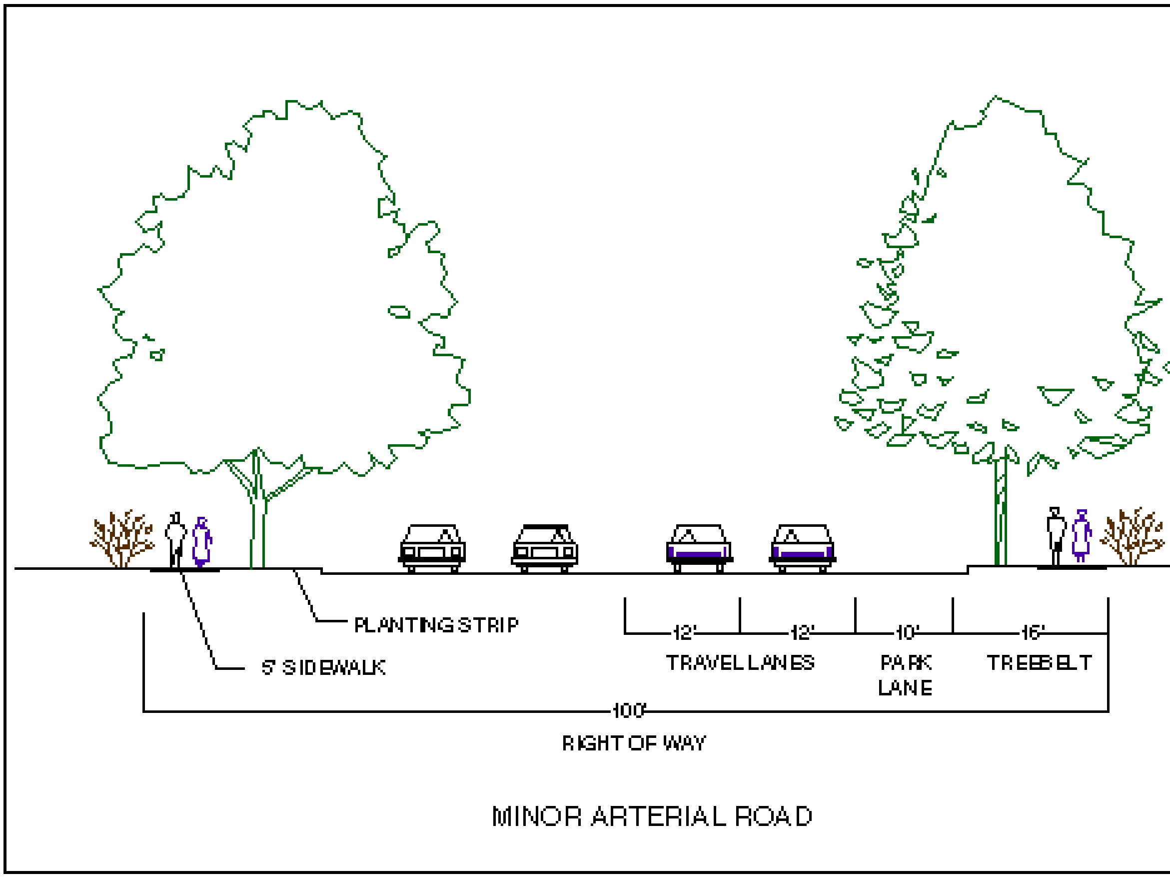


FIGURE 36 - Cross section of a minor arterial road .

Collector Streets

Collector streets present further limitations on the availability of tree planting space increasing the likelihood of infrastructure damage., In the communities studied, much of the space available for planting was limited to only several feet resulting severe problems when attempting to establish street trees along this type of roadway. FIGURE 37 below illustrates a collector street, and shows the characteristics of this type of street. Note that there is a sidewalk on only one side of the street, although in some cases sidewalks are seen on both sides of collector streets. The tree is planted immediately next to the sidewalk, resulting in the possibility of impacting the sidewalk and nearby curbing. Underground components of the streetscape are not illustrated, but the reduced right-of-way area indicates that underground structures are likely to occur in the vicinity of the street trees.

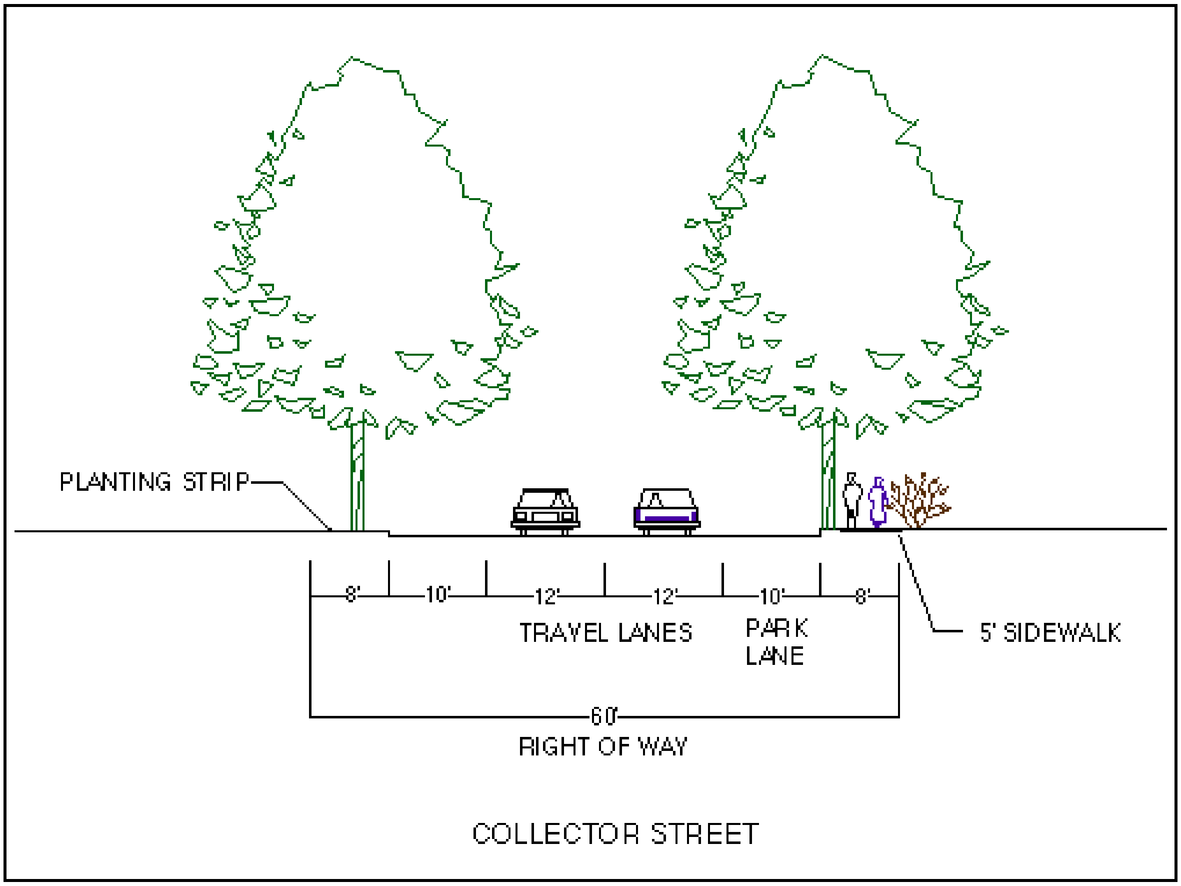


FIGURE 37 - Cross section of a collector street .

Local Streets

The Local Street, as illustrated in FIGURE 38, has a reduced right of way width, which ranges between 50 and 80 feet depending on the specific streetscape situation. In the communities examined, the narrower of these ranges appears to be the most common. With a reduced right of way, the available room for street tree planting is severely restricted, presenting limitations on planting space within the right of way. The installation of a sidewalk further reduces any available planting space, and results in the absence of street trees on the side of the roadway with the sidewalk. The shrub shown in the illustration is located on private property, acting as a separation between the public right of way and the private landscape adjacent to it.

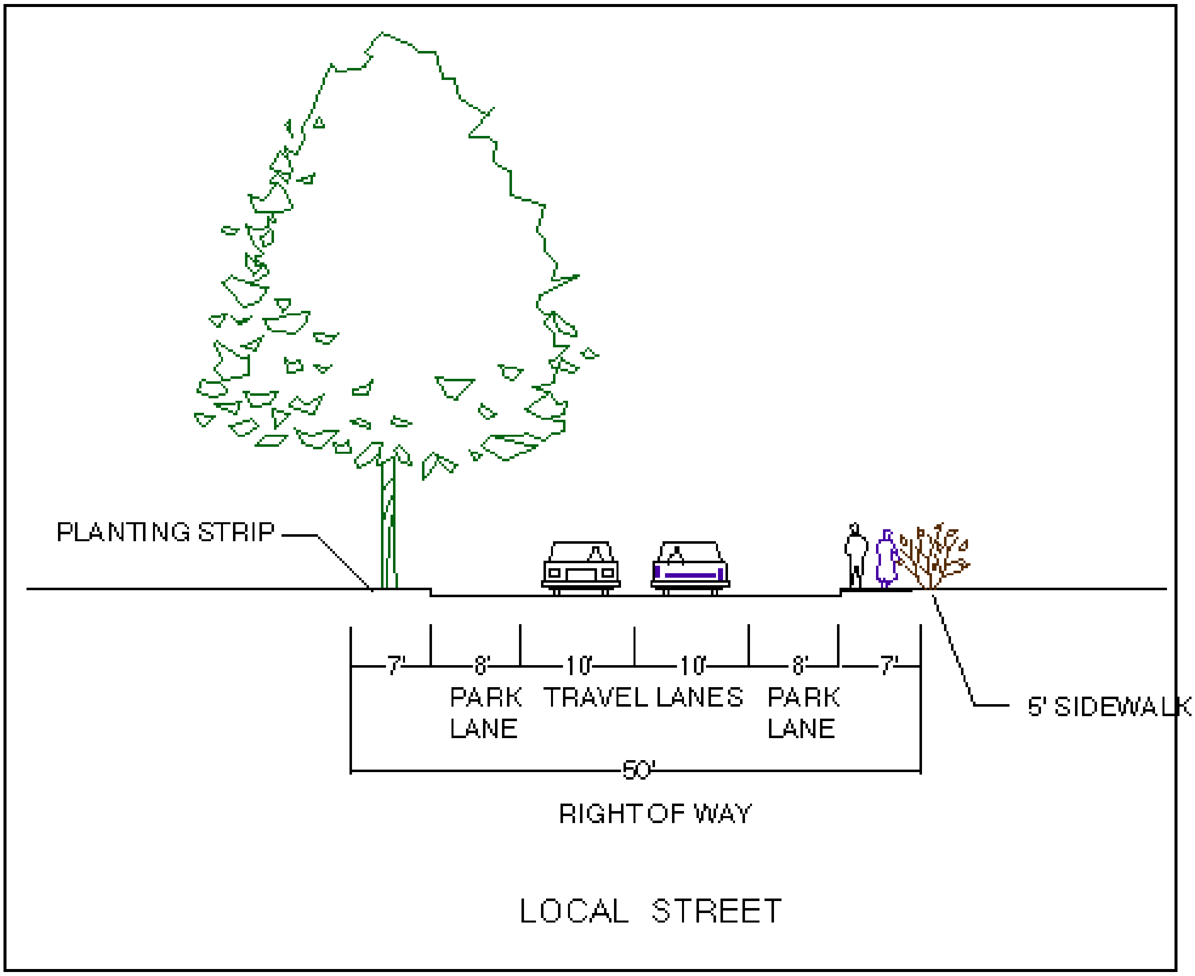


FIGURE 38 - Cross section of a local street .

A plan view of a Local Street types is shown in FIGURE 39. The street is planted in a typical manner with street trees planted on one side of the street opposite the sidewalk and other trees planted on private property. This arrangement is common on streets which contain no overhead utilities and ample right of way.

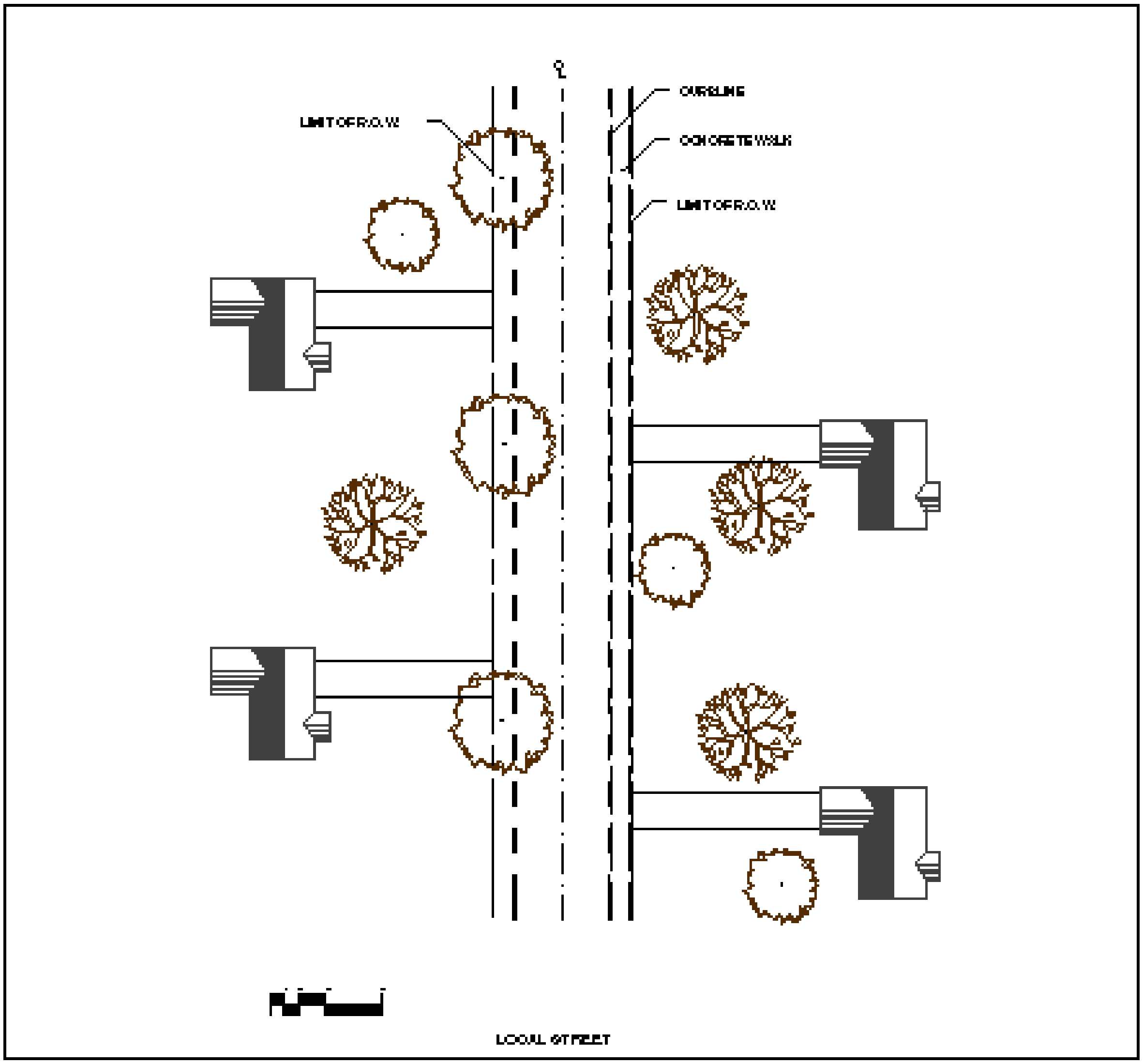


FIGURE 39 - Plan of a local street showing right-of-way, sidewalk and street trees.

Boulevard or Parkway Street

Another street type which is found in many communities is the Boulevard or Parkway, which includes a planting strip along the center of the roadway. The width of the planting strip varies with the function and location of the street (ie: collector street, minor arterial, etc.) as well as the width of the right of way. FIGURE 40 shown below illustrates a Boulevard or Parkway street type which might function as a collector or local street. In the communities studied, several boulevard streets occur along 3-phase backbone delivery routes.

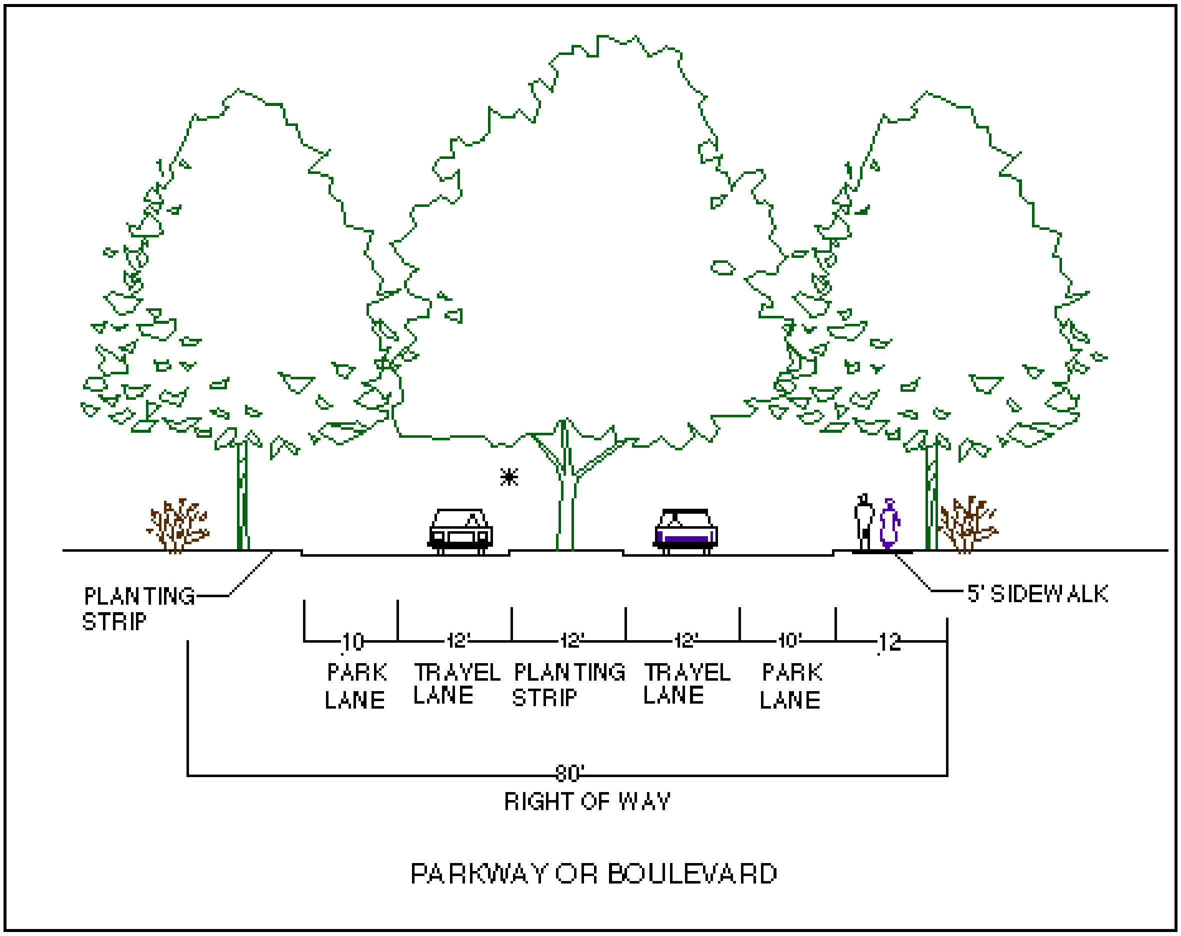


FIGURE 40 - Cross section of a boulevard street with overhead utility lines on one side of roadway.

Street Tree and Utility Line Interfacing

The conflict between utility lines and street trees can be found in almost any community one examines. The degree of interfacing between the two is most evident on streets carrying 3 Phase primary conductors, and having the wires anchored to cross-bars. The example shown below compares this type of electric distribution system with single phase primary conductors (See FIGURE 41). The illustration shows that the 3-Phase type of wiring needs more overhead clearance space, than does the single phase wiring, and therefore increases the potential for interference with trees which grow nearby.

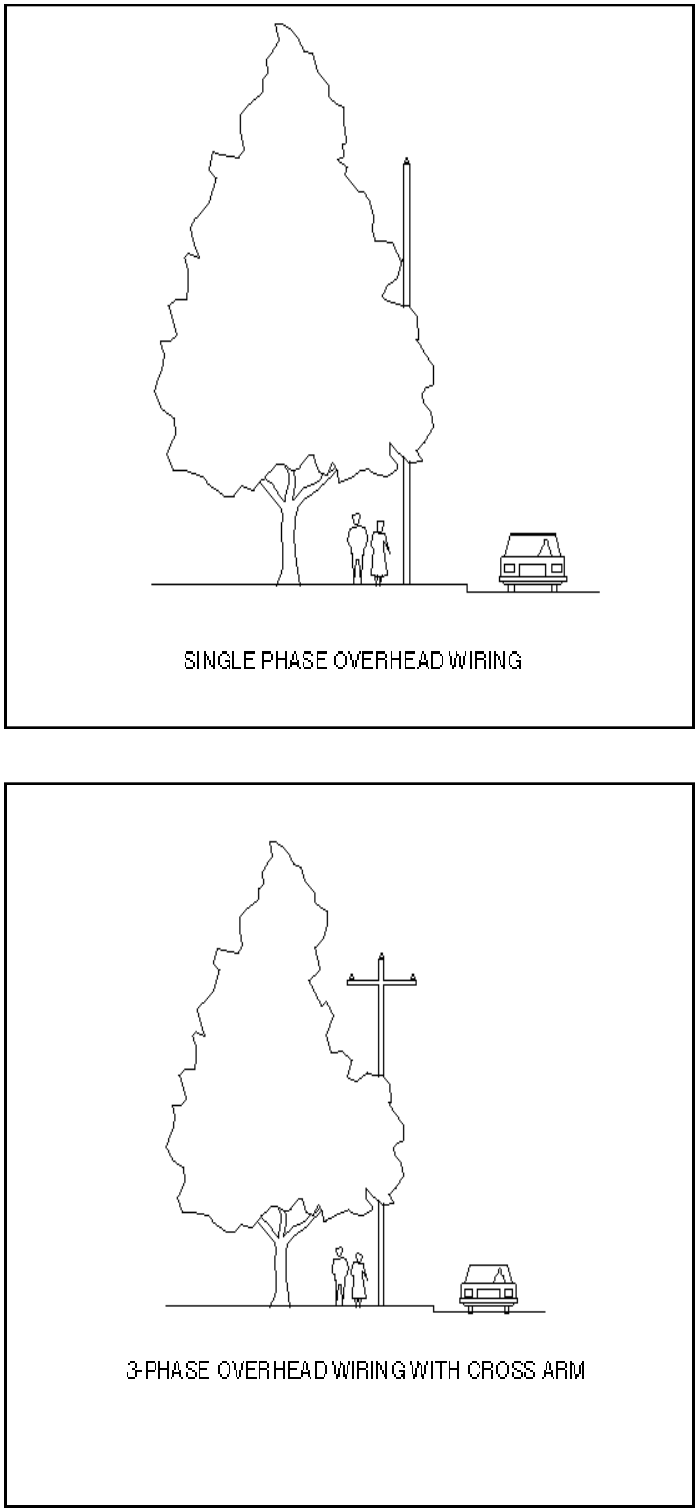


FIGURE 41 - Utility poles with vegetation trimmed away for proper clearance from electric lines.

Increased use of the crossarm on most 3-Phase electric delivery systems has presented a problem for street trees, since many trees come in range of the clearance area around the wires as the crossarms are added to nearby poles. The use of crossarms also occurs on most of the "backbone" streets, or primary delivery routes of the electric system, resulting in many situations along these streets where wires and trees come into conflict with each other. The importance of maintaining clearance around the wires is most important on these "backbone" routes, since outages in these areas are more likely to affect more customers and result in more wide-spread impact. The increased use of the crossbar means that the right of way or clearance around wires is more likely to impact the aesthetics and health of nearby trees. The eight foot crossbar increases the total clearance area needed around the wires, resulting in more tree pruning. This is critical when new crossarms are added to poles previously having no crossbar, and therefore required less area for clearance. The addition of the crossbar necessitates drastic trimming of trees which previously did not interfere with the wiring. The following illustration (FIGURE 42) illustrates the minimum clearance distances required between the overhead wiring and surrounding vegetation. Note that the horizontal distance needed on a single phase line is 16 feet compared to the 24 feet necessary when a crossarm is added. This increased clearance requirement can sometimes necessitate major pruning of nearby trees when a pole has a crossarm added to it.

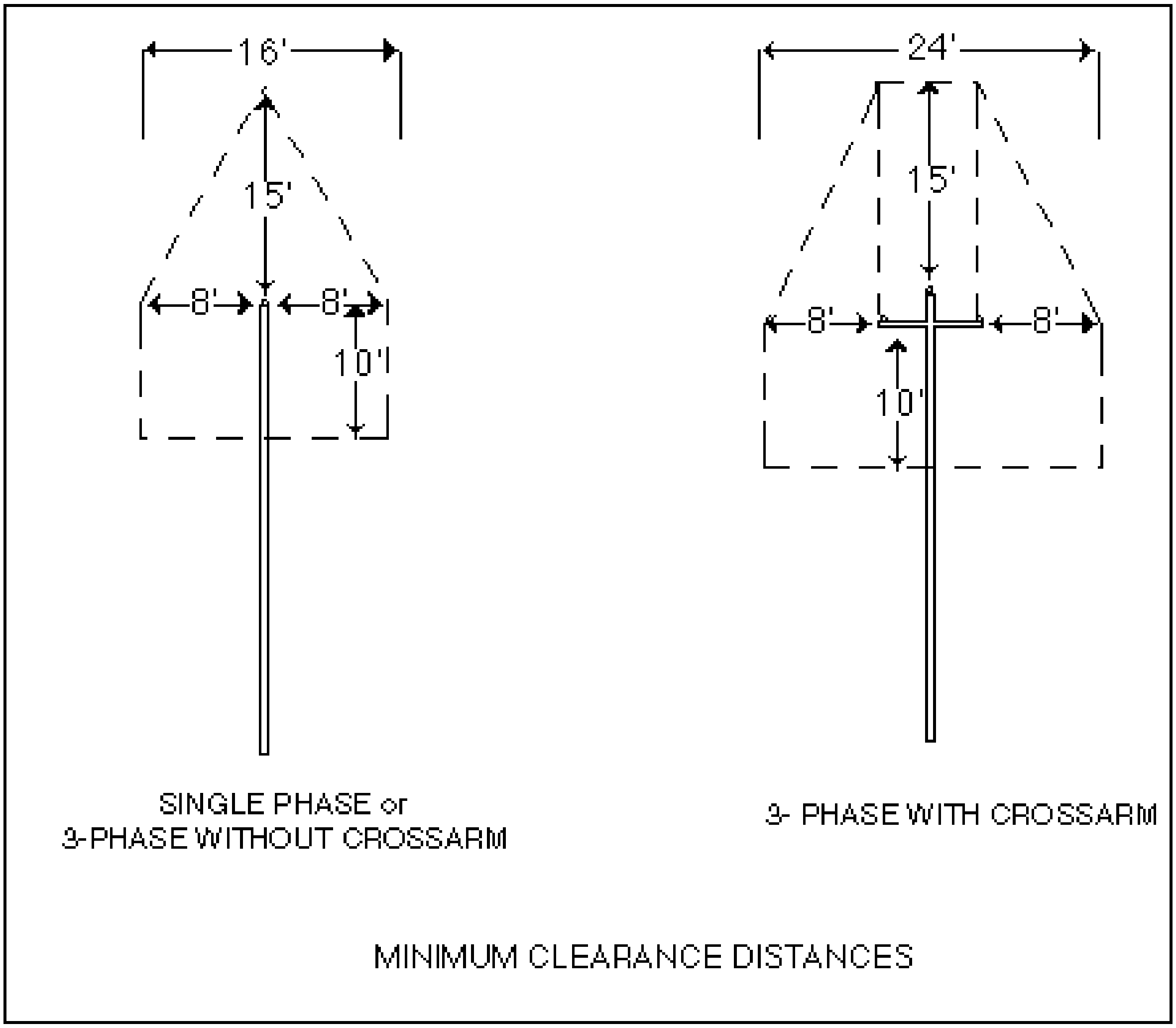


FIGURE 42 - Minimum clearance distances required from overhead electric wiring.

Inventory and Street Type Identification

Use and Value

In the communities targeted for this study, each of the street types discussed earlier were examined in an effort to determine the relationship between the street trees, the overhead utilities and the infrastructure found on these street types. It was intended that several samples of each street type be found in each of the 3 communities examined. The examples could be used to develop recommendations and specifications for the selection, management, and care of new and existing street trees. The identification of sample streets which could be used for the basis of further examination was undertaken in several ways. First, the identification of "backbone" streets was accomplished by examination of existing maps of the electric delivery system in each community. Second, the streets were then separated into districts of each city or town, so that streets from various geographic parts of the community could be examined. Finally, a field survey was conducted, whereby the initially identified streets could be analyzed using a simple survey form. This allowed for the ability to compile a list of sample streets that would include each of the street types, contain various kinds of vegetation, different types of infrastructure, and illustrate various instances of utility wiring and street tree interfacing. The following illustration (FIGURE 43) shows the sample analysis form that was developed for use in the field examination of the street types. The form was designed to easily compile information about streets to be sampled. Important information as to sizes of the right-of-way, types of vegetation, the presence of overhead utilities and condition of physical infrastructure are included on the analysis form. Completion of the form allows information on each street to be used as the basis for more in depth street tree databases in the event they are necessary. The information required to complete the form is easily obtainable, even by a person not trained in design, arboriculture, or urban forestry, allowing for flexibility in implementation of the analysis.

CITY OR TOWN: **STREET NAME:**

STREET TYPE: Major Arterial ☐ Minor Arterial ☐ Collector ☐ Local ☐ Other ☐

ROW WIDTH feet
ROADWAY WIDTH feet
PLANTING STRIP Y or N ☐ WIDTH feet
TREEBELT Y or N ☐ WIDTH feet

UTILITY LINES Y or N ☐ 1 Phase ☐ 3 Phase ☐ Crossbar ☐ No Crossbar ☐ Other ☐ Crossbar ☐ No Crossbar ☐

INFRASTRUCTURE Sidewalks: One ☐ Two ☐ Width feet Curbs ☐ Storm Drainage ☐ Other ☐

Notes:

VEGETATION Trees: Type Deciduous ☐ Conifer ☐
Shrubs: Type Deciduous ☐ Conifer ☐

Form: Excellent ☐ Good ☐ Fair ☐ Poor ☐

VEG. CONDITION Excellent ☐ Good ☐ Fair ☐ Poor ☐

VEG. DENSITY Sparse ☐ Adequate ☐ Heavy ☐

Notes:

SET BACK Approximate Distance to Structures from ROW edge feet

BUILDING DENSITY Dense ☐ Moderate ☐ Low ☐

OTHER FEATURES Views ☐ Historic District ☐ Industrial ☐ Commercial ☐ Single Family Multi-family Public land Other

NOTES:

Name:
Date:

FIGURE 43 - Sample street inventory form.

The field visits determined the range of street types in each community that would contain the elements which effect the use of the street tree as a design element, as a functional part of the landscape, and as a potential problem for the infrastructure of the streetscape. By inventorying the streets these characteristics were easily identified, and were used to develop findings and recommendations.

The street types were subdivided into other categories, as needed, to more specifically identify a particular situation or occurrence. The following table illustrates some sub-groups that were derived from the initial street types previously described. (FIGURE 44)

Street Type	Urban	Suburb	Rural	Wires	Infrastruc-ture	No Trees	Varied Vegetation	Significant Vegetation	Historic District
Arterial Major Minor Collector Local Boulevard Other									

FIGURE 44 - Table of additional street types based on characteristics contained within the streetscape.

It can be seen from this table that identification of street types presents a general overview of situations that are likely to occur in the streetscape. An exhaustive listing of specific attributes could be compiled based on individual situations. For simplicity of implementation and usefulness to the utility arborist, tree warden and urban forester, the street types chosen for examination have been limited, based on the street types previously outlined. The street types chosen can be adapted to serve most situations which might occur in a community, such as an historic district, a rural landscape, or areas presently without vegetation. The street types that were chosen to be examined more closely are: Major Arterial Roads, Minor Arterial Roads, Collector Streets, Local Streets, and Boulevards. Design implications, tree species selection, planting location, infrastructure management, utility distribution, arboriculture practice, and street tree management will be looked at and related to the specific examples used.

Methods

The following table (FIGURE 45) contains a list of streets examined in each community, and gives a classification for the street type based on field visits. This list is intended to provide a range of streetscape situations, allowing for the development of specific recommendations that can be applied to actual streets as well as developing recommendations for general street types.

Street Name	Street Type	Street Name	Street Type
SPRINGFIELD			
Alden Street	Collector Street	Harkness Avenue	Minor Arterial
Appleton Street	Local Street	Mayfair Avenue	Local Street
Ardmore Street	Local Street	Newbury Street	Collector Street
Bolton Street	Local Street	North Branch Pkwy.	Minor Arterial
Bradley Road	Collector Street	Parker Street	Major Arterial
Breckwood Blvd.	Collector Street	Tiffany Street	Collector Street
Devonshire Road	Local Stret	Morrison Terrace.	Boulevard Street
Dickenson Street	Collector Street	Warrenton	Local Street
Dwight Road	Collector Street	Wilbraham Road	Major Arterial
Gillette Avenue	Boulvevard		
LONGMEADOW		**AGAWAM**	
Bliss Road	Minor Arterial	Annable Street	Local Street
Burbank Road	Collector Street	Anthony Street	Local Street
Converse Street	Minor Arterial	Clematis Street	Local Street
Merriweather Drive	Local Street	Colemore Street	Local Street
Shaker Road	Collector Street	North Street	Collector Street
Williams Street	Minor Arterial	Silver Street	Collector Street
Wolf Swamp Road	Collector Street	Suffield Street	Minor Arterial
		Valentine Street	Local Street

FIGURE 45 - Streets examined in this study.

The use of a street tree inventory is a very important component of a urban forestry management plan, and the more complete the inventory is, the more helpful it can be in developing recommendations and implementing policy for the planting and care of the street trees. Using the inventory method, employed in this study, a useful inventory can be easily compiled, allowing for more informed management decisions to be made. Various forms of inventory sheets are used by tree wardens, street tree managers, and utility arborists with the intent of developing a more complete understanding of the quality of the urban forest. An inventory can also be of value, since it allows for identification of damage to infrastructure and surrounding streetscape features. As identified by ACRT, Inc. (1990) "a complete street tree inventory is a necessary management tool for integrating service requests with work planning/scheduling and the development of tree work histories." The development of a street tree inventory can assist in efficient work management, master planning, cost analysis, liability identification, species evaluation and costing, IPM and insect and disease control, and population monitoring on a tree-by-tree basis. The usefulness of the information can be expanded through the development of a computerized inventory system, allowing for increased analysis and manipulation of the data, than would occur with a manual paper inventory.

Commercial software is available which is specifically designed for street tree inventories, and municipalities and utilities are increasingly relying on this technology to increase the effectiveness of their street tree management programs. Shown below (FIGURE 46) is a sample output of of a tree inventory program developed by ACRT, Inc. which illustrates the type of report which can be easily compiled using a computerized program. (ACRT 1991)

FIGURE 46 - Sample street tree inventory data from ACRT, Inc. Tree Manager computer software program.

Other data can be compiled using the basic inventory information, which is useful to tree wardens, design professionals, and utility arborists in planning changes to the streetscape. The following table (FIGURE 47) is a sample report determining percentages of various tree species from a sample community, produced by ACRT Inc.'s Tree Manager computer software. (ACRT, 1991) Information of this type is important to the designer or arborist during the plant selection process and the use of up to date and accurate information is critical to the success of ensuring species diversity in a plant community.

FIGURE 47 - Sample street tree inventory data from ACRT, Inc. Tree Manager computer software program.

Photography can also be employed as part of a useful street tree inventory, which will more accurately measure the quality of the streetscape environment. The following photographs show scenes of various streetscapes, and illustrate some of the features that were inventoryed in each of the communities examined in this study. Tree form, planting location, proximity to overhead utility lines, and damage to infrastructure are shown. The use of a photographic inventory is useful when examining specific situations, such as an individual street blocks, specific locations or in areas of high visual importance. The photographs can become part of a street tree inventory, either in computer-based or traditional form, and allow for added accuracy when reviewing existing conditions or recommending changes to the streetscape. Image processing can be used to visualize changes made to the streetscape, by manipulating photographs to reflect changes that might be recommended for a particular streetscape situation. FIGURES 48 show the use of image processing to visualize changes to a Boulevard streetscape in Springfield. The use of this technology allows for the designer and arborist to better understand the design and aesthetic implications of suggested changes to the streetscape. A photographic inventory can also be used to demonstrate general recommendations that are made concerning species selection, planting location, and maintenance procedures.

FIGURE 48 - Photograph of existing street in Springfield.

The photograph shown above is a Boulevard Street type located in Springfield, and it shows a median strip with no vegetation and a variety of overhead utility lines, with 3-phase electric lines and crossarms, running the length of the roadway.

FIGURE 49 - Street with computer processed image.

The processed image shown above (FIGURE 49) is a view of the Boulevard Street shown in the previous photograph with the overhead utility lines and poles removed, as well as the addition of a large shade tree. The image is intended to illustrate how changes to the streetscape can be visualized using image processing techniques. This technique can be combined with traditional photographic inventories to better develop a street tree management program and to understand design implications of recommendations which might be part of that plan.

The development of an image catalog of existing streetscape conditions, using a computer database or traditional photographic techniques, is useful to the arborist and designer to keep a record of tree growth, decline, or other impacts made on the streetscape. It is of value, since actual situations can be recorded and any changes reviewed and assessed. The images could also serve as a means to visualize impacts of pruning on the street trees. By having actual images of existing conditions, and showing the results of trimming or removal of parts of the tree a better understanding of the implications of the maintenance can be obtained.

Identification of problems or conflicts

The identification of problems resulting from the use of trees as a streetscape element is important in order to recommend changes to the streetscape and to prevent future problems from occurring. By using identifiable problems as a basis for study, the development of workable solutions to streetscape situations can be more effectively implemented. By developing an understanding of how problem situations come about, the solutions to the problems can be more effectively recommended. By examining the various street types in the target communities an understanding of common problems associated with street trees can be developed, and serve as the basis for recommendations for changes to species selection, planting location, and management techniques. The causes of problems that occur must be identified so that the factors presenting the problem can be changed or eliminated.

In addition to problems to the physical infrastructure of the streetscape, aesthetic problems are likely to occur when street trees are grown near overhead utility lines or in close proximity to buildings, signs, or other amenities since the trees are often trimmed back from these streetscape elements. By identifying situations that present problems such as this, recommendations for prevention of future occurrences are more readily found, and elimination of existing problems can be proposed. A complete understanding of design implications of changes is necessary so that the identification of problems and recommended solutions might be suggested. A thorough study and inventorying of street tree problems and conflicts can lead to more effective design and management programs.

Chapter Four

Procedures and Implementation-
Alternatives for Improving the Streetscape

Street tree planting and Management

An examination of communities throughout the United States, reveals that there are many cities and towns which have successfully implemented street tree management programs that allow for successful design implementation, as well as providing for the inclusion of overhead utilities and minimal disturbance to municipal infrastructure. The development of ordinances, design guidelines, regulations, and recommendations are some of the methods that have been effectively employed by various communities. Miller(1988) categorizes municipal tree ordinances in three categories: (1) preservation ordinances that "regulate the cutting of trees within a given jurisdiction", (2) development ordinances, regulating "the impact of construction and development upon the area landscape", and (3) street tree ordinances, that "ensure that proper species are planted in the proper location." Miller (1988) summarizes some far-reaching municipal tree ordinances, as shown in the following table. (FIGURE 50) As is illustrated in the table, there are a fair number of communities which have implemented, or are planning to implement ordinances concerned with the care of street trees. These ordinances vary in the purpose, definition, and implementation of the statutes provided for, but all are intended to improve the health and quality of the urban street tree. Most of the ordinances implement specific procedures for the selection, planting, and maintenance of street trees which should be a common procedure for qualified professionals. The instituting of legal measures mandating the exercise of this professional approach is very important, since it puts legal strength in common sense approaches to street tree care.

FIGURE 50 - Summary of municipal tree ordinances. *Source Miller, 1988.*

Kielbaso (1989) cites several communities having implemented successful street tree planting and management programs. These serve as models for other communities to follow. The cities he identifies include Austin, Texas, Cincinnati, Ohio, Lansing, Michigan, Highland Park, Illinois, Charlotte, North Carolina, Minneapolis, Minnesota, and Milwaukee, Wisconsin. In addition to identifying cities and their tree care programs, Kielbaso concludes that there are components of these forestry programs that approach ideal models. "First is a city's commitment to making trees a high priority, usually made in view of their total environmental, economic, and aesthetic assets, Second, this commitment is legal: the city has a precise ordinance that assigns responsibility for the planting anc care of all the city's trees." (Kilebaso, 1989) The role of the municipality as an advocate for the street trees is stressed by Kielbaso, and "when a city's tree policies are sufficiently clear, a good manager can assure that tree spaces are vigorously defended, that tree removals are not permitted without strong reason, and that new tree spaces are provided when new projects are contemplated." (Kilebaso, 1989)

Seattle, Washington has been one of the more visionary communities in regard to it's street trees. The City of Seattle requires a Street use Permit for all trees planted on pubic streets or rights-of-way. Encouraged by city officials, Seattle City Light, the electric utility provider for Seattle has taken a pro-active role in the management of the street trees in the community. The development of community relations and interagency communications has allowed for the utility to take a more active role in the management of the street trees within the distribution area. A Street Tree Task Force was established in 1986 to develop a procedure for dealing with the immediate and long term conflicts between street trees and the utility's electric distribution system. The Task Force developed a plan that increased interagency involvement, combining the efforts of the Seattle Design Commission, the City Engineering Department, the Parks Department, the utility, and the City Arborist. The plan included several recommendations including establishment of a citywide street tree plan, the development of a interagency computer system to be used exclusively to manage the street trees, and to develop a pilot program area to study and analyze street tree problems.

Seattle's Task force recommended this increase in community involvement and public outreach to improve the urban forest. Development of community relations skills, a crew manual, the holding of community meetings, and the development of "The Right Tree Book" followed. (Seattle City Light, 1988) Customers could then choose the right trees for their particular situation, suggesting the best possible placement of these trees to avoid trimming and removal problems. As part of this the creation of a citizen's forum to addressing the issues of tree selection criteria, development of a tree replacement policy, and public information/marketing efforts. The establishment of an atmosphere which encourages active public involvement has been utilized by Seattle City Light that appears to help run a more effective and reliable tree management program, and benefits the health of Seattle's urban forest.

Puget Sound Power and Light Company, another provider of electricity in Washington state has taken a similar pro-active role in encouraging proper species selection, planting, and maintenance procedures for street trees growing within their distribution area. "As part of Puget Power's obligation to provide reliable electrical service to all of its customers, the company has developed a vegetation management program designed to keep tree limbs and shrubs safely away from power lines" and " to ensure reliable electric service for the future, special care must be taken in the selection and placement of new trees" (Puget Sound Power and Light Company,1987) The utility has also prepared a handbook on vegetation management, distributing it to all its customers. The "Tree Book" recommends tree species, gives guidelines for selecting planting location, and outlines proper planting and maintenance procedures. The pro-active approaches of the two Washington state utilities serves as models for other public utilities to follow as they become more involved with the management of trees along public streets.

Other communities have instituted programs encouraging proper species selection, placement and maintenance practices. Included in these programs are ordinances in many municipalities that legally enforce street tree recommendations. Sample street tree ordinances from several communities are included in the Appendix 3 (Miller, 1988) Each of the ordinances sets minimums, address design issues, demand acceptable maintenance practices, and encourage the growth of a healthier urban forest.

Local Programs

The City of Springfield has a preservation ordinance (See Appendix #) that protects "significant trees" over seventy-five years old or are more than three feet in diameter. The ordinance applies to both public and private trees and mandates that significant trees be removed "only upon a showing by a preponderance of the evidence that the continued present state of such tree endangers persons or property". This provision is intended to preserve, not only street trees, but other components of the urban forest. By mandating the tree warden to oversee significant trees throughout the community, the quality of the landscape is enhanced and the importance of urban trees is reinforced.

The tree warden in each community is responsible for the trees on public land, thereby including most of the street trees in their community. In the communities examined in this study the street tree planting programs are under the jurisdiction of the tree warden. New street tree plantings are being undertaken, although budget reductions have led to reduced numbers of new trees introduced along the public streets. Springfield currently spends about $3700 for new street trees annually, translating into between 200 and 600 new trees planted each year. Trees are, first planted in treebelts or planting strips as requested by residents, and then in other locations selected by the tree warden. The species and size of the planted tree, is primarily a result of the best value available from the grower, and therefore it is difficult to predict the exact tree type that will be planted from year to year, although several species are preferred for planting along the more urban streets. Over the past several years Linden, Oak, Sycamore, London Plane, Carolina Silverbell, Maple varieties, and Callary Pears have dominated new plantings along the streets. Because of staff reductions and budget constraints a plan for more effective plant selection criteria remains questionable for the foreseeable future.

Springfield has completed a computerized street tree inventory for a portion of the city, through a federal grant, but the database has not been used thus far as part of a management approach to street tree plantings. The use of such a database has been used successfully in other communities, (Wagar and Smilley, 1990) and would seem to facilitate the more effective management of Springfield's street trees.

Although not a substitute for management objectives, the computer database will assist the tree warden in understanding the health, vigor, and quality of the street trees in the community. This will allow for more informed decisions to be made resulting in more effective management of the urban street trees. According to Wagar and Smiley, computers can "move street tree management dramatically ahead by letting municipal arborists and urban foresters summarize records and current work needs, project future workloads, and track costs and opportunities for savings. By increasing the effectiveness and efficiency of management, computerized records can contribute not only to growing professionalism but to coping with ever present budget constraints.". It is evident that Springfield should continue the development of its database, so as to more efficiently manage its street tree planting and maintenance programs.

In Longmeadow, budget restriction have had similar effects on new street tree planting within the community. Prior to 1987, approximately $15,000 was allocated to planting an average of 125 new trees each year. Currently new street trees are planted only when a resident pays for the purchase of a tree by the town. The town also has a Beautification Program that plants 2 or 3 trees annually on town land, far less than the number planted prior to 1987. The trees that are planted along streets are mainly ornamental species chosen by the tree warden, and have included Bradford Pear, Kwansan Cherry, Redbud, Hawthone varieties, Lilac, Mimmossa, and Sassafras. The town has no planting guidelines in place, that assist in species selection or planting location. There is also no inventory of existing street trees, which could be used in the establishment of planting management guidelines, or general management procedures. Although the town currently spends $120,000 annually on the care of its street trees, management of the street trees could be more effectively accomplished through the use of a database, computerized or otherwise, which would furnish the tree warden with an up to date inventory of the street tree stock.

Agawam currently has a budget of approximately $30,000. for the care and maintenance of its street trees. All of the funding is used for maintenance of the public trees located in the 28 sq. mile community. Planting of trees, however, is required by town ordinance in all new subdivisions, and this accounts for many new trees being planted along Agawam's streets. The stature calls for two trees to be planted for each new residence in any subdivision. The trees must be planted within

20 feet of the roadway edge, and must be a minimum of 2 1/2" caliper, allowing the trees to be planted on private property, provided they are within the twenty foot distance from the roadway. This allows greater design flexibility, since all trees do not have to be located along specific lines of sight or right of ways. Species selection is left up to the property owner or developer, with approval by the tree warden. The increase in new development in the town over the fast five years has led to an increase in the street tree stock, however maintenance of these trees will have to be addressed as the age of the plantings increases.

Amherst, Massachusetts has initiated a similar requirement of new subdivision developments for two trees to be planted for each residence constructed. The town also allows for the trees to be planted up to 20 feet from the roadway edge, but allows for the developer to chose the species, presenting potential for the introduction of a monocultural landscape in portions of the community. New plantings along existing streets is undertaken by the Forestry Division of the Department of Public Works, under the direction of the tree warden. Presently the town plants from 50 to 100 new trees annually along town streets. These trees are grown in two town nurseries, which produce a surplus number of trees for availible street planting locations. Consequently, the town continues an ongoing program of identification of locations for new plantings, and discussed with residents their wishes for species type, exact planting location, and care of newly planted trees. The town also allows and advocates the planting of public trees on private property, up to 20 feet from the property line, and recommends planting of trees in this area when feasible.

Worcester is another Massachusetts community that has implemented a strong street tree management program, and has utilized available federal funds through the Urban Park and Recreation Recovery Program. Worcester has been very successful in developing the methods necessary to plant the right tree in the right spot. A physical inventory of Worcester's 20,227 street trees was undertaken and an appraised value of $42 million placed on the tree stock. The importance of an inventory is critical to forming a management plan that is be realistic and obtainable. Appendix 4 presents the Executive Summary of Worcester's street tree management plan, completed in 1988. The importance of developing a complete analysis and assessment of the street trees is evidenced by the recommendations that were made in the report based on the completeness and accuracy of the analysis, inventory, and assessment.

Monetary benefits

The effective management of street trees is critical to the health and quality of the the urban forest, from both an aesthetic and ecological standpoint. Findings by Sommer, Barker et al. (1989) and others show the value of street trees in other than monetary measure. The psychological and societal benefit of street trees is understood, but it is difficult to put a dollar value on this for the community. This presents problems for the allocation of funds for the planting and maintenance of street trees in municipal situations, since a specific monetary amount cannot be placed on the value of the trees to the mental health of the community.

Neely, et al (1988) have developed a method for placing a value reflecting the portion of the market value of a property due to trees. This formula can be used by individual property owners to assess the value of trees on their property, and has been used by municipalities in determining the approximate value of their street trees. It is of use to communities since it allows for a better understanding of the true value of the street trees, in a monetary manner.

Franks and Reeves (1988) have developed a formula for assessing the ecological value of trees, placing a monetary figure on the ecological benefits that are gained by the urban trees. This is based on the significance of its effects on soil, nutrient, and water conservation, animal usage, and habitat characteristics. The benefit from this type of assessment is that the value of the trees can be placed in a monetary form, which can be directly related to street tree management costs. Assessments of this type are important because they begin to place a value on the true measure of a street tree's value to the community.

Aesthetic considerations

The use of the tree as a design element along the streetscape is an important component of the design process, presenting unique opportunities, while at the same time creating conflicts to be resolved before a design can be implemented and considered successful. The use of the tree offers a richness that is not found in any other construction material, and therefore presents a special chance for the environmental designer to achieve objectives that otherwise might be unobtainable. The following illustration (FIGURE 51) demonstrates major characteristic tree forms that occur in natural and cultivated species.

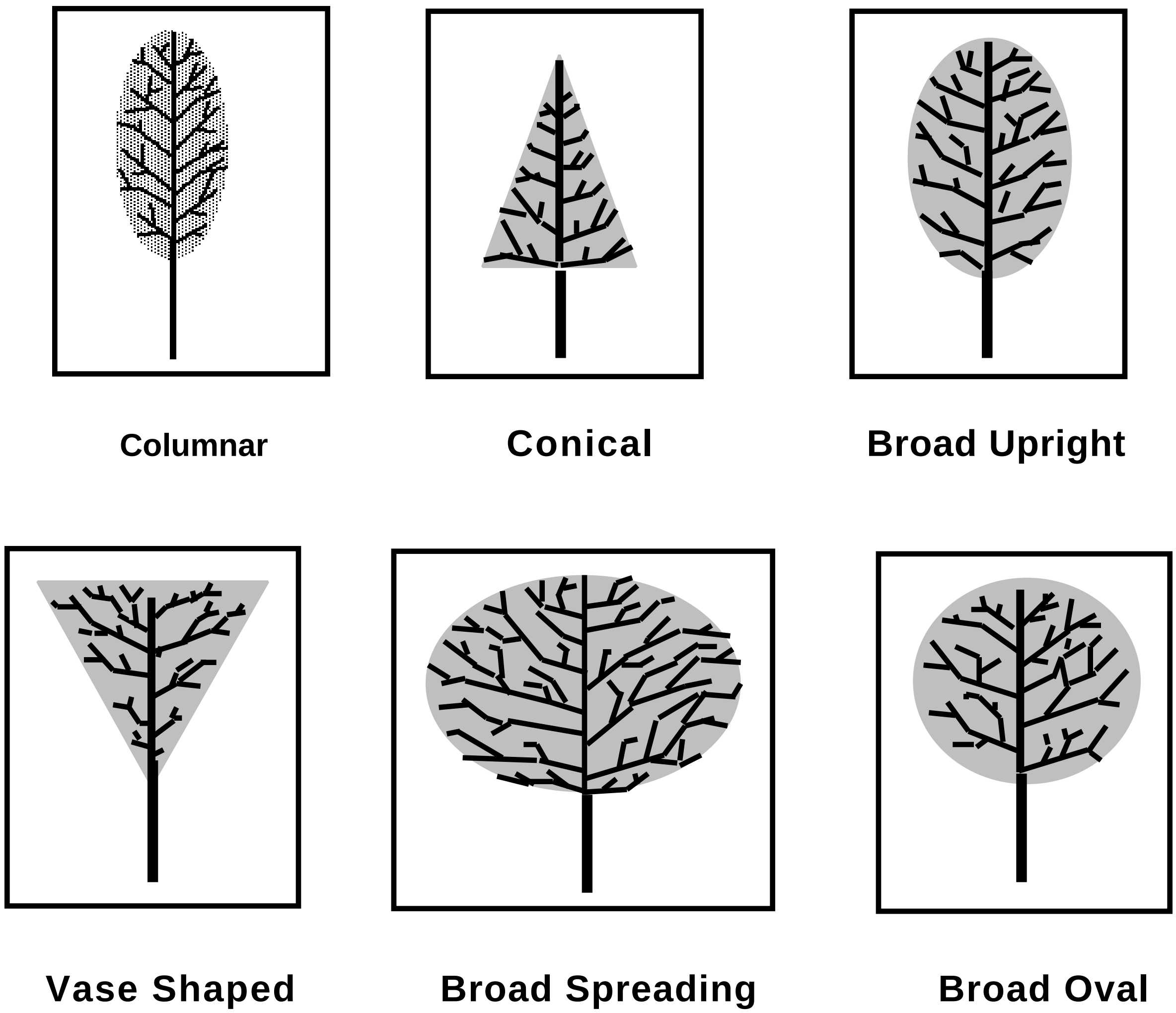


FIGURE 51 - Basic shapes of native and cultivated tree species.

The tree is also valuable due to its variation in size, including the uniqueness of increasing in size as the tree matures. The young tree may have a completely different size and shape at maturity than it does when it is first introduced into the landscape. The landscape designer or arborist who places a tree along a street must be aware of the mature size and shape of the tree, as well as what the tree looks like and its size as it grows toward its ultimate form. The following drawing

(FIGURE 52) illustrates the relative size categories of mature trees for design purposes.

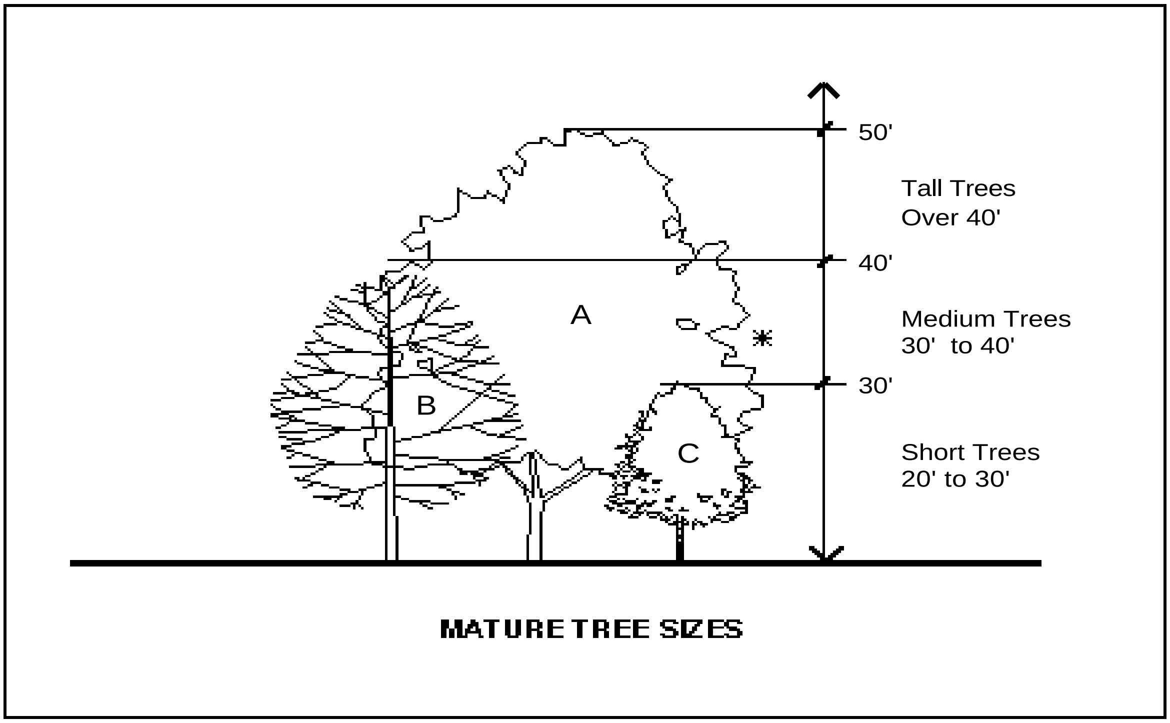


FIGURE 52 - Mature tree sizes for design purposes.
Source Grey and Deneke, 1978

The two previous illustrations demonstrate the variety and uniqueness of the tree as a potential component of streetscape design, and suggest that size, form, and texture are an important component of the design use of the tree as a design element.

Grey and Deneke (1978), Miller (1988), Arnold (1980) and others have all examined the use of the tree as a design element and have demonstrated its adaptability and range of uses within the streetscape. Discussion of space, spatial variety, enclosure, edge, form, and corridor, among others, are themes common to all of these examinations. Grey and Deneke (1978) demonstrate street corridor space developed through the use of trees, as illustrated below (FIGURE 53).

FIGURE 53 - Street corridor space. *Source Grey and Deneke, 1978.*

Arnold presents a careful examination of the use of trees to enforce geometric principles in the landscape and (FIGURE 54) illustrates several of the principles that he proposes as uses of the tree as design elements in the landscape.

FIGURE 54 - Trees used to define space. *Source Arnold, 1980.*

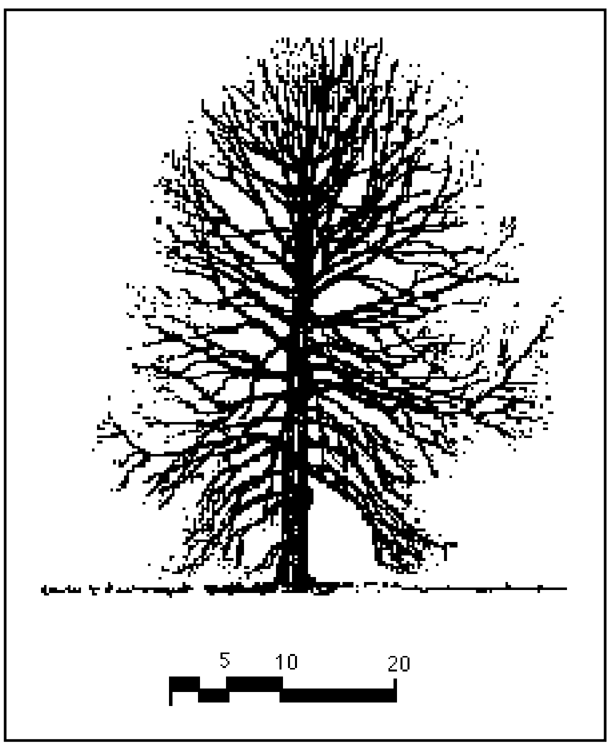
Miller discusses the role of the tree as an aesthetic contribution to the landscape, and states that " from an architectural point of view plants are described as occupying space and define space. Aesthetic uses are similar, except that each plant is an object possessing its own aesthetic quality." (Miller, 1988) He further describes how trees should be used when part of a streetscape, stating that "plantings on boulevards and streets should follow principles of design constrained by the economics of management. All urban vegetation planning should be guided by aesthetic considerations, designated uses, and management constraints." (Miller, 1988)

Stephen Anlian (1989) relates the work of the landscape architect to the quality of the aesthetic landscape around us. "The art of the landscape architect frequently lies in public view, in crated places within towns and cities, along transportation systems, and in natural conservatories. While employing synthetic materials and man-made forms, the landscape architect strives to incorporate design elements derived from natural features such as rock, earth, water, and vegetation. The most dominant element, and often the most memorable, is the tree." He further says that "landscape architects employ trees to crate such recognizable imager, to embellish architecture, and to enrich the urban environment. Trees give a shape to architecture through their size and familiarity. They provide shade, enclosure of spaces, screening, framing, and other important assets. As a result they are vital tools in responding to difficult contemporary design challenges."

The use of the tree as the most important design feature of the streetscape landscape is proposed by the previous designers and architects, and the influence which the street tree plays on the make-up of the environment around us cannot be discounted. The tree seems to move from being just a simple component of design, to becoming part of ourselves and the community. Anlian says, " the sense of community celebrated by the very presence of trees is perhaps the most inspiring of all effects. Our care for the trees in our communities is a reflection for our care for the environment at large." (Anlian, 1989) This appreciation for trees, although not always celebrated fully, has deep roots in our sense of community. The trees are a very special design component, and one that seems to bring special reward to those who are able to experience their impact on the landscape around us.

Lewis (1989) sees trees in the landscape in a similar manner, stating "though each of us may be looking at the same tree or landscape, through the filters of a lifetime of experiences we place our unique value and meaning on what is seen. These meanings will resonate within us to produce both obvious and very subtle physical and psychological effects. A holistic view of landscapes must go beyond physical aspects of vegetation and design, It must take into account the human dimensions, the diversity of personal meaning that each of us adds to create our personal mental landscape." (Lewis, 1989) This view must be understood and recognized by the designer of the streetscape landscape, and the design intent must enforce the role of the tree as an integral part of not only the streetscape landscape, but as a part of each one of us.

In many instances, however, the design intent of the landscape architect or designer, is never realized because of problems inherent in the use of trees as a streetscape element, thereby denying the tree its full meaning in the landscape. When the street trees is used for a specific design intent, such as to define an edge, it is intended that the tree have a desired size, texture, and ultimate form in order to fulfill the requirements of the design. Often times, however, the tree never achieves the desired size, texture, or form because of problems which occur in the streetscape. Overhead electric and other utility lines are probably the most troublesome factor which effects the success of a streetscape design. When taller trees are planted in proximity to overhead utility lines, they must be pruned away from the wires in order to maintain a safe delivery system, resulting in immediate changes to the size, texture, and form of the street tree. The following illustrations (FIGURE 55) show Pin Oak trees which exhibit two different characteristics as a result of the influence of overhead utility lines. The tree on the left shows a tree which is growing in an area where overhead utility lines are not present. This tree exhibits the size and form of a tree that the designer probably has in mind when specifying Pin Oak in an intended design. The tree on the right has been dramatically influenced by overhead utility lines, causing an obvious change in the ability of the tree to perform its design intent. The tree has be altered in shape, and no longer has the characteristics of the tree as envisioned by the designer, thus affecting the success of the streetscape design.



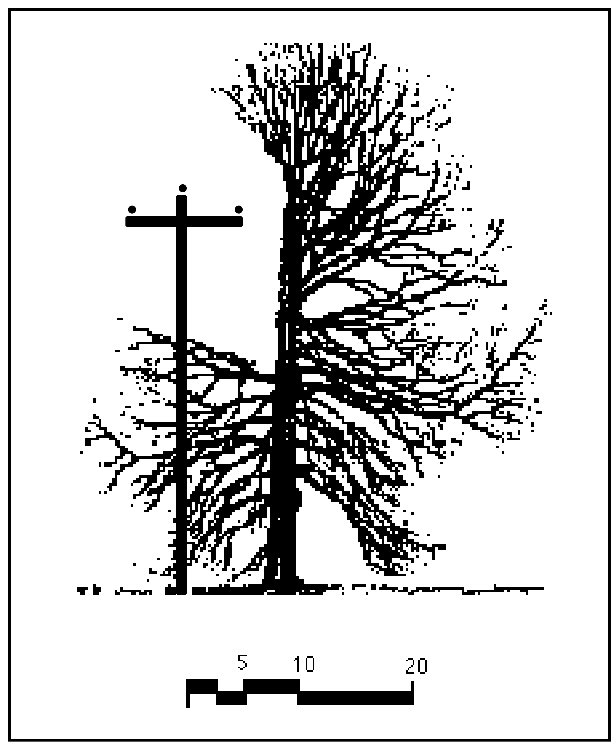


FIGURE 55 - Pin Oak showing comparison of design intent and utility clearance impact.

Another example of failed design intent can be demonstrated in the following cross-sections (FIGURES 56 and 57) looking at a typical collector street and showing trees intended to create a sense of enclosure as one travels along the street. The first figure illustrates the successful use of the tree to develop the design and to create the feeling of enclosure. In the second example it can be seen how several factors have influenced the trees on the street, thereby negating the original design intent. The canopy of the tree has been pruned back to maintain clearance around the electric wires, and has destroyed the ability of the tree to provide overhead canopy, necessary to complete the desired sense of enclosure.

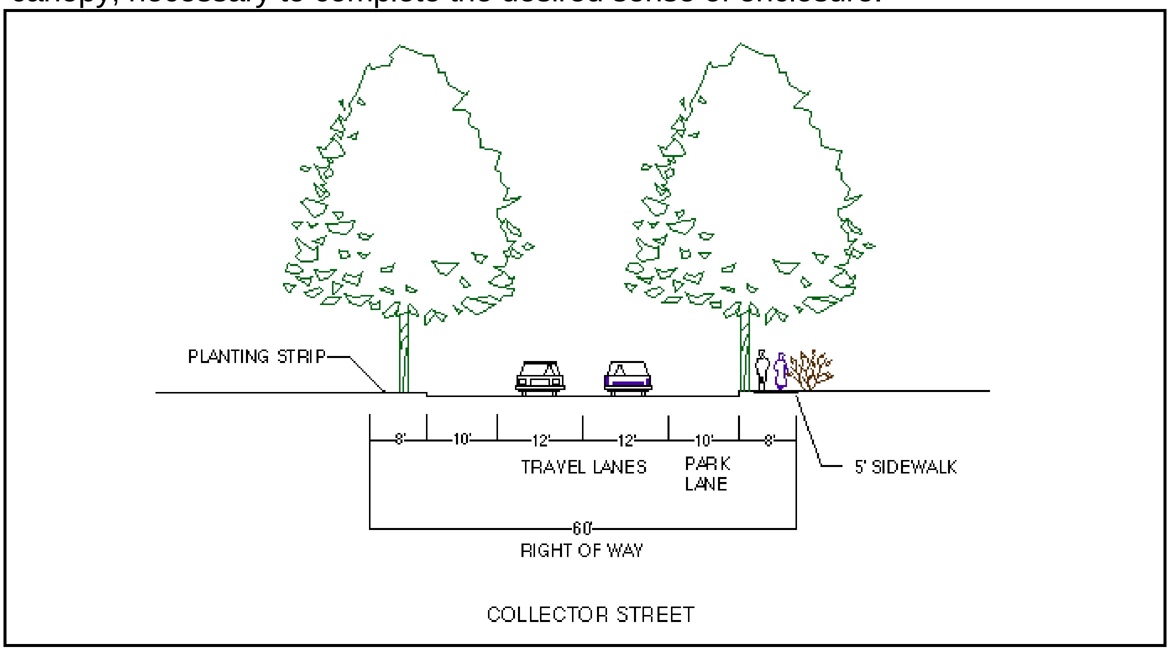


FIGURE 56 - Collector street illustrating design features including edge, enclosure and separation.

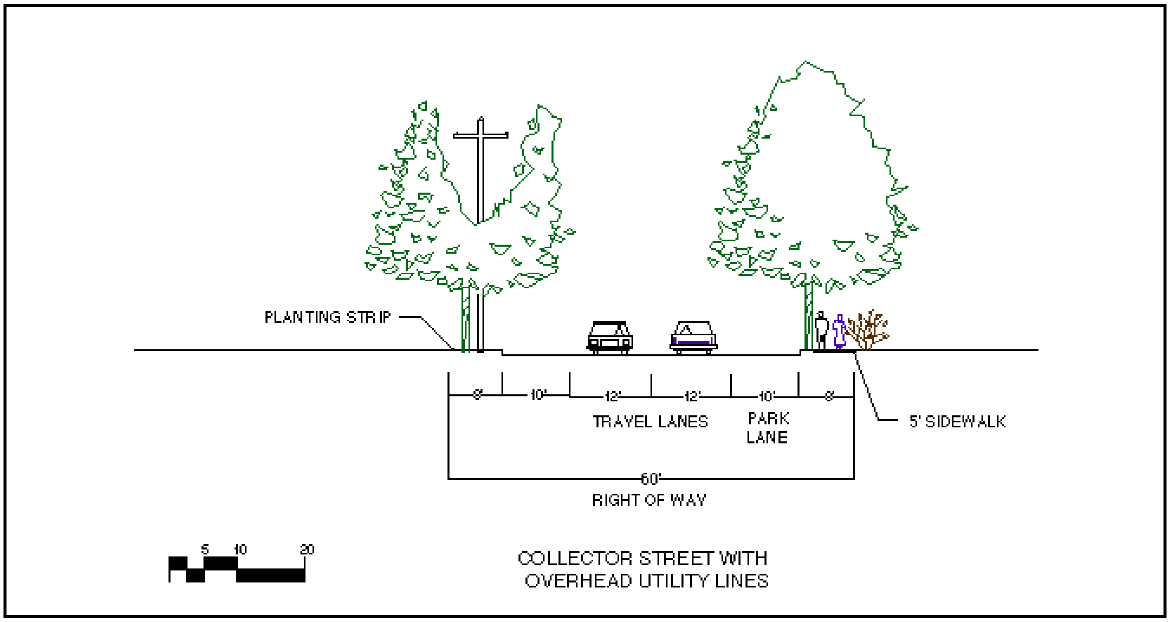


FIGURE 57 - Collector street illustrating influence of overhead utility clearance affecting design intent.

In the following example, (FIGURE 58) the use of the street tree to define an edge is demonstrated in plan view. The trees on the left plan have been planted along the planting strip of a typical local residential street, and show a sense of rhythm, order and definition of the edge of the public way. The drawing on the right shows what typically might be the result when the trees begin to grow into the area of the overhead utility lines, necessitating their pruning away from the areas. Note that the wires cross the street midway through one of the blocks, another typical occurrence along right-of-ways. The trees begin to take on different appearances resulting from repeated cutting back, and causing a degradation of the sense of rhythm, order, and definition of the edge. Eventually several of the trees are removed, due to other stress conditions resulting from the severity of the streetscape environment.

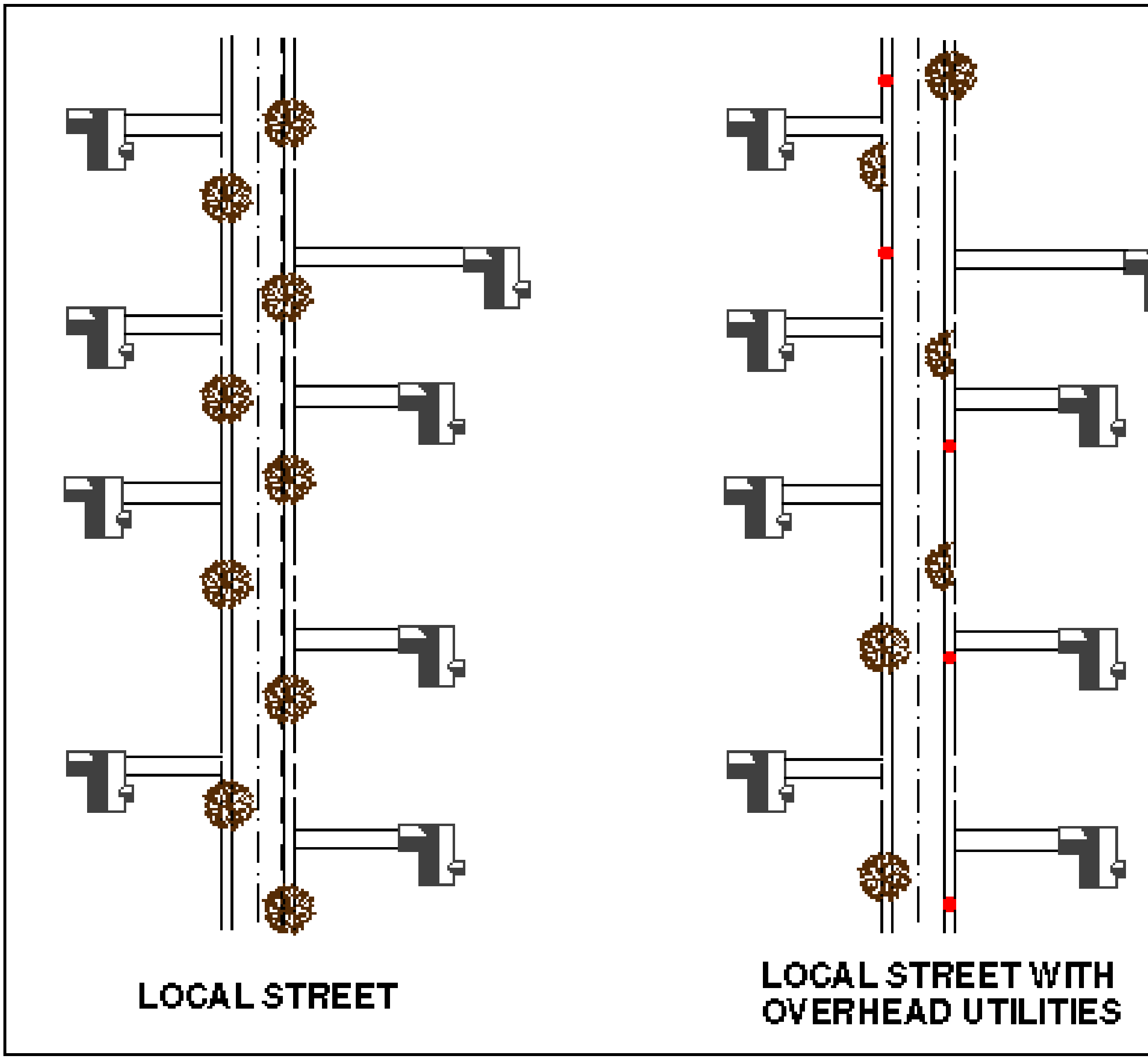


FIGURE 58 - Local streets illustrating effect of overhead utility clearance on design intent.

Trees can also effect the physical infrastructure around them, thereby having an impact on the quality of the streetscape in which they are an element. The tree may cause problems for underground services such as sewer, water, and other utilities. The installation of new underground services can cause problems for existing trees when roots are disturbed. Damage to roots will effect the overall health and vigor of the street tree. Compaction of soil, damage to the trunk and branches, and other physical damage may result from nearby construction, all of which can cause the tree to decline in health.

Existing physical services might be damaged by expanding tree roots dislocating conduit, breaking pipes, and growing into older sewer and drainage lines. Street curbs, concrete and brick sidewalks, and asphalt paving are moved, cracked, or otherwise damaged by the tree roots and expansion of the trunk. Each of these effects on the physical surroundings will impact the success of the streetscape design and will also cost the municipality for repairs. The following illustrations (FIGURE 59 and 60) show two views of a tree used in the streetscape, and demonstrates how impact on the infrastructure can be much different than what the designer might have envisioned. FIGURE 59 shows a sidewalk and curb installed in a manner with very little impact on the physical infrastructure surrounding it, wheres FIGURE 60 demonstrates what occurs when a tree grows beyond what is envisioned by the designer.

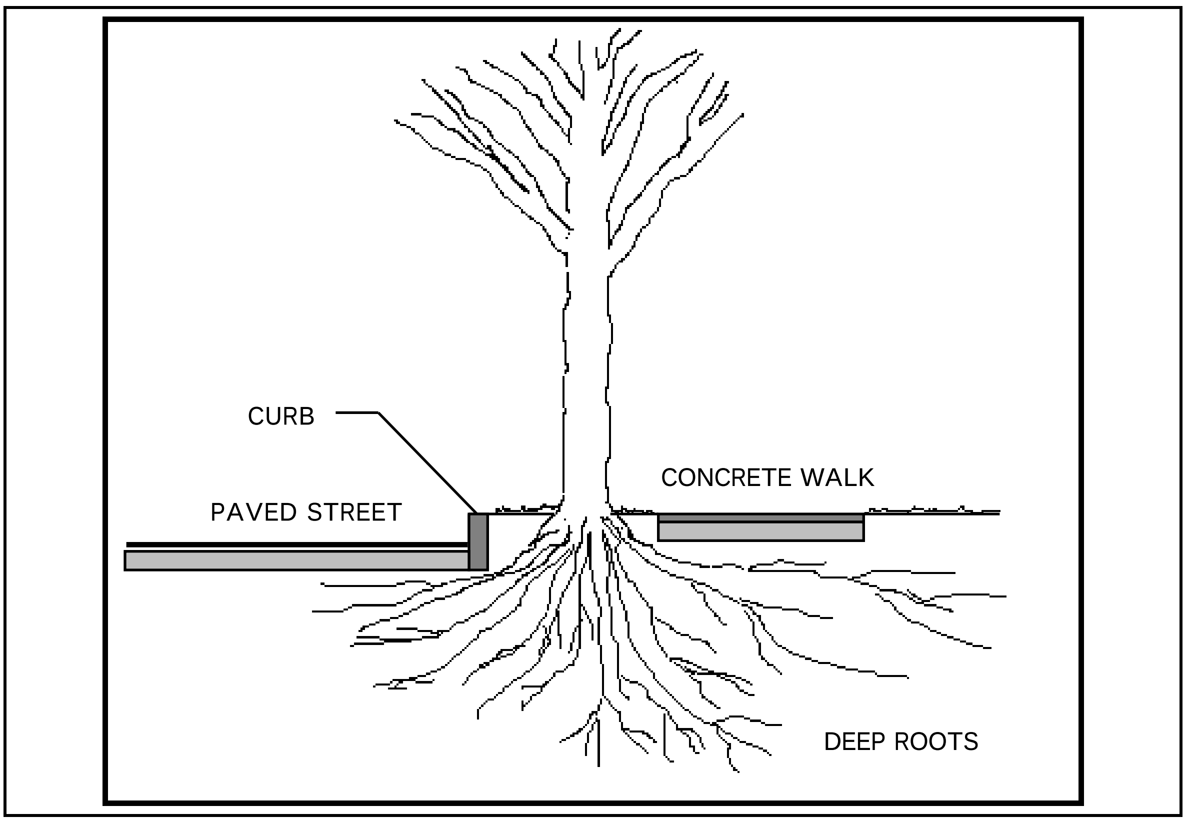


FIGURE 59 - Tree roots and surface infrastructure.

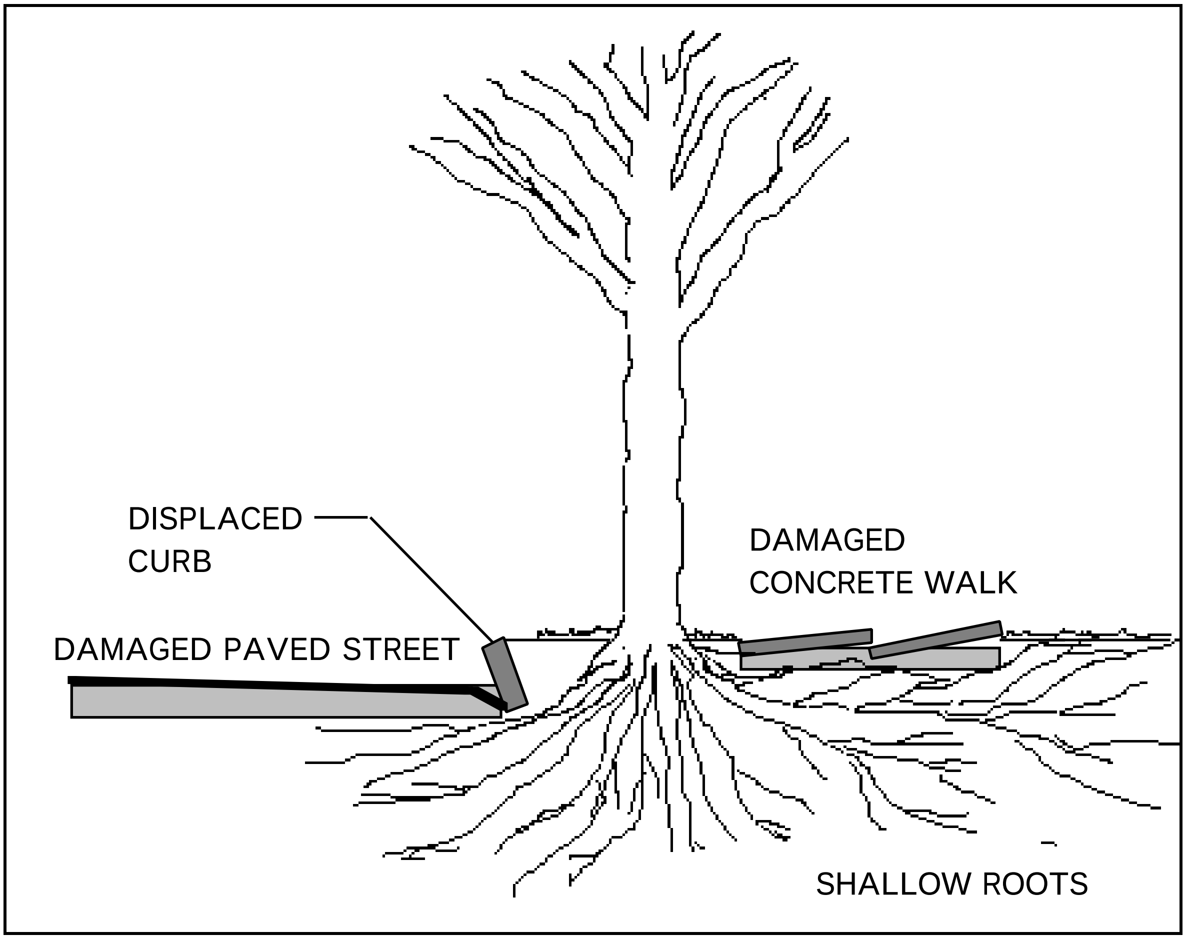


FIGURE 60 - Tree roots and damage to surface infrastructure.

In this case the tree is causing damage to nearby paving and curbs, and presents, not only safety problems, but aesthetic implications as well. The well ordered and clean looking paving in the first example is contrasted with the uplifted and somewhat disturbed look of the second situation. Liabiliry may also become an issue in the event of a fall. Careful consideration of the implications of the growth of specific varieties of plants is necessary in order to ensure that the proper species is selected for growth in the right spot, resulting in successful implementation of design ideas.

Design implementation and success

To ensure that the design intent of the landscape architect or other designer be fulfilled, recognition of the methods that can be implemented successfully and economically must be addressed. It is important for the designer to recognize situations that will not allow for the inclusion of trees or vegetation, and will require the use of another landscape element. The use of appropriate species that can fulfil the intended design intent, and at the same time achieve full growth and form, must be understood in order for the designer to develop successful schemes. Replacement of dead or dying trees must be undertaken with the understanding of what the replacement plant will do to the streetscape space. Will the tree be affected by overhead and underground utilities, or the surrounding physical infrastructure? Is the tree being planted using the most advanced technical specifications? In order for the street tree to be healthy, add to the aesthetic make-up of the streetscape, and require minimal maintenance, all of these factors must be considered before the tree is ever planted.

It becomes apparent that street patterns, combined with street type along with the other site factors all play a role in the selection of plant materials and their placement. It is critical that the designer understand the implications of planting a particular species in a particular location. The plant selected should be able to achieve its purpose, as it matures in the streetscape environment.

Proposed Changes to Street Types

Although the street types used as examples in this study do not illustrate every particular streetscape situation that might appear. They do present a wide range of street types that are likely to appear in municipalities. The changes that are presented are meant to serve as a guideline to assist in making informed decisions as to planting the right tree in the right spot. This will ensure that the design intent is achieved while maintenance costs and damage to physical infrastructure is kept to a minimum. If the aesthetic quality of the streetscape can be improved, while at the same time the overall cost of maintenance is lowered along with damage to the surrounding amenities, then the goal of this study will be realized. A thorough examination of the long-term implications of every street planted, will ensure the quality and health of the streetscape forest, keeping the costs of maintaining its vitality to a minimum. The following examples are meant to assist in this process of planting the right tree in the right spot.

When replacing street trees or the reconstruction of a major arterial roadway there are several alternative planting procedures that can be implemented allowing for increased viability of the streetscape trees. The design intent and aesthetic quality of the street scene can also be maintained with these rules. These include the following:

> 1.) Proper species selection, so that only trees that will not interfere with overhead utility lines, buildings, and sidewalks will be planted along streets.
>
> 2.) Setback planting of the street trees to a location where they will be able to grow without interfering with the overhead utility lines, buildings, and sidewalks.
>
> 3.) Planting trees in locations within the right of way other than directly below the utility lines, and could include construction of new planting islands along the street edge.

It is important that design and aesthetic considerations be taken into account when determining the most suitable street tree replacement method to employ. So that the streetscape will fulfil the design intent while at the same time be economical to implement and maintain. The cost of maintaining the wrong tree in the wrong place can be tremendous, in both monetary and aesthetic values for both the municipality and the utility.

The following pages contain examples of street types and recommended planting alternatives to the planting techniques which traditionally plant a shade tree on the treebelt, in close proximity to the overhead utility lines. The proposed solutions are an attempt to ensure a healthy and aesthetically pleasing street tree planting that cost less to maintain, while at the same time reducing potential damage to the municipal physical infrastructure.

Major Arterial Streets

The following drawing (FIGURE 61) illustrates a cross section of a major arterial street, including sidewalks on both sides of the street and planting strips adjacent to the walks. The roadway width also includes four travel lanes and two parking lanes, an arrangement common to most major arterial streets. Although some streets of this type might have sidewalks only on one side of the street, the majority of those streets within the target communities had walks on both side of the roadway. The exact dimensions and layout of major arterial streets found in each community differ from this section slightly, but the major constraints on planting location and design intent remain the same.

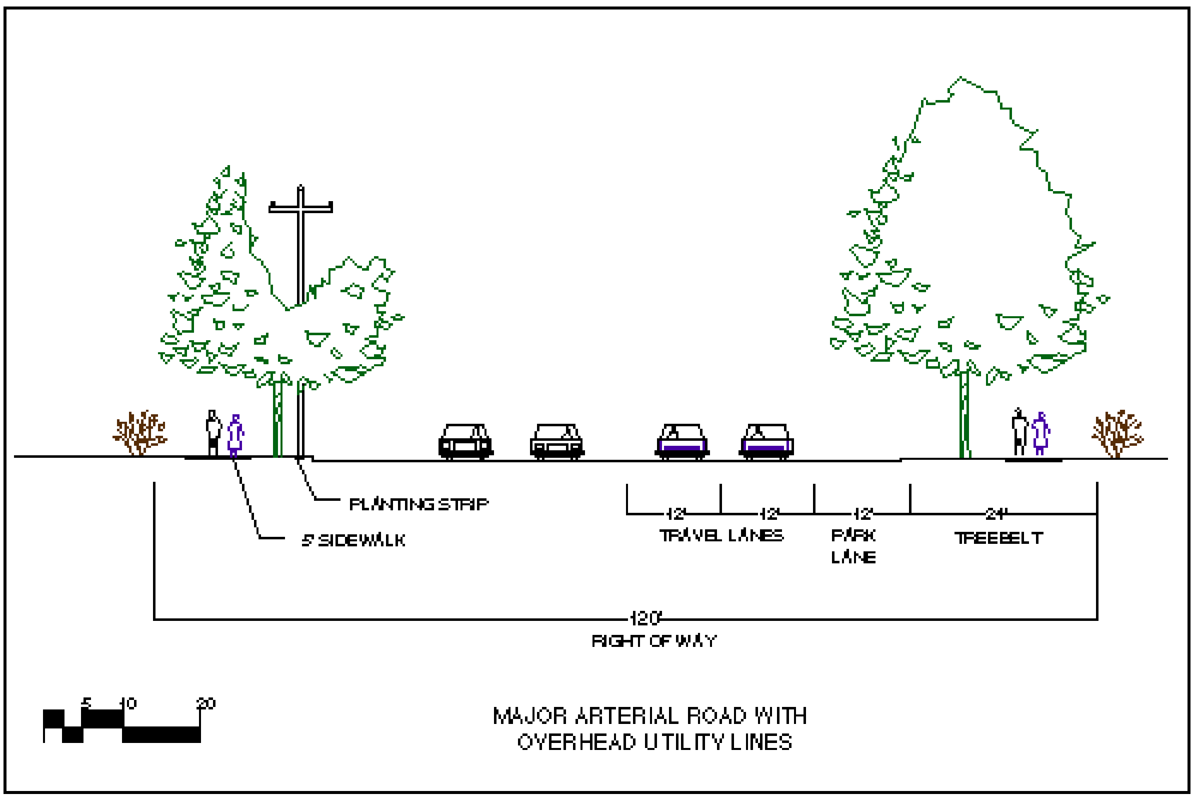


FIGURE 61 - Cross section of a major arterial street, including sidewalks on both sides of the street and planting strips.

Note that the trees near the utility lines have been trimmed and pruned so as to provide clearance from the lines, resulting in a degradation of the aesthetic quality of the streetscape, increased likelihood of insect and disease damage, and a possible failure in achieving any design intent that may have been intended for the street. The loss of enclosure, edge, and separation of public and private space possibly may occur, thereby changing the entire sense of space that otherwise would be part of this streetscape. The following drawing (FIGURE 62) shows a plan view of the same major arterial street as the previous cross section. Note that the trees growing along the side of the street where the utility lines run are shown in a degraded state, or one which is most likely to occur in this type of a situation.

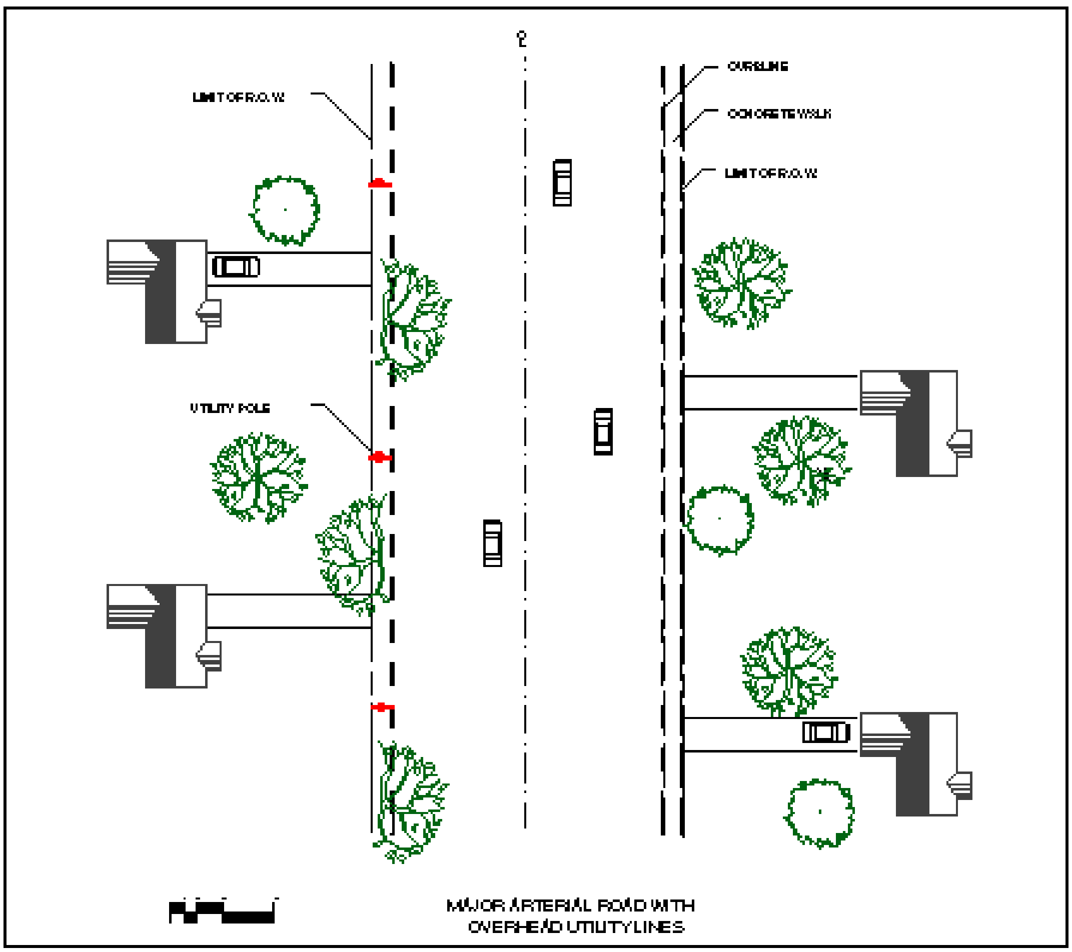


FIGURE 62 - Plan view of a major arterial street with utility lines on one side of roadway.

Setback Planting

The following drawing (Figure 63) show the same major arterial street previously shown with the street trees planted in a set back location from the edge of the right of way. Although the planting of the trees, in this instance is on private property, the trees remain within 20 feet of the edge of the right-of-way, therefore within the jurisdiction of the city or town tree warden according to Chapter 87 of the Massachusetts General Laws. (See Appendix 5 and Private Property Planting later in this chapter). This planting location allows for sufficient room for the street tree to grow without reaching the clearance distance from the utility lines, thereby not requiring the maintenance trimming that street trees planted in a more traditional arrangement on the treebelt or planting strip.

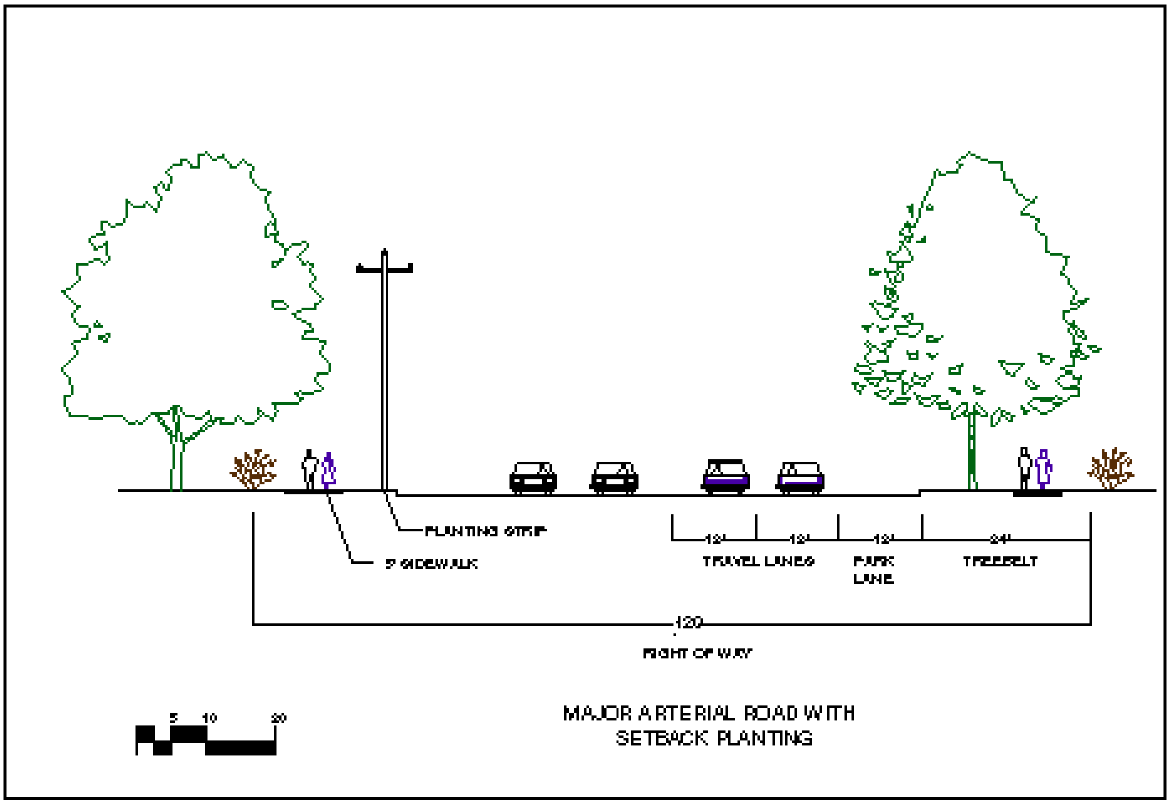


FIGURE 63 - Cross section of a major arterial road with setback planting.

The following plan (FIGURE 64) view is of the same setback planting along a major arterial roadway. Note that the setback planting allows for full growth of the selected tree species, while at the same time enforcing an edge of the street and separating the public and private properties. The plan view also illustrates how this same planting arrangement can be employed on the opposite side of the roadway, thereby increasing the sense of place that is achieved by developing edges and increasing the feeling of enclosure.

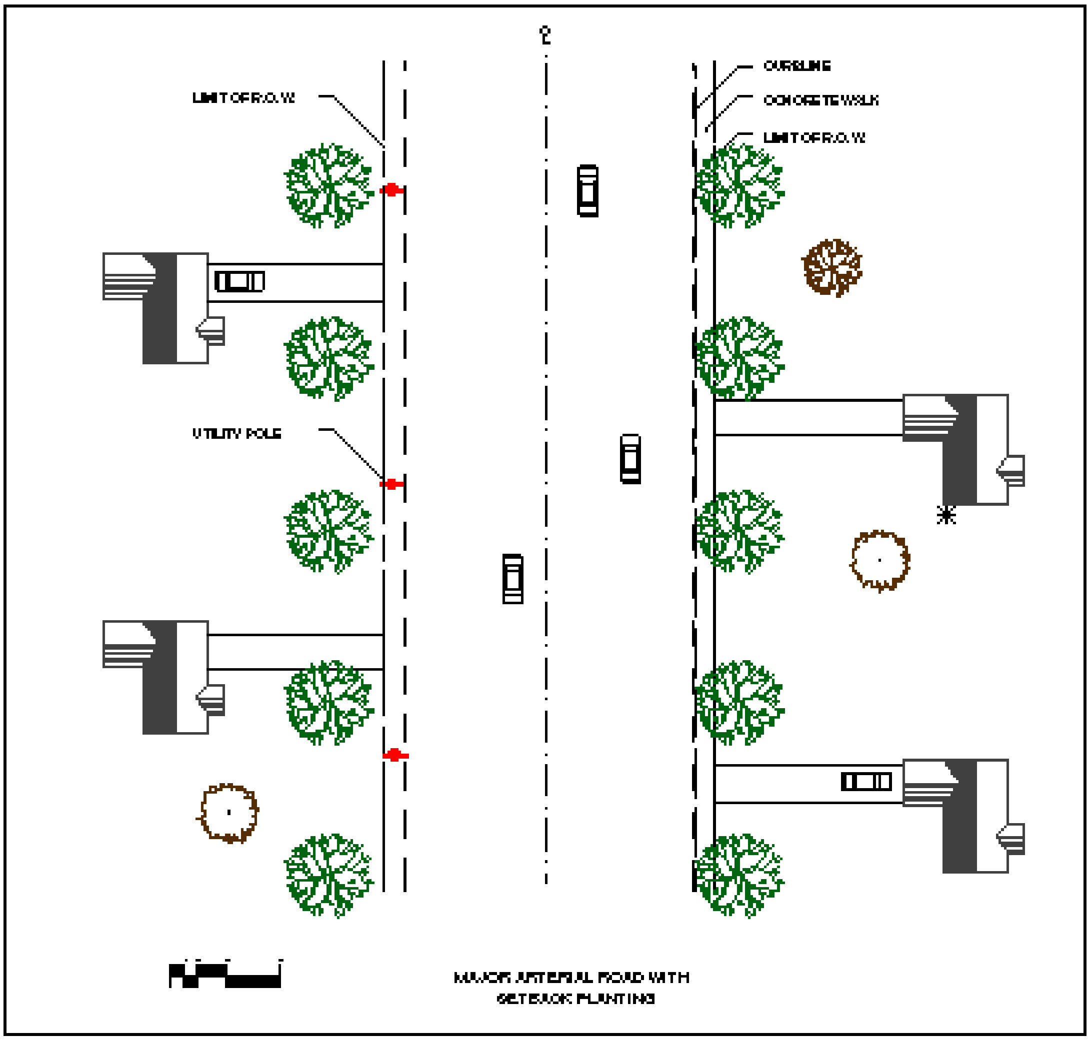


FIGURE 64 - Plan of a major arterial road with setback planting.

Planting with reduced plant size

In the following drawing (FIGURE 65) the selection of a tree species whose ultimate size will not allow for growth within the vicinity of the overhead utility lines is shown. The use of slower growing species and smaller species, which also tolerate streetscape conditions, can be accomplished so as to eliminate the need for maintenance trimming near the utility lines. The selection of tree types that will be able to achieve the same design intent as a larger species is possible if the plant selection process is fully reviewed. The use of newer varieities of plants and the planting of trees that will achieve aesthetically pleasing results must be encouraged in an effort to develop the streetscape as a viable and successful place.

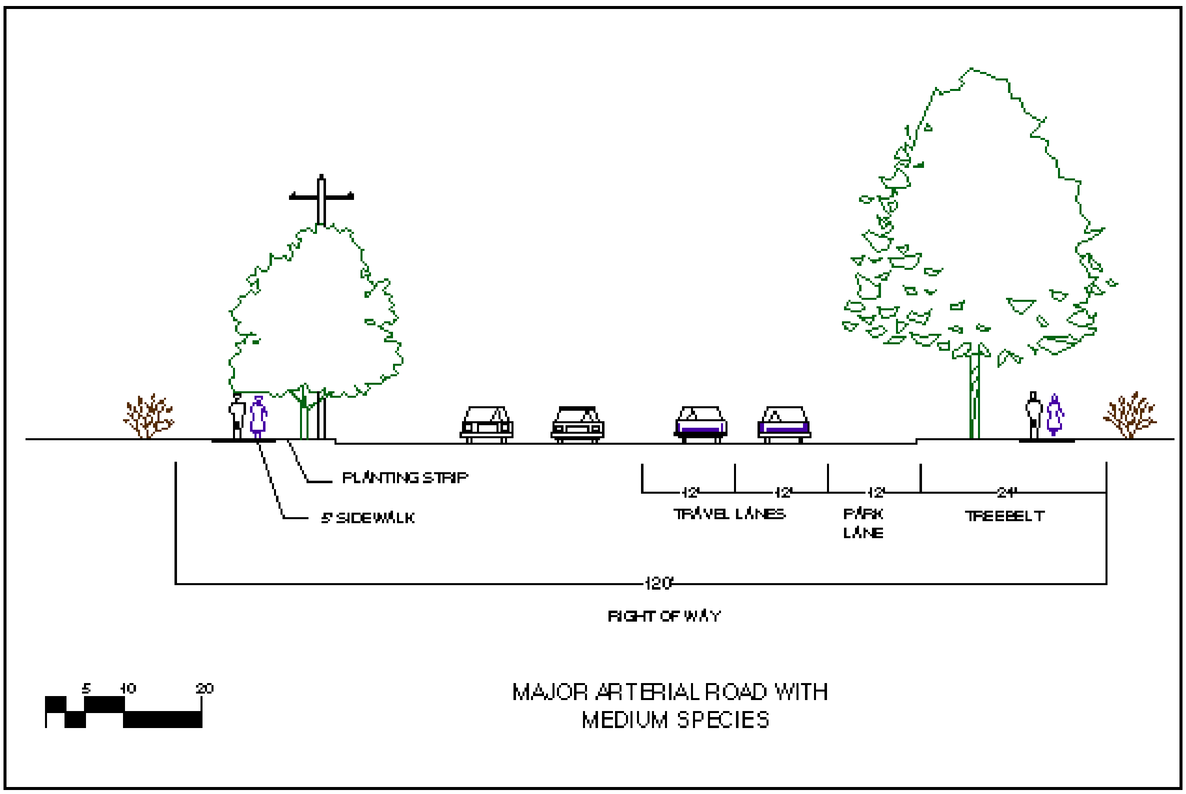


FIGURE 65 - Cross section of a major arterial road with medium size tree species.

Planting with columnar plants

When choosing tree species for use on a street where overhead utility lines occur, sometimes it may be advantageous to choose a columnar or fastigiate variety of a plant species. There are many species available that have been developed having a form that will grow in a narrower streetscape space. These types of trees can be used to enforce the design scheme, while at the same time maintaining the attributes of height, color, and texture that would occur with a species which does not have the columnar form. The following drawing (FIGURE 66) illustrates the use of a columnar species on a major arterial roadway with overhead utility lines.

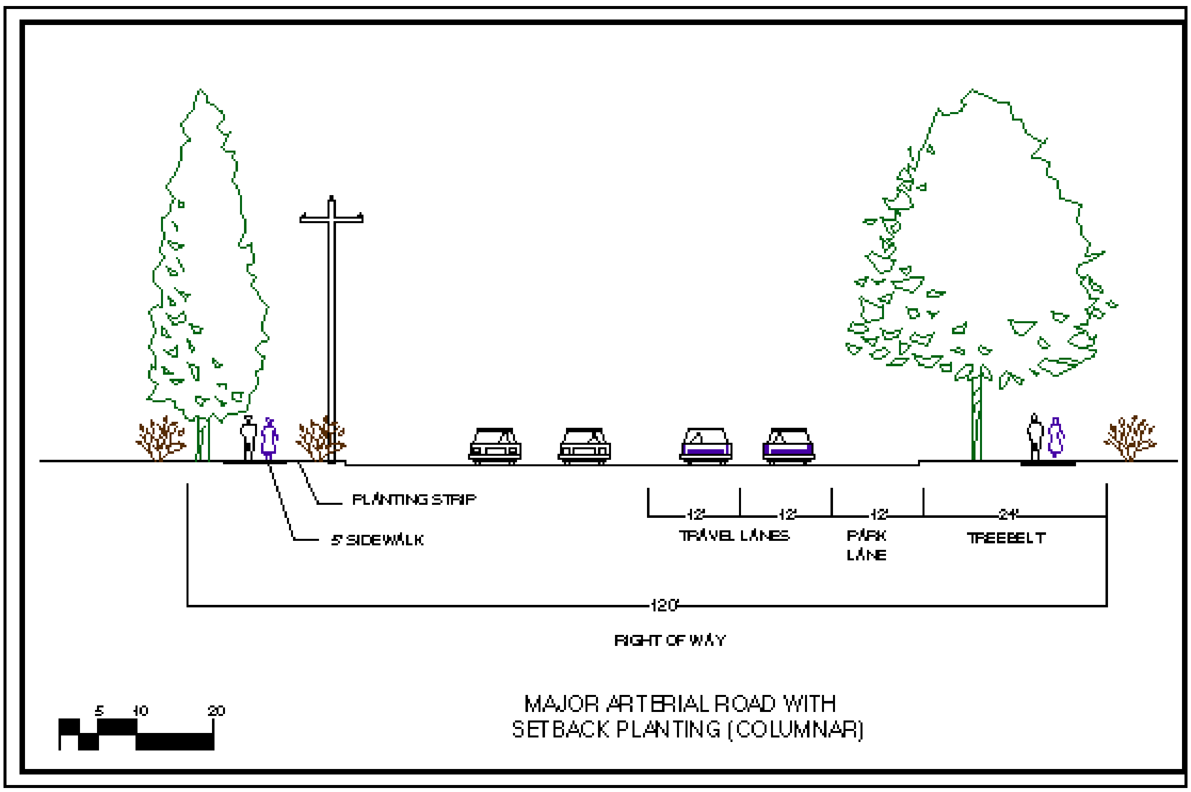


FIGURE 66 - Cross section of a major arterial road with columnar setback planting.

Planting in parking lanes

Major arterial streets most often contain four traffic lanes and parking lanes on each side of the street. This arrangement allows for the possibility of adding planting islands where parts of the parking lanes occur. By eliminating portions of the paved surface new planting space is created where smaller species trees can be planted, as well as other shrub species. This increases the number of trees which might be planted along the street as well as adds to the aesthetic integrity of the streetscape.

The following cross section (FIGURE 67) illustrates the use of an island planting in a parking lane on one side of a major arterial street. Note the ability to include the plants in the island as well as a taller shade tree planted in a setback location from the right-of-way. This is illustrative of a combination of planting schemes which improve the aesthetic and visual quality of the streetscape.

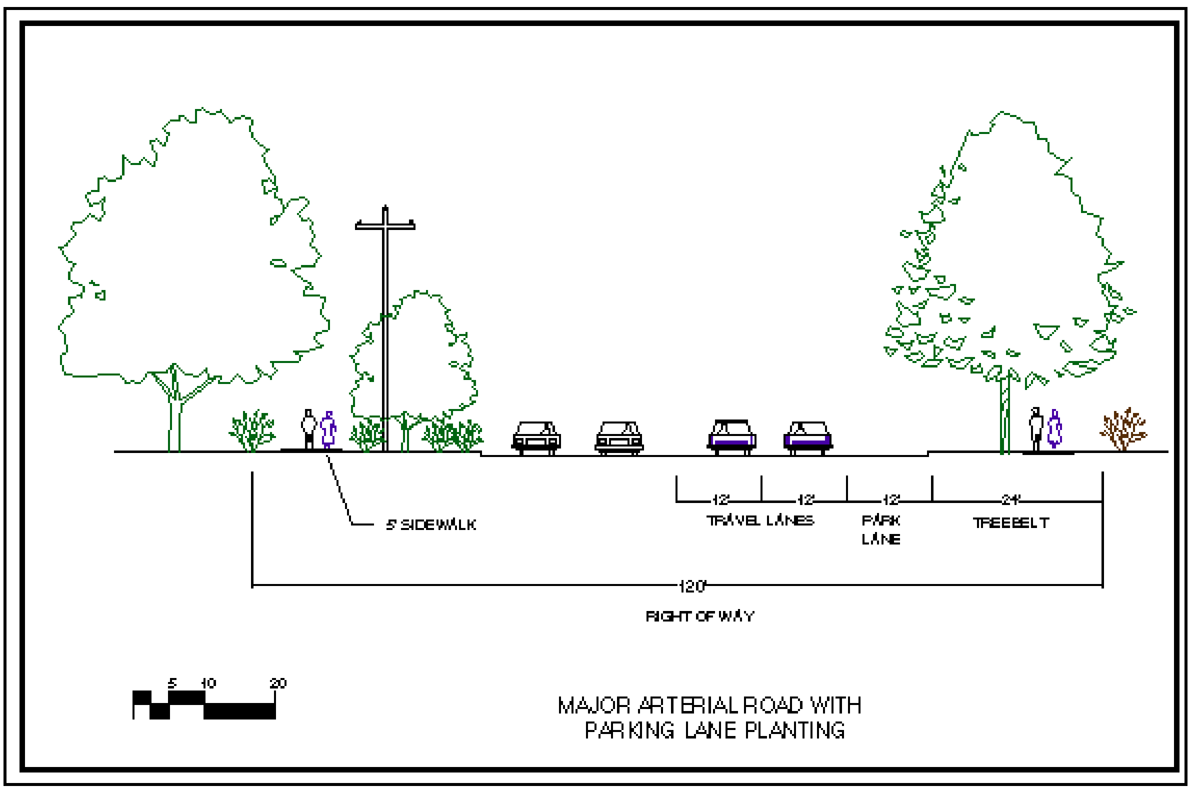


FIGURE 67 - Cross section of a major arterial road with planting in parking lane island.

This concept of creating planting islands in portions of the parking lanes of major arterial roadways is illustrated in plan view bellow. (FIGURE 68) As can be seen in the drawing the installation of planting islands eliminates some parking spaces, but the impact of reduced parking must be compared to the increased aesthetic, ecological, and psychological value of the improved streetscape condition.

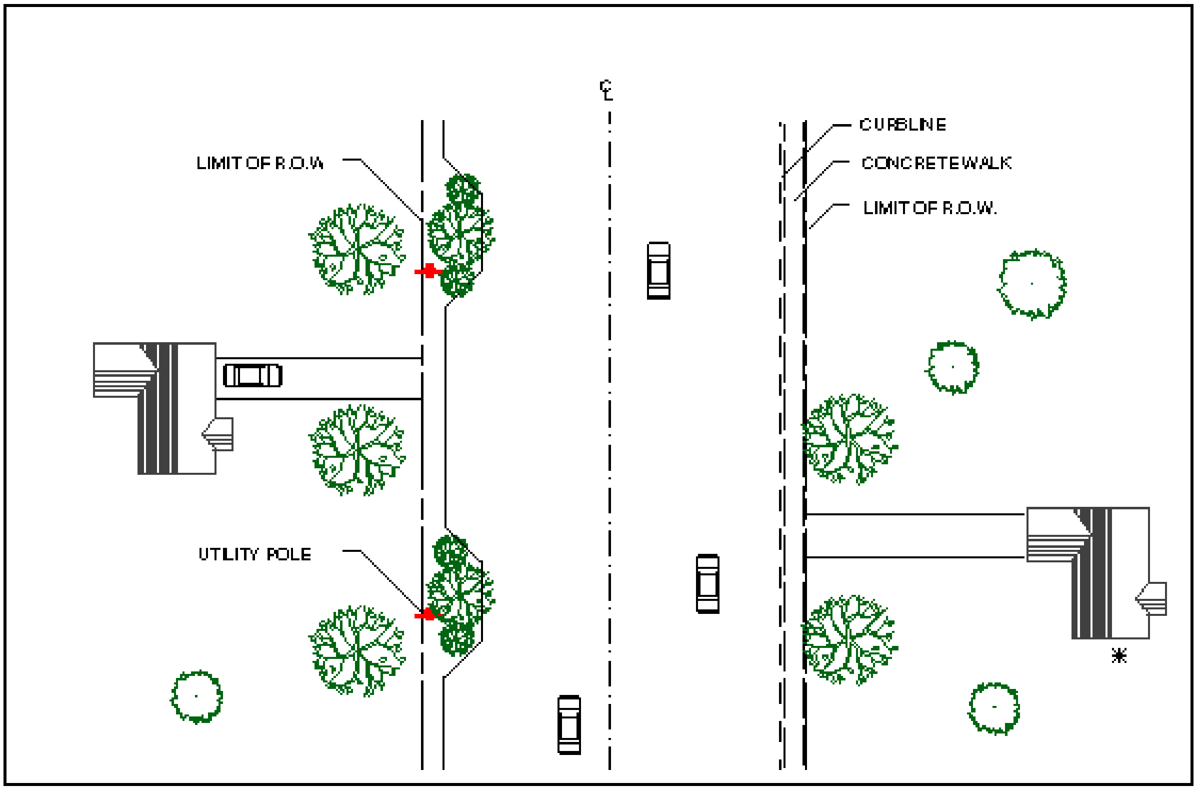


FIGURE 68 - Plan of a major arterial road with parking lane islands and setback planting.

Minor Arterial Streets

The following drawing (FIGURE 69) illustrates a cross section of a minor arterial street, including sidewalks on both sides of the street and planting strips adjacent to the walks. The roadway width also includes two travel lanes and two parking lanes, an arrangement common to many minor arterial streets. Although some streets of this type might have sidewalks only on one side of the street, the majority of those streets within the target communities had walks on both side of the roadway. The exact dimensions and layout of minor arterial streets found in each community differ from this section slightly, but the major constraints on planting location and design intent remain the same.

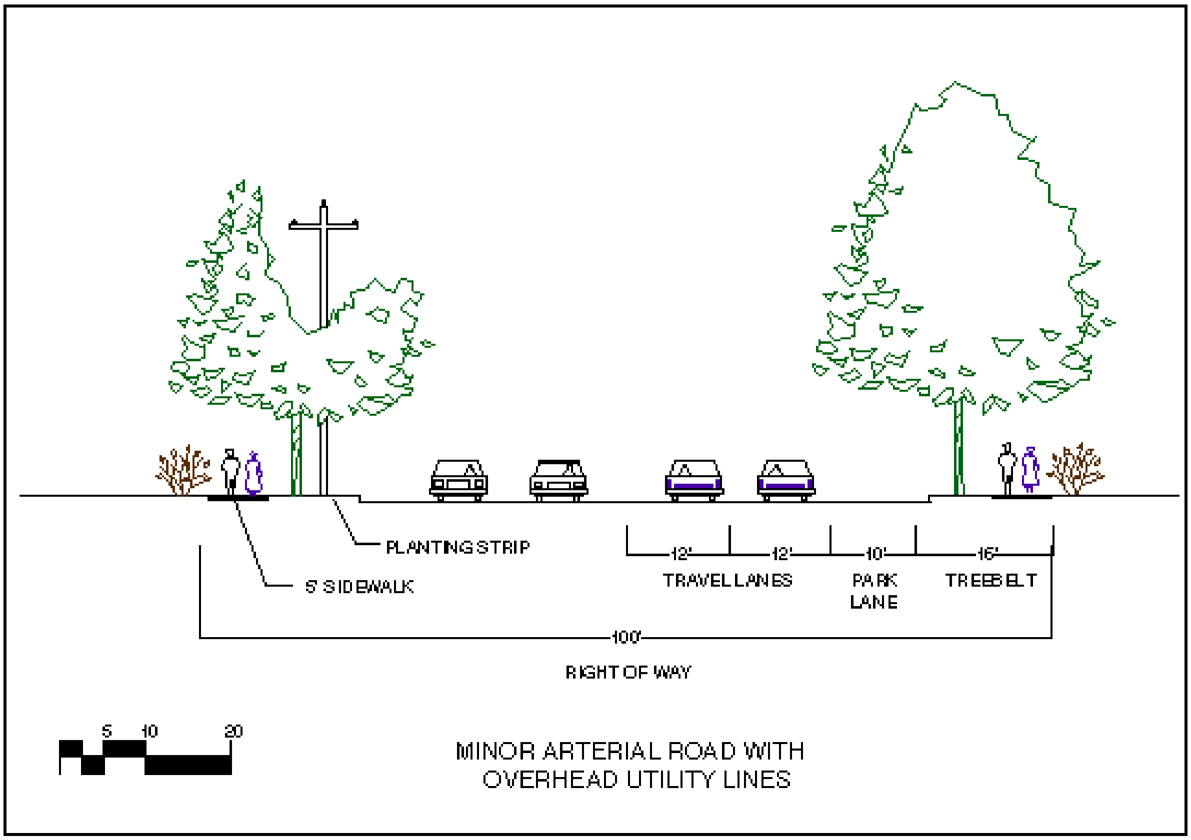


FIGURE 69 - Cross section of a minor arterial road with overhead utility lines.

Setback Planting

The following drawing (FIGURE 70) show the same minor arterial street previously illustrated, with the street trees planted in a set back location from the edge of the right of way. As discussed earlier the setback of up to 20 feet beyond the right-of-way creates a situation which is still under the control of the municipal tree warden, yet places the tree in a much more desirable location. (See Appendix 5). This planting location allows for sufficient room for the street tree to grow without reaching the clearance distance from the utility lines, thereby not requiring the maintenance trimming that street trees planted in a more traditional arrangement on the treebelt or planting strip. Note that the setback planting allows for full growth of the selected tree species, while at the same time enforcing an edge of the street and separating the public and private properties.

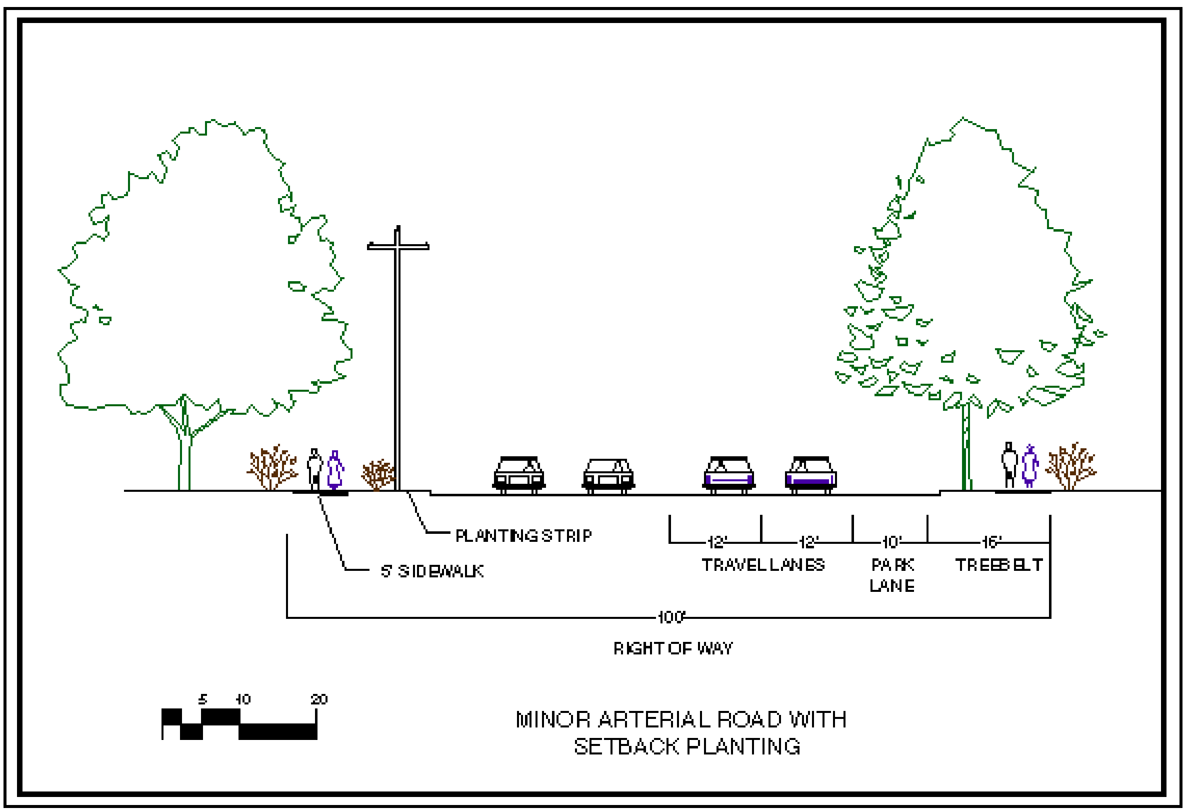


FIGURE 70 - Cross section of a minor arterial road with setback planting.

Planting with reduced plant size

As was discussed in the previous section concerning major arterial streets, the use of a tree species whose ultimate size will not allow for growth within the vicinity of the overhead utility lines, can also be used on minor arterial streets. In the same manner as in other street type situations the use of slower growing species and smaller plant types, can be done so as to eliminate the need for maintenance trimming near the utility lines. The selection of tree types that will be able to achieve the same design intent as a larger species is possible if the plant selection process is fully reviewed. The use of newer varieities of plants and the planting of trees that will achieve aesthetically pleasing results should be considered when changes to the streetscape condition are proposed. The following drawing (FIGURE 71) illustrates this concept on a minor arterial street.

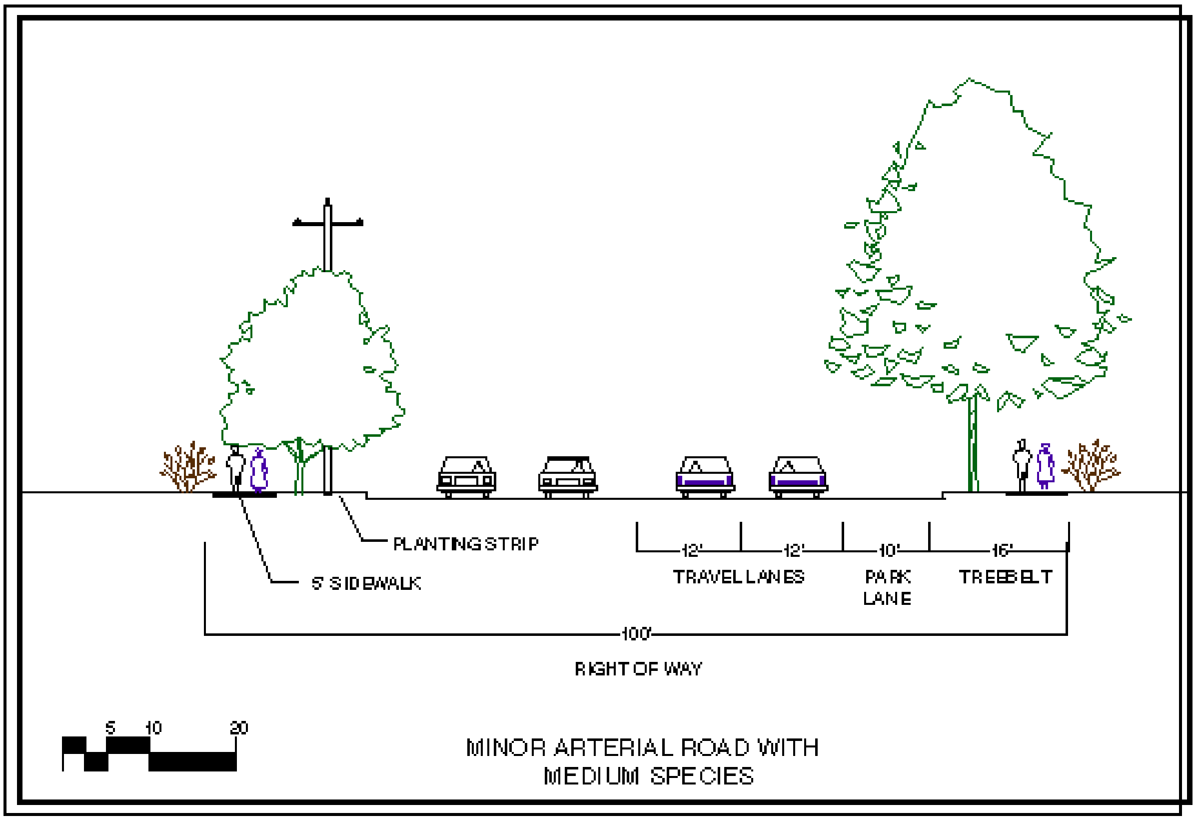


FIGURE 71 - Cross section of a minor arterial road with smaller tree species.

Planting with columnar plants

In the same manner as major arterial streets, when choosing tree species for use on a minor arterial where overhead utility lines occur, it may be advantageous to choose a columnar or fastigiate variety of a plant species. There are many species available which have been developed which have a form which grows in a narrower streetscape space, and these types of trees can be used to enforce the design scheme, while at the same time maintaining the attributes of height, color, and texture that would occur with a species which does not have the columnar form. The following drawing (FIGURE 72) illustrates the use of a columnar species on a minor arterial roadway demonstrating the use of this design scheme.

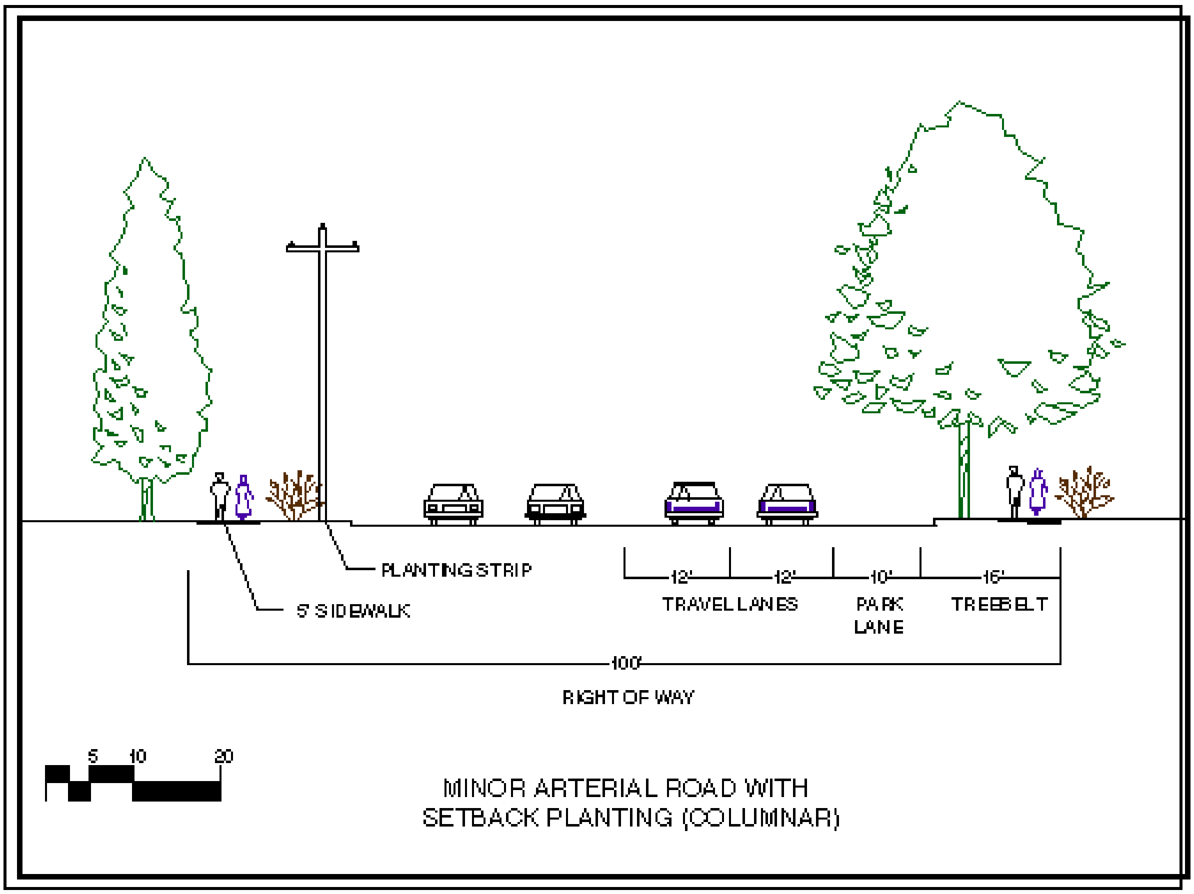


FIGURE 72 - Cross section of a minor arterial road with columnar tree species.

Planting in parking lanes

Minor arterial streets often contain parking lanes on each side of the street in addition to the travel lanes. As on the major arterial street this arrangement allows for the possibility of adding planting islands where parts of the parking lanes occur. The increased number of trees which might be planted along the street adds to the aesthetic integrity of the streetscape while at the same time reducing the maintenance cost required to keep the tree growth away from the overhead utility lines. The following cross section (FIGURE 73) illustrates the use of an island planting in a parking lane on one side of a minor arterial street. Note the use of plant species which will not interfere with the overhead utility wires and enforce the visual quality of the streetscape.

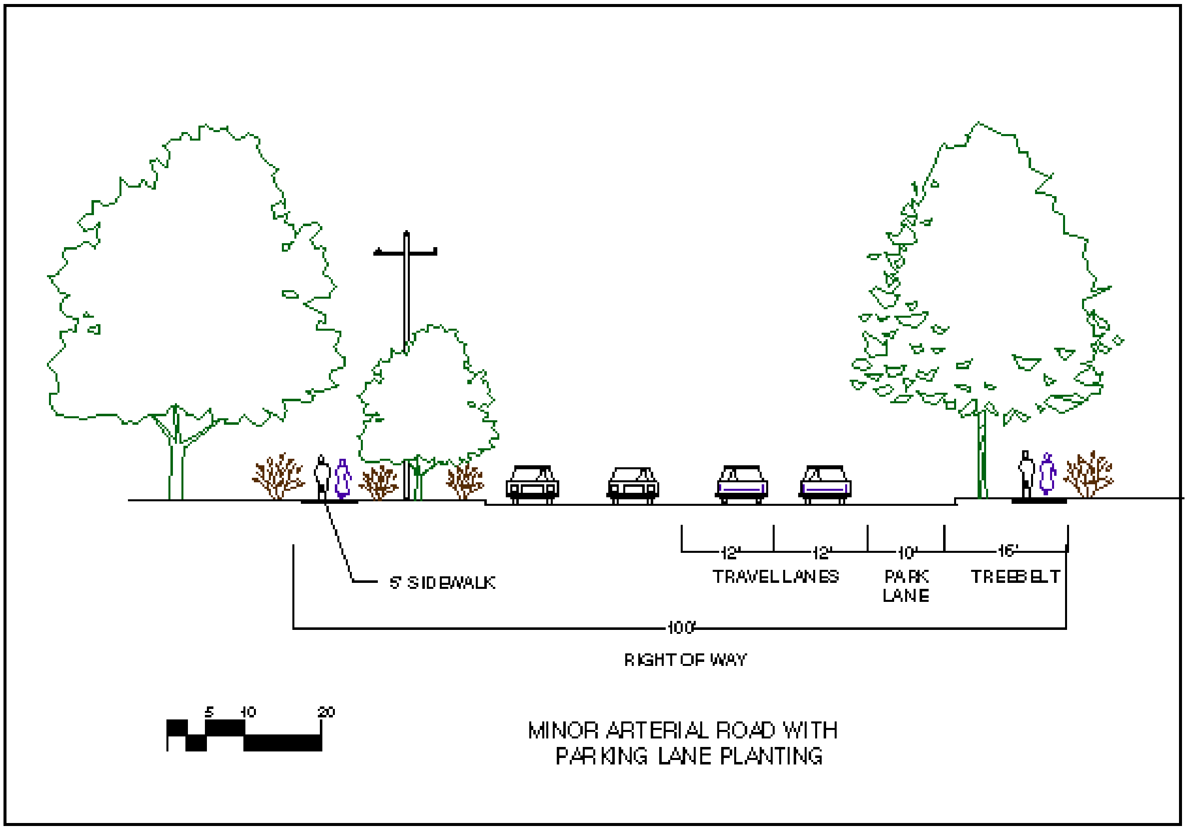


FIGURE 73 - Cross section of a minor arterial road with planting in parking lane.

Collector Streets

The following drawing (FIGURE 74) illustrates a cross section of a collector street, including sidewalks, planting strips, and the right-of-way. The roadway width also includes travel lanes and two parking lanes, an arrangement common to most collector streets. The exact dimensions and layout of collector streets found in each community were slightly different in each case, but the major constraints on planting location and design intent remain the same.

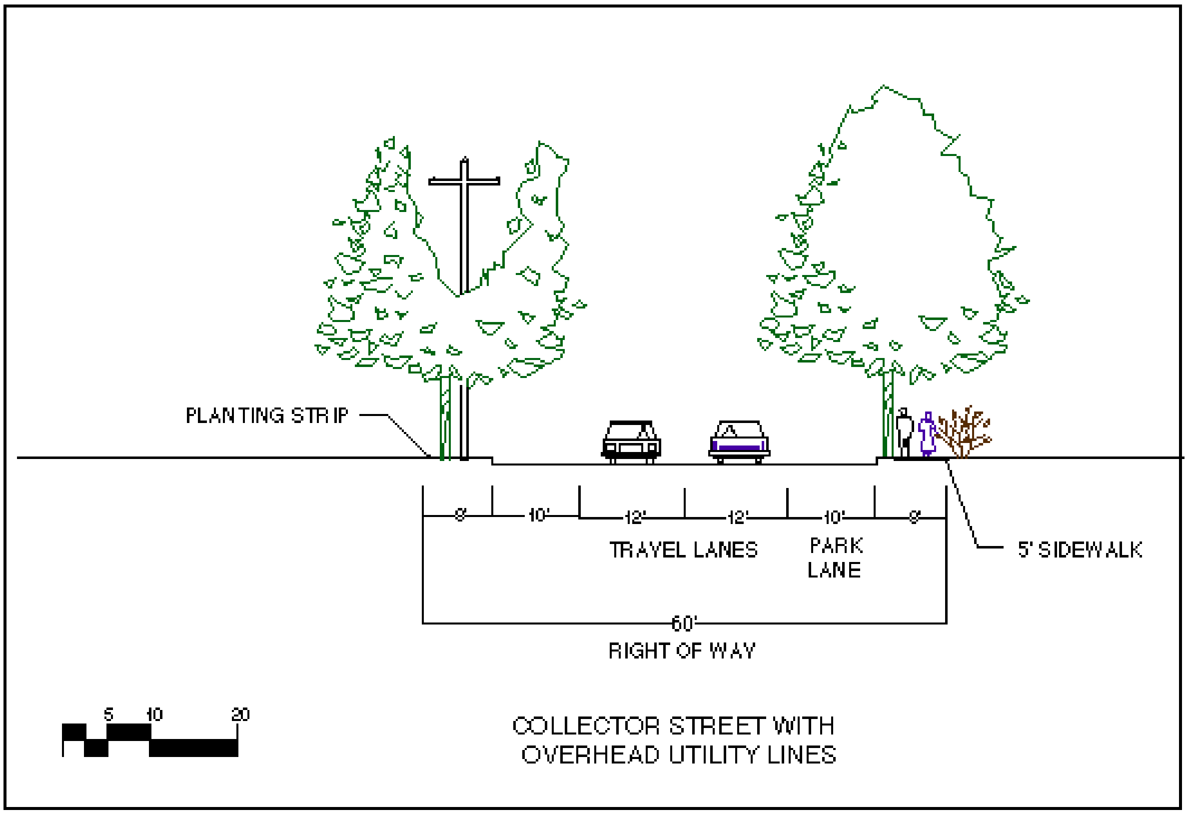


FIGURE 74 - Cross section of a collector street with overhead utility lines.

Setback Planting

The following drawing (FIGURE 75) illustrates the collector street, previously shown, with the street trees planted in a set back location from the edge of the right of way. As with the major and minor arterial streets the planting of the trees, is on private property, with the trees remaining within 20 feet of the edge of the right-of-way, therefore within the control of the city or town tree warden according to Chapter 87 of the Massachusetts General Laws. (See Appendix 5). This planting location allows for sufficient room for the street tree to grow without reaching the utility lines, thereby not requiring the maintenance trimming that street trees planted closer to the street.

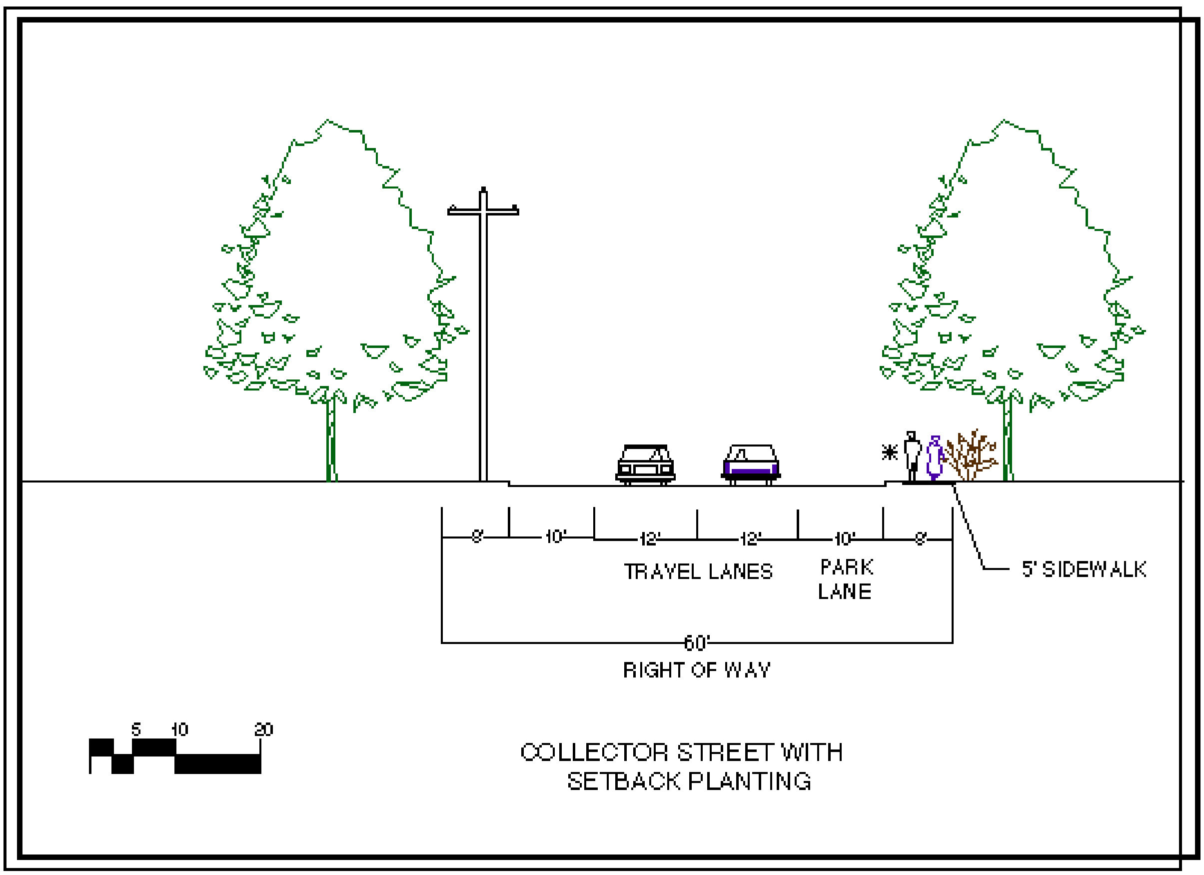


FIGURE 75 - Cross section of a collector street with setback planting.

Planting with reduced plant size

As with other street types, the use of a tree species whose ultimate size will not allow for growth within the vicinity of the overhead utility lines can be effectively used on minor arterial streets. In the same manner as in other street type situations the use of slower growing species and smaller plant types, can be incorporated so as to eliminate the need for maintenance trimming near the utility lines. The planting of varieties that retain the design intent while at the same time reduce the cost of keeping the trees healthy is a practice that makes sense for many streetscape conditions. The implementation of designs which incorporate this type of careful plant selection should be encouraged. The following drawing (FIGURE 76) illustrates this concept on a collector street.

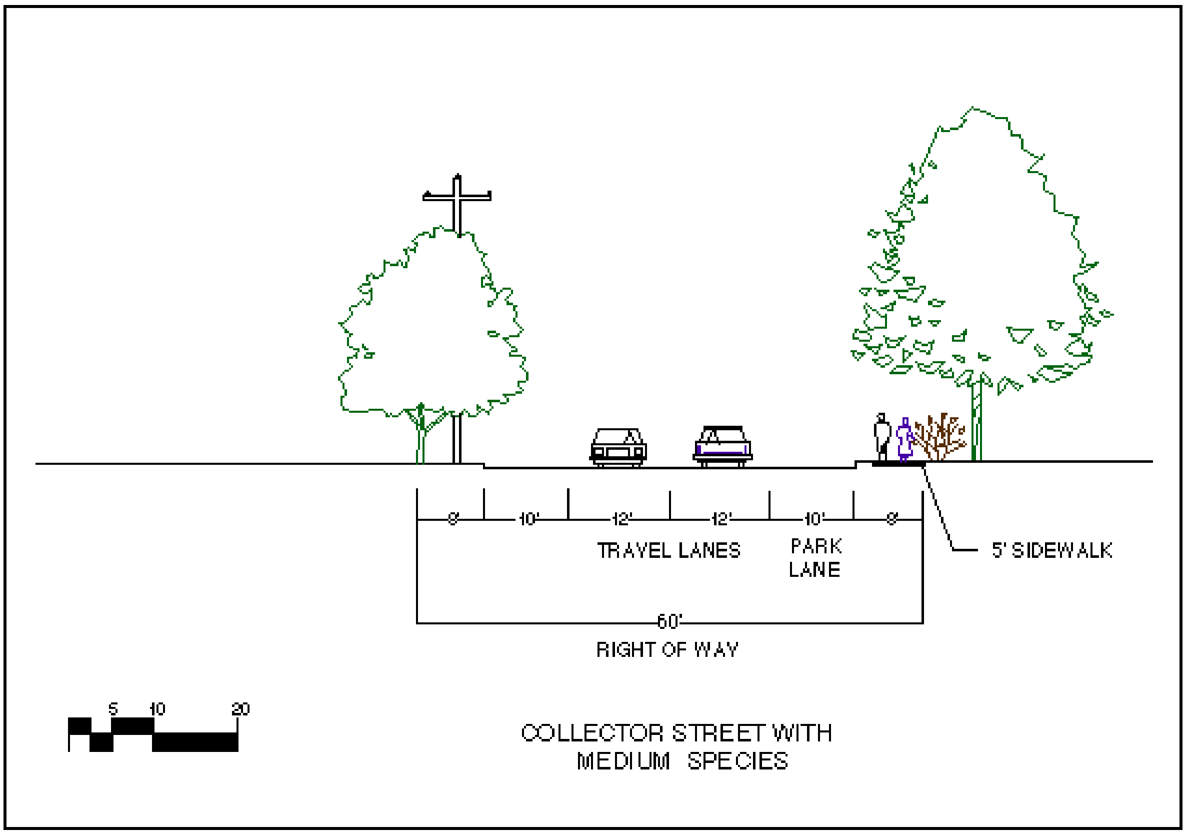


FIGURE 76 - Cross section of a collector street with smaller growing tree species.

Planting with columnar plants

It may be advantageous to choose a columnar or fastigiate variety of a plant species when selecting tree species for use on a collector street where overhead utility lines occur. This type of tree can be used to develop the streetscape with a plant which will achieve its full growth, yet not interfere with overhead utility lines or traffic patterns. The columnar types of trees can be used to develop the design scheme, while at the same time maintaining the attributes of height, texture and color that would occur with a species which does not have the columnar form. The following drawing (FIGURE 77) illustrates the use of a columnar species on a major arterial roadway with overhead utility lines.

FIGURE 77 - Cross section of a collector street with a columnar setback planting.

Local Streets

The following drawing (FIGURE 78) illustrates a cross section of a local street including a sidewalk, a planting strip adjacent to the walk and and a treebelt on the opposite side of the street. The roadway width includes the travel lanes and a parking lane, an arrangement common to many local streets. The exact dimensions and layout of local streets found in various communities may differ from this section slightly, but the major constraints on planting location and design intent remain the same and can be visualized in the drawing.

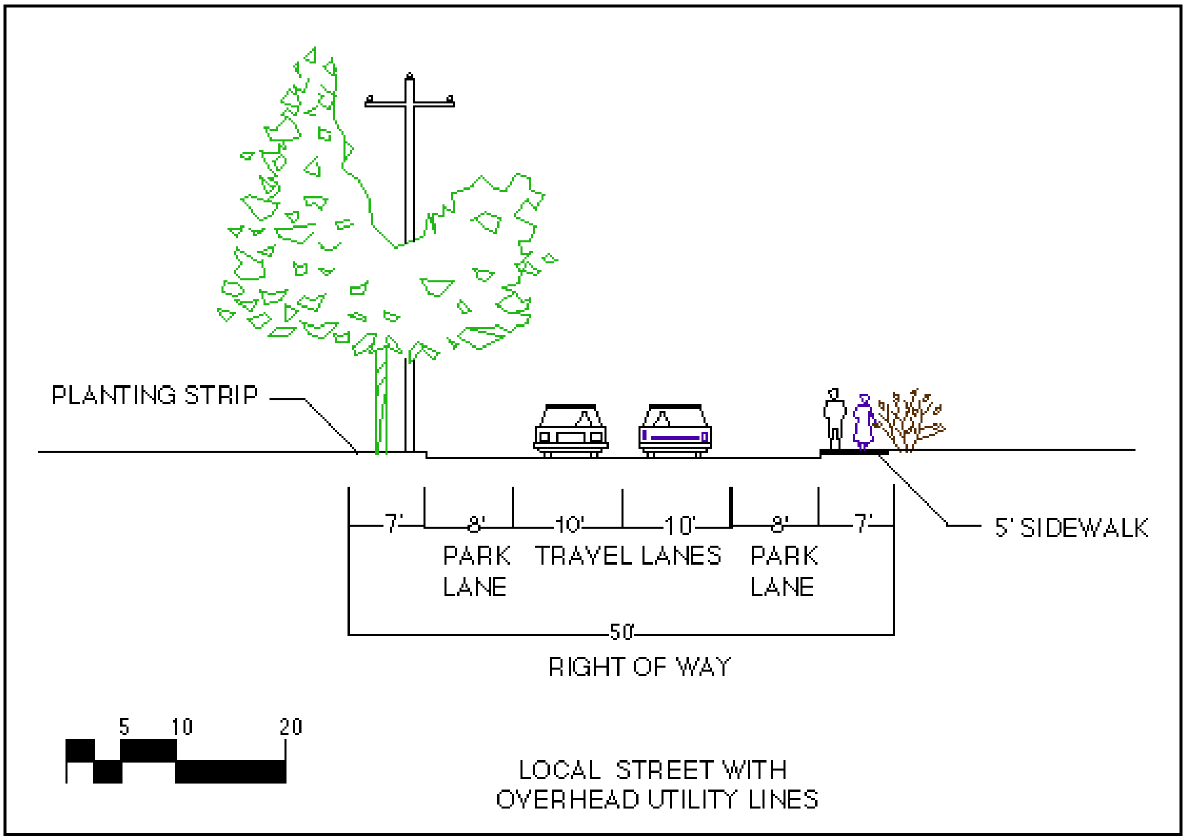


FIGURE 78 - Cross section of a local street with overhead utility lines, including sidewalks and planting strip.

In the drawing it is shown that the trees near the utility lines have been trimmed to provide clearance from the lines, resulting in a degradation of the aesthetic and visual quality of the streetscape The loss of enclosure, edge, and separation of public and private space may occur, thereby changing the landscape that is perceived. The following drawing (FIGURE 79) shows a plan view of the same local street as the previous cross section. Note that the trees growing along the side of the street where the utility lines run are shown in manner in which they often appear.

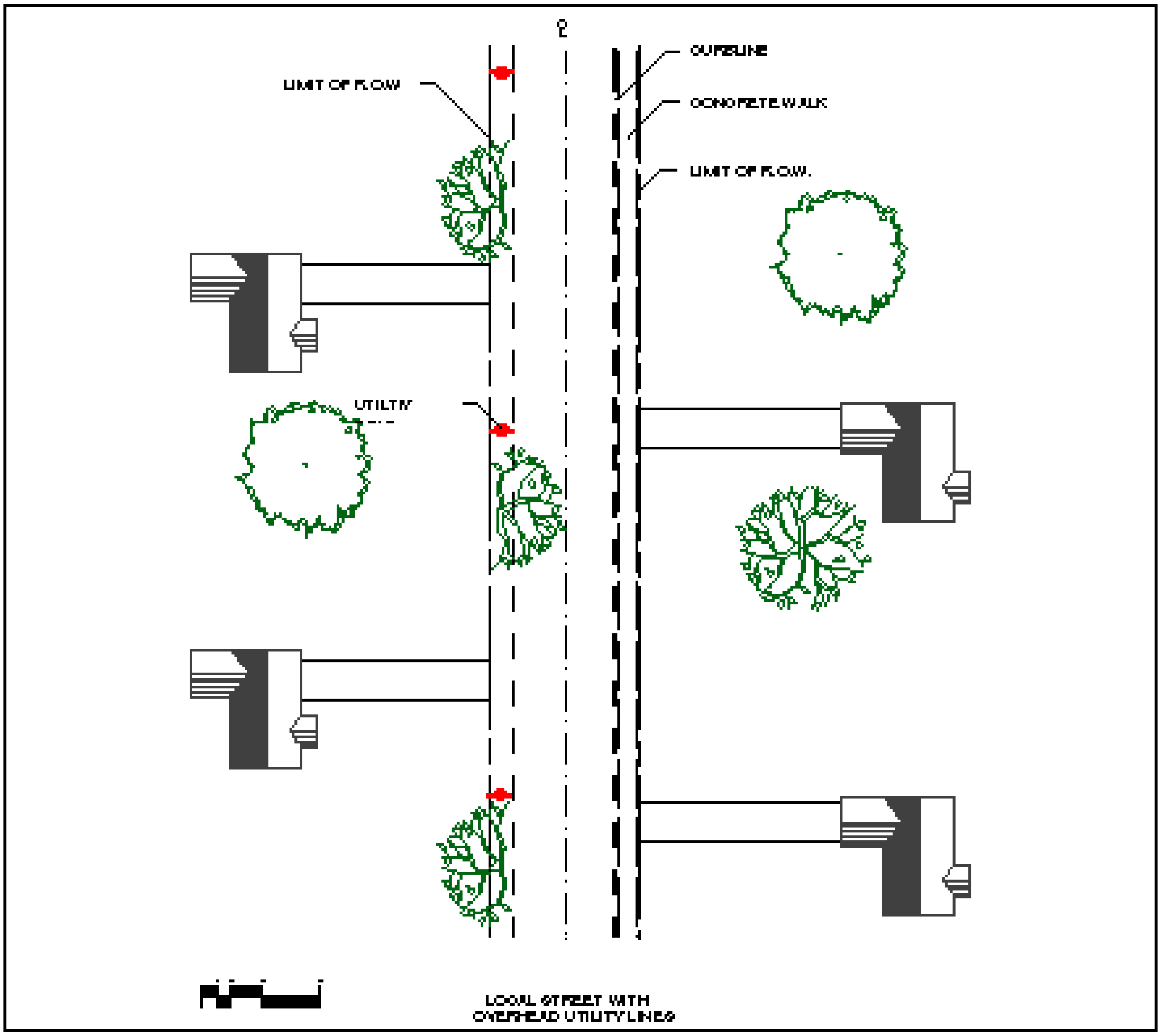


FIGURE 79 - Plan view of a local street with utility lines on one side of roadway.

Setback Planting

The following drawing (FIGURE 80) illustrates a local street, with the street trees planted in a set back location from the edge of the right of way. As with the previously discussed streets, the planting of the trees is on private property, with the trees remaining within 20 feet of the edge of the right-of-way, therefore within the control of the city or town tree warden as per Chapter 87 of the Massachusetts General Laws. (See Appendix 5). If sufficient room exists on the local street, the planting may occur on public property if there is room within the right-of-way to allow proper setback. The planting location shown allows for sufficient room for the street tree to grow without reaching the utility lines.

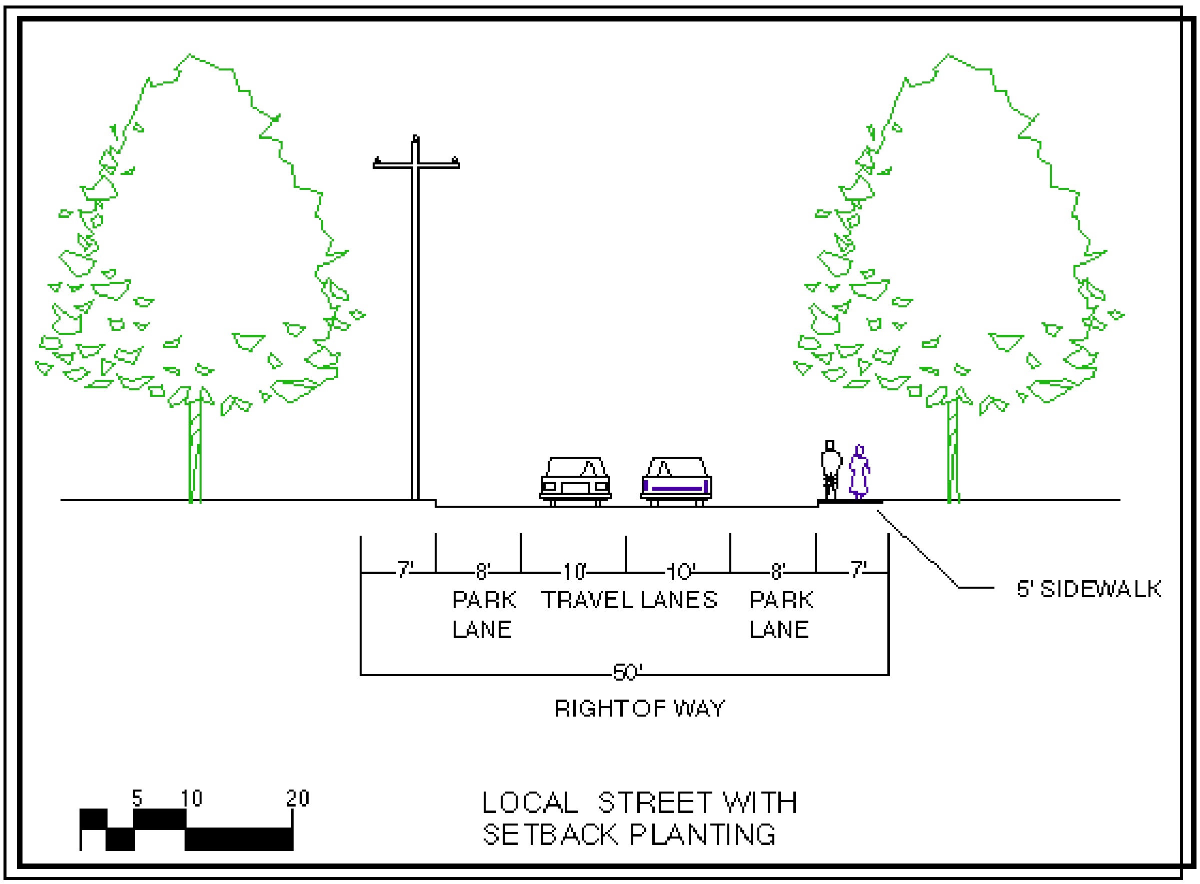


FIGURE 80 - Cross section of a local street with setback planting.

The following plan view (FIGURE 81) is of the same setback planting on a local street. The setback planting allows for full growth of the selected tree species, while at the same time enforcing an edge of the street and separating the public and private properties. This view also demonstrates how this same setback arrangement can be developed on the opposite side of the street, thereby increasing the sense of place that is achieved by developing edges and increasing the separation of public and private space.

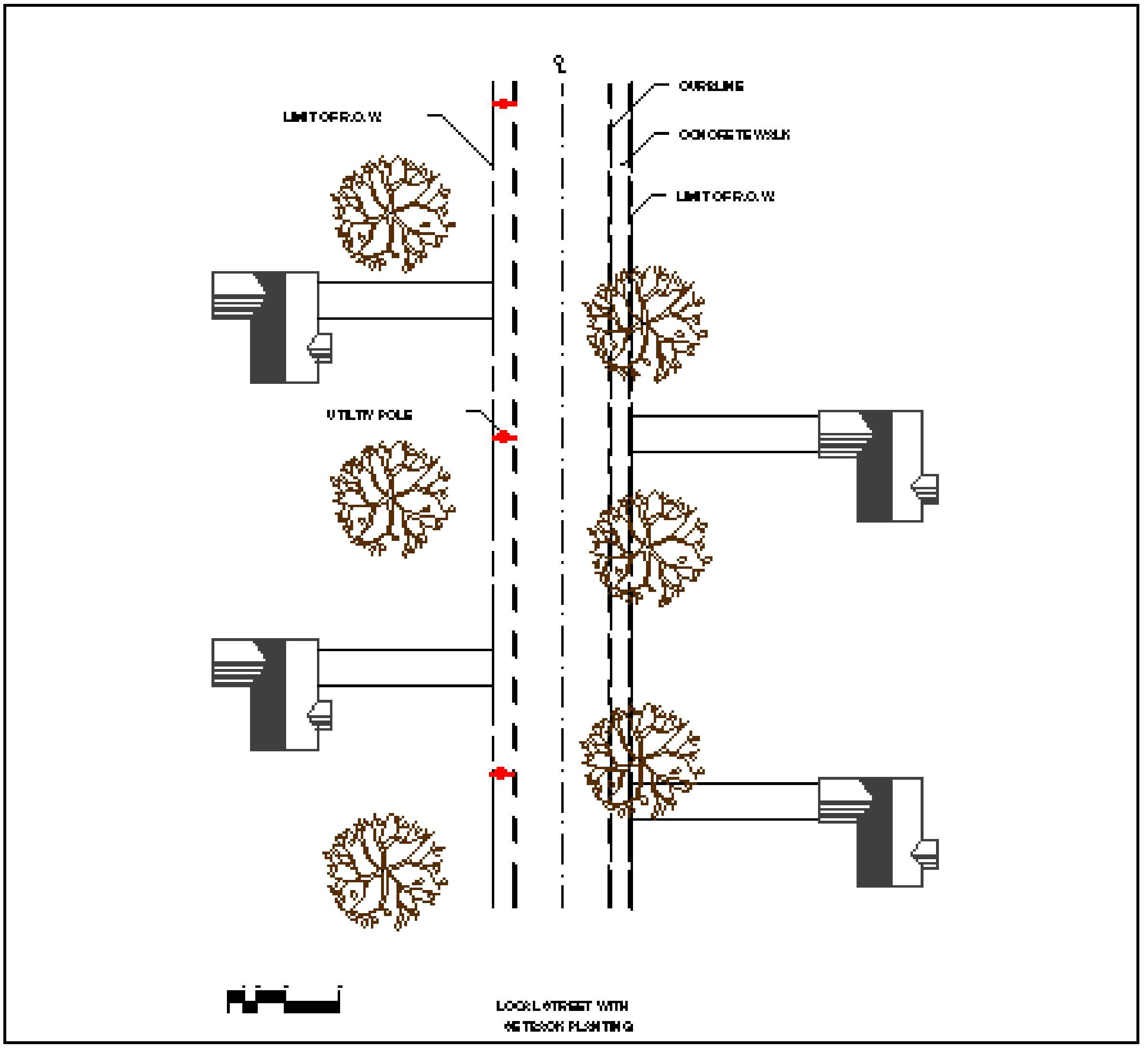


FIGURE 81 - Plan view of a local street with setback planting.

Planting with reduced plant size

The following drawing (FIGURE 82) illustrates the selection of a tree species whose ultimate size does not include growth within the vicinity of the overhead utility lines. The use of slower growing species and smaller plant types can eliminate the need for trimming to ensure clearance around overhead utility lints. The selection of tree types that will be able to achieve the same design intent as a larger species is possible if the plant selection process is fully reviewed. The use of the latest varieities of plants and the planting of proven species must be encouraged in an effort to develop the streetscape as an ecologically viable and aesthetically pleasing place.

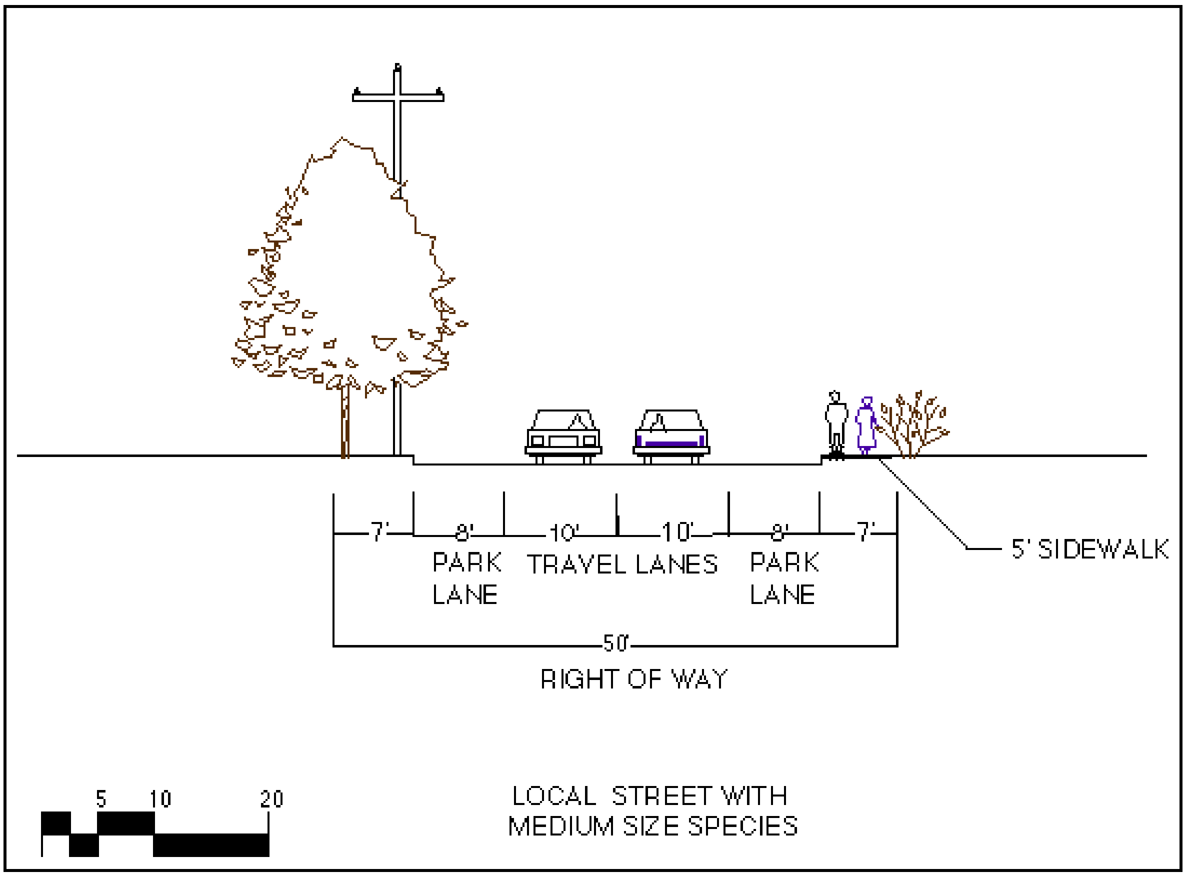


FIGURE 82 - Cross section of a local street with planting of a smaller tree species.

Planting with columnar plants

When choosing tree species for use on a street where overhead utility lines occur, the use of a columnar or fastigiate variety of a plant species should be considered. There are currently many species available that have a form ideally suited to grow in a narrower streetscape space. These types of trees can be used to enforce the design scheme, while at the same time maintaining the attributes of height, color, and texture that would occur with a species not have the columnar form. The following illustration (FIGURE 83) shows the use of a columnar species on a local street containing overhead utility lines.

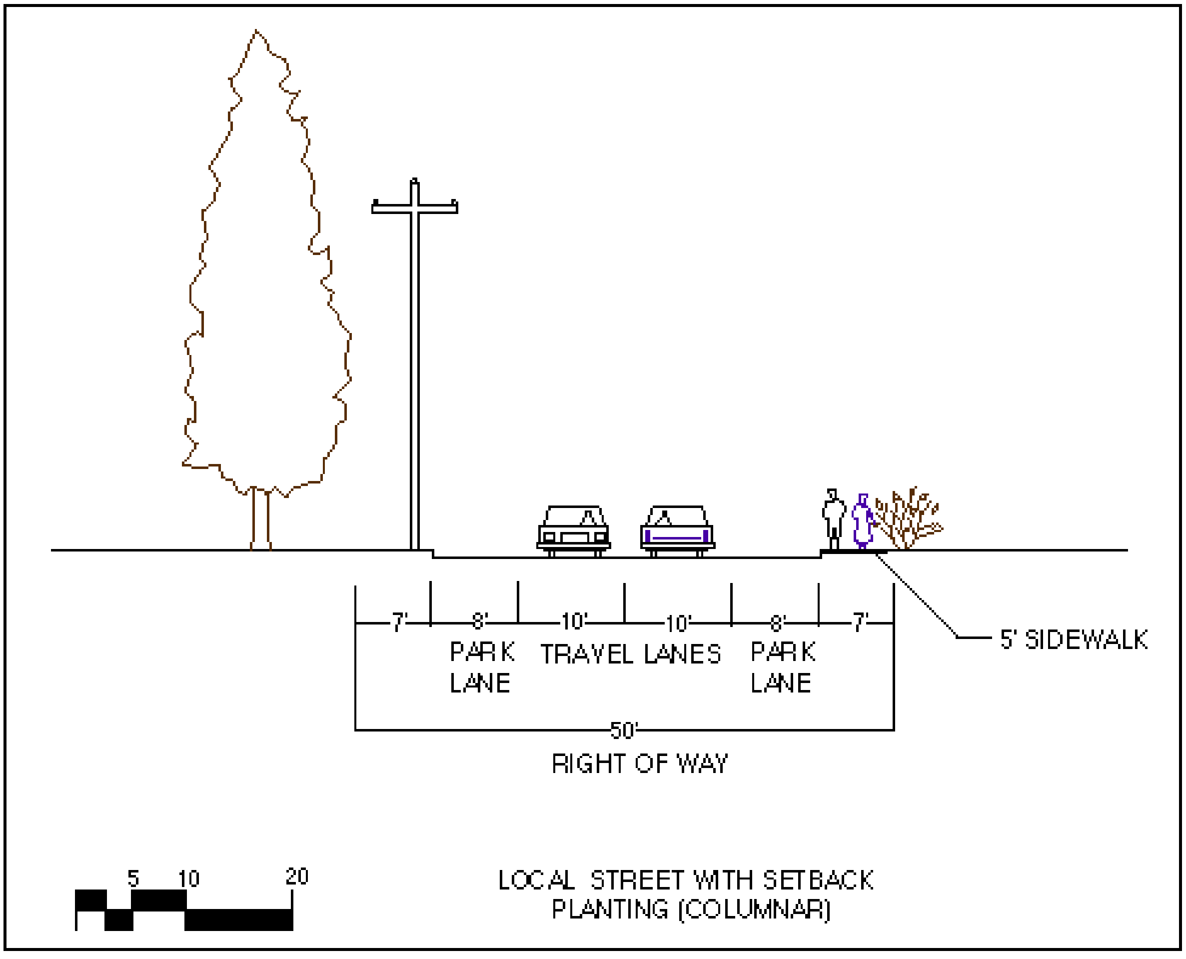


FIGURE 83 - Cross section of a local street with a columnar setback planting.

Boulevard or Parkway Streets

Shown below is a (FIGURE 84) cross section of a boulevard or parkway street, including two travel roadways and a planting strip in the middle. The drawing illustrates this type of street when the utility lines are found running along one of the two roadways. The exact dimensions and layout of boulevard or streets differ from community to community, but the major constraints on planting location and design intent can be illustrated using this example.

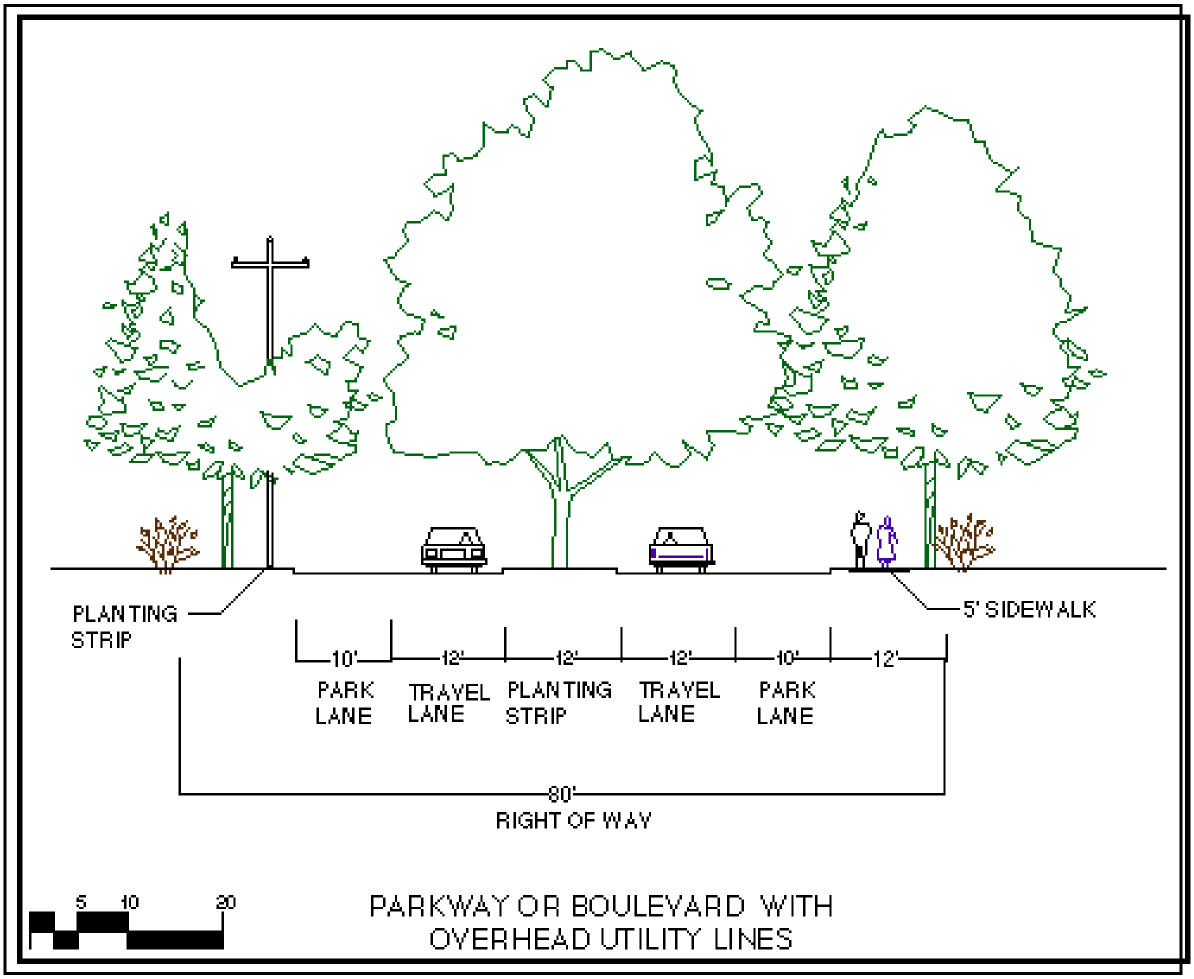


FIGURE 84 - Cross section of a boulevard street with overhead utility lines on one side of roadway.

The following drawing (FIGURE 85) shows the same boulevard street with overhead utility lines running down the center planting strip. This type of situation occurs often and presents serious threats to the success of the intended design scheme. The degradation of the aesthetic quality of the streetscape planting occurs when trimming of the trees to ensure utility line clearance is undertaken, resulting in a situation illustrated in the following drawing.

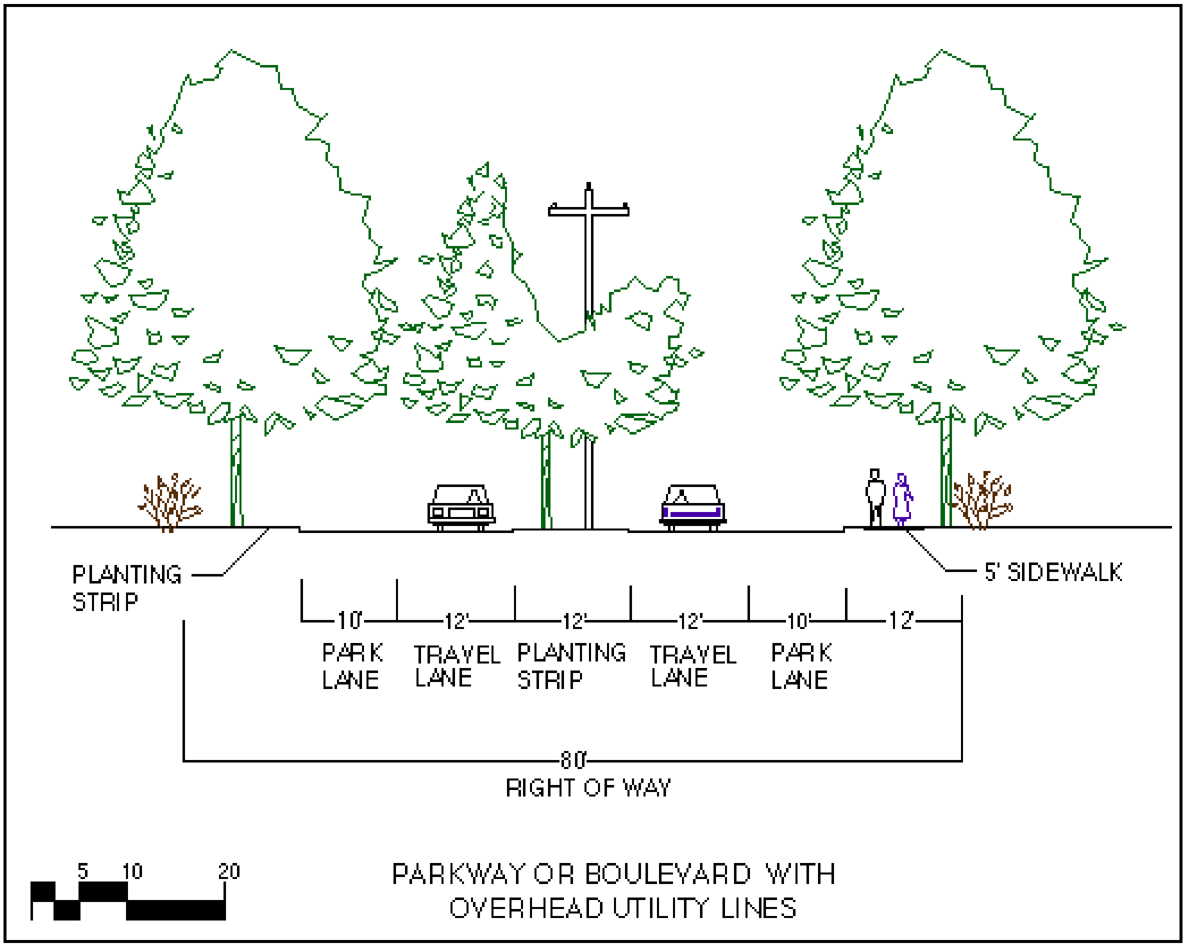


FIGURE 85 - Cross section of a boulevard street with overhead utility lines along center planting strip.

Setback Planting

The following drawing (FIGURE 86) illustrates a boulevard street with the street trees planted in a set back location from the edge of the right of way. This planting location allows for sufficient room for the street tree to grow to its full size without interfering with the utility lines. The setback planting allows for full growth while at the same time enforcing an edge of the street and separating the public and private properties along this boulevard street.

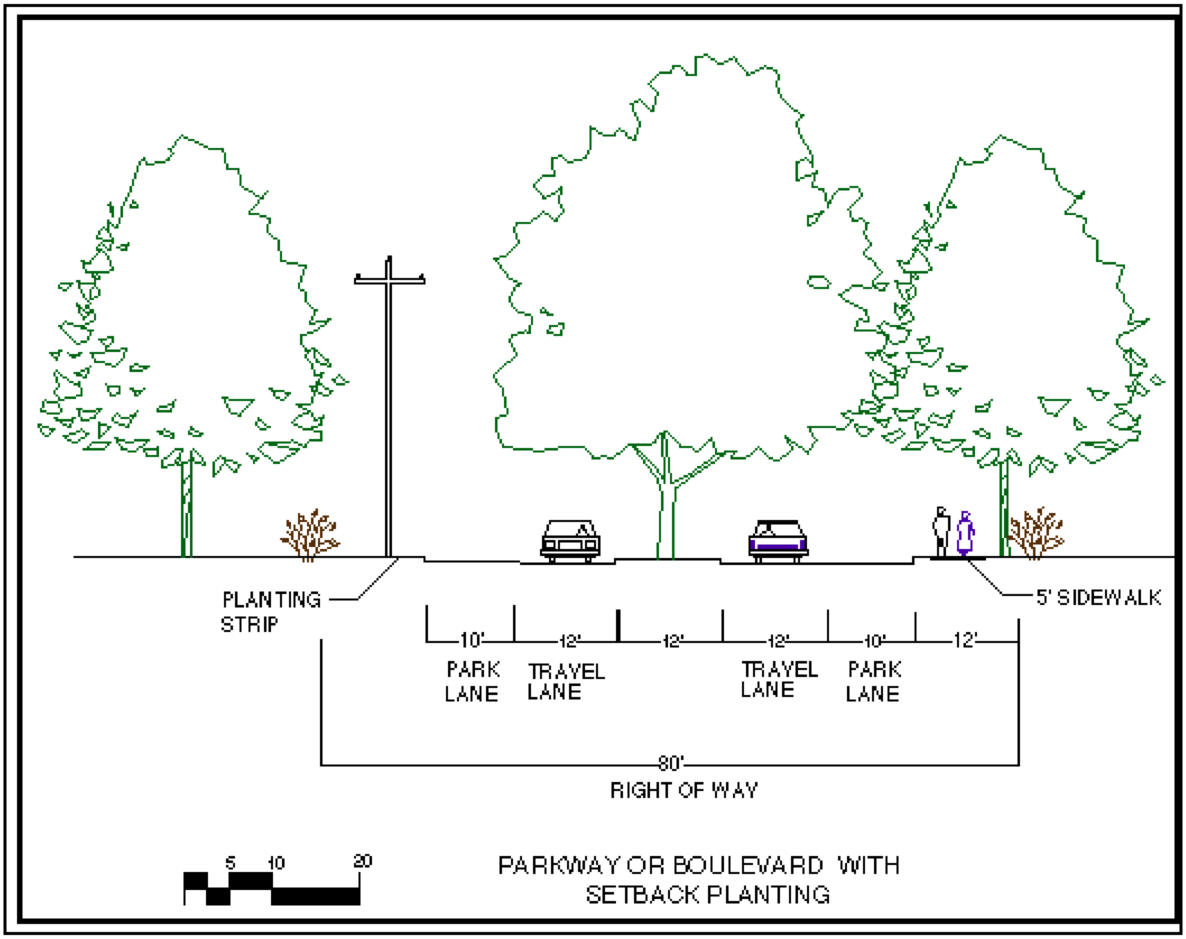


FIGURE 86 - Cross section of a boulevard street with setback planting.

Planting with reduced plant size

The use of a tree species whose ultimate size will not allow for growth within the vicinity of the overhead utility lines, can also be used on boulevard streets. In the same manner as in other street type situations the use of slower growing species and smaller plant types, can be done so as to eliminate the need for maintenance trimming near the utility lines. The selection of tree types that will be able to achieve the same design intent as a larger species is possible if the plant selection process is fully reviewed. The following drawing (FIGURE 87) illustrates this concept on a minor arterial street where the overhead utility lines run along one of the travel lanes.

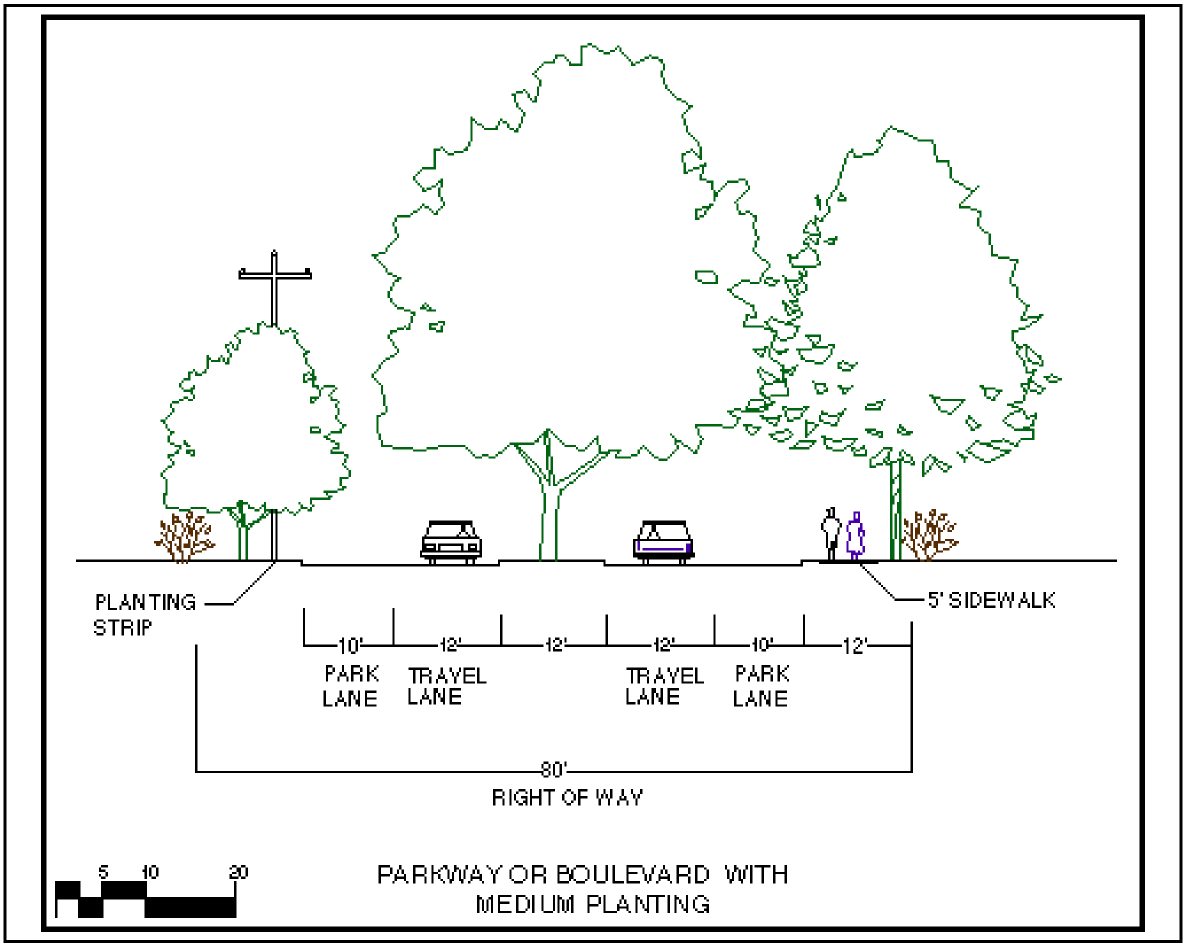


FIGURE 87 - Cross section of a boulevard street using smaller tree species, near overhead utility lines.

The following illustration (FIGURE 88) shows the use of a smaller tree species used on a boulevard street when the overhead utility lines run down the center planting strip. The use of smaller tree species and larger shrub types allows for increased variety and interest along this type of street. The use of these kinds of plant materials allows for flexibility in plant selection while at the same time maintaining the design integrity of the streetscape.

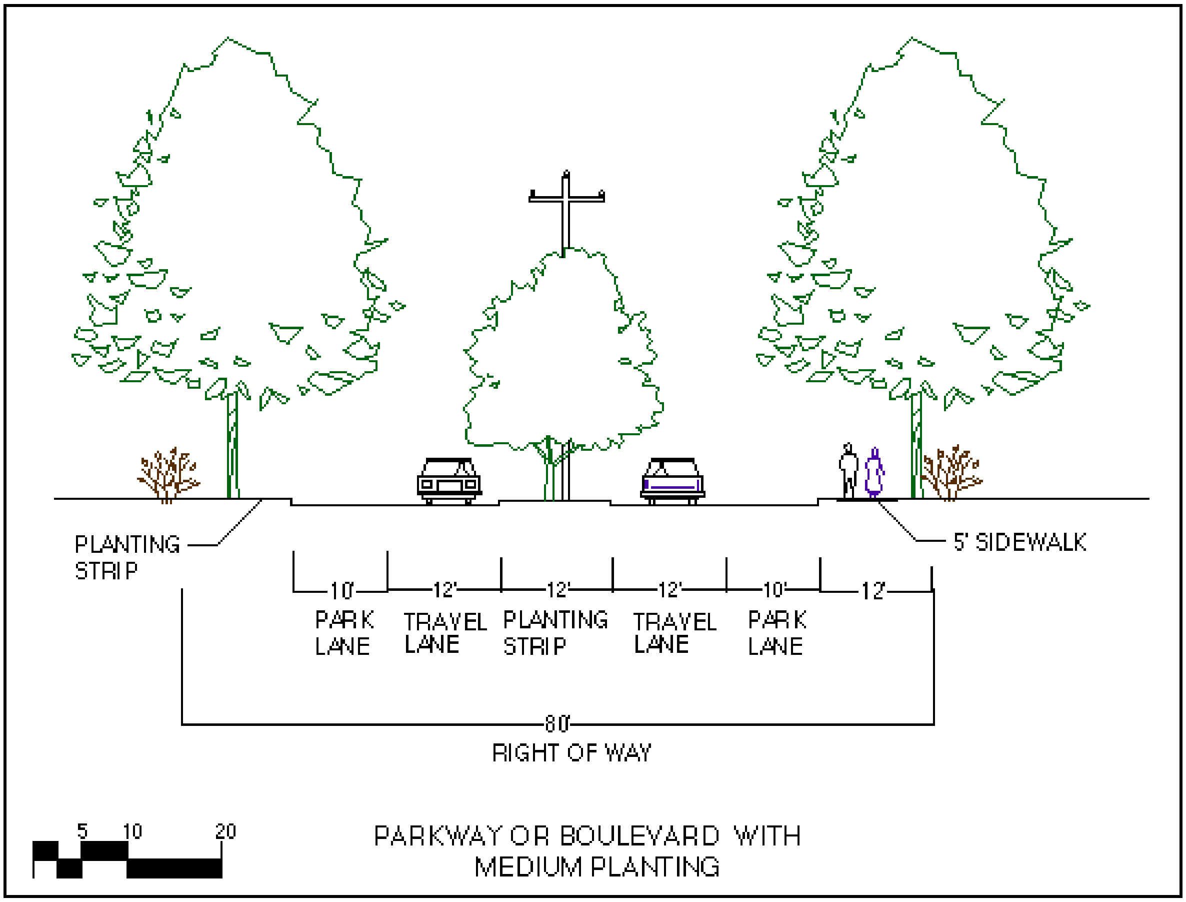


FIGURE 88 - Cross section of a boulevard street using smaller tree species along center planting strip.

The following illustration (FIGURE 89) shows the use of a shrub grouping on a boulevard street where the overhead utility lines run down the center planting strip. The use of larger shrub types mixed with smaller tree species allows for increased variety and interest along this type of street. Flexibility in plant selection is one of the advantages of this type of planting, enhancing the design integrity of the streetscape.

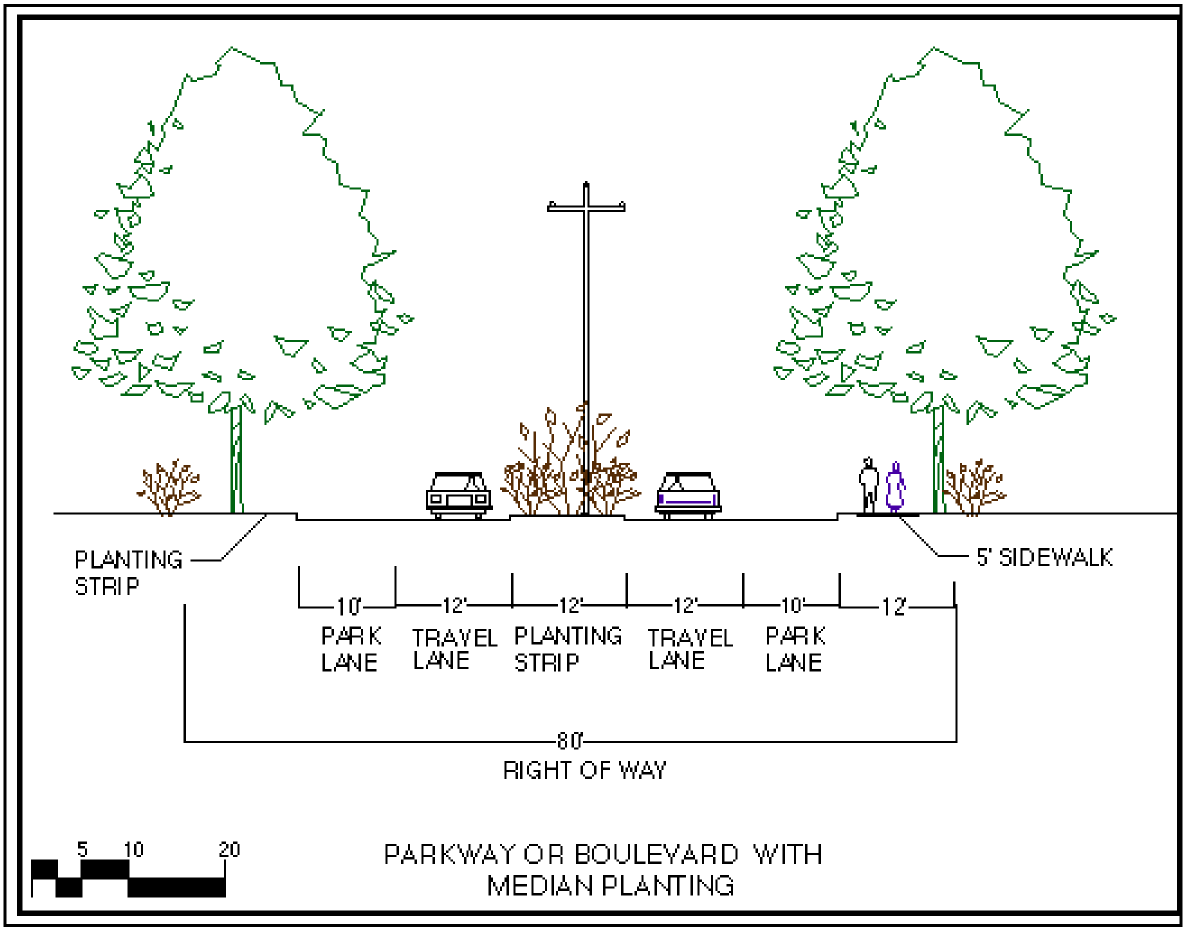


FIGURE 89 - Cross section of a boulevard street with shrub and small tree planting along center planting strip.

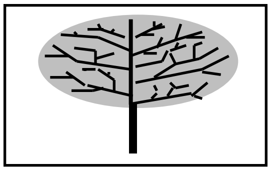
Recommendations for Plant Selection

In addition to proposing changes in the location that trees are planted, the selection of plant species that will tolerate conditions common to streetscape plantings. The trees must be adaptive to the varied soils that the urban situation presents, must withstand a wide range of moisture availability, have the ability to overcome poorer air quality, and survive people pressure, while at the same time fulfil the design intent of the streetscape. The trees must be able to maintain the shape and form that are true to the species so that their intended use in the landscape is achieved.

In choosing plant species and varieities to be used in streetscape situations the cultural, aesthetic, and maintenance necessities of the plant must be addressed. The ability of a planted tree to adapt, survive and thrive as part of a streetscape is critical to the success of a designed street planting. The plants must be able to overcome the pressures placed on them and grow to a size where their impact on the design intent is greatest. Therefore quality plant stock must always be chosen for planting, and tree species that they are fully hardy in the climatic zone in which they are to be planted. Ideally the plant material should be locally grown, so as to assure the plant hardiness for the particular planting region.

The following pages contain suggested tree species for use in street planting situations. The plants that are listed were chosen on a basis of form, hardiness and availability. Most of the trees are available from nurseries throughout the Northeast U.S. and many are available from local growers within 10 miles of the target communities examined in this study. There are many other plants available for use as street trees, but this list contains varieties readily available locally.

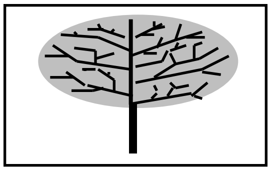
The trees are listed on sheets based on the growth habit of the plant discussed earlier in this chapter, and are organized by the ultimate height of the plant.



Broad Oval Branching

Tall - 40 Ft. and Up

Acer platanoides Cleveland	**Cleveland Norway Maple**
Acer platanoides Crimson King	**Crimson King Maple**
Acer platanoides Olmsted	**Olmsted Norway Maple**
Acer platanoides Schwedleri	**Schwedler Norway Maple**
Acer platanoides Summershade	**Summershade Norway Maple**
Acer pseudoplatanus	**Planetree Maple**
Acer rubrum	**Red Maple**
Acer rubrum Karpick	**Karpick Red Maple**
Acer rubrum October Glory	**October Glory Red Maple**
Acer rubrum Red Sunset	**Red Sunset Red Maple**
Acer saccharum	**Sugar Maple**
Cercidiphyllum japonicum	**Katsura Tree**
Fagus sylvatica	**European Beech**
Fraxinus lanceolata Newport	**Newport Ash**
Fraxinus lanceolata Patmore	**Patmore Ash**
Gleditsia triacanthos inermis Continental	**Continental Honeylocust**
Gleditsia triacanthos inermis Skyline	**Skyline Honeylocust**
Gleditsia triacanthos inermis Shademaster	**Shademaster Thronless Honeylocust**
Gymnocladus dioicus	**Kentucky Coffeetree**
Liriodendron tulipifera	**Tuliptree**
Magnolia acuminata	**Cucumber Tree**
Nyssa sylvatica	**Sourgum**
Quercus alba	**White Oak**
Quercus borealis	**Northern Red Oak**
Quercus imbricaria	**Shingle Oak**
Sophora japonica Regent	**Regent Scholartree**



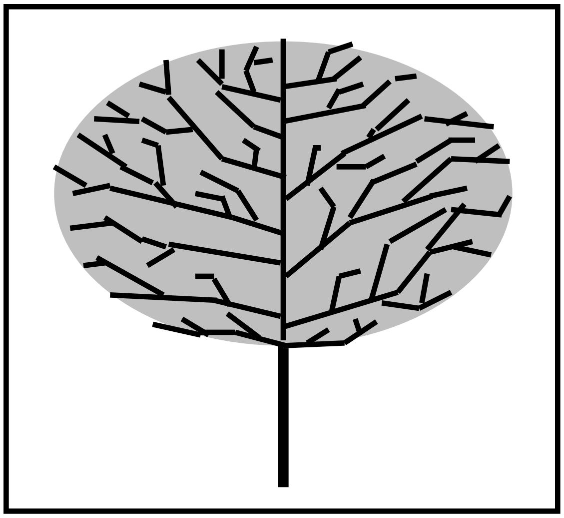
Broad Oval Branching

Medium - 30 to 40 Ft. and Up

Aesculus carnea Briotii	**Ruby Red Horsechestnut**
Cladrastis lutea	**Yellowwood**
Corylus colurna	**Turkish Filbert**

Short - 20 to 30 Ft. and Up

Acer campestre	**Hedge Maple**
Acer ginnala Flame	**Amur Maple**
Crataegus cordata	**Washington Hawthorne**
Crataegus Vaughn	**Vaughn Hawthorn**
Crataegus viridis Winter King	**Winter King hawthorn**
Halesia corolina	**Carolina Silverbell**



Broad Spreading Branching

Tall - 40 Ft. and Up

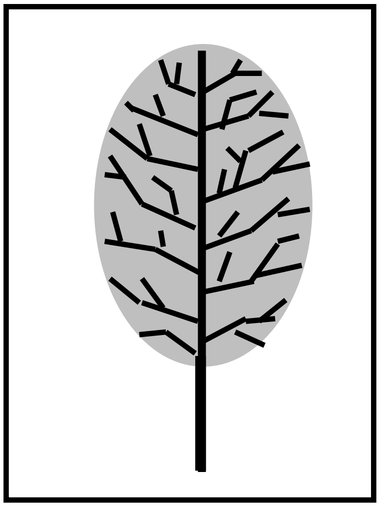
Fagus sylvatica asplenifolia	**Fernleaf Beech**
Gleditsia triacanthos intermis Sunburst	**Sunburst Locust**

M edium - 30 to 40 Ft. and Up

Betula nigra	**River Birch**
Phellodendron amurense	**Amur Corktree**
Prunus serrulata Kwanzan	**Kwanzan Cherry**
Prunus subhirtella Autumnalis	**Autumn Flowering Cherry**
Prunus yedoensis	**Yoshino Cherry**

Short - 20 to 30 Ft. and Up

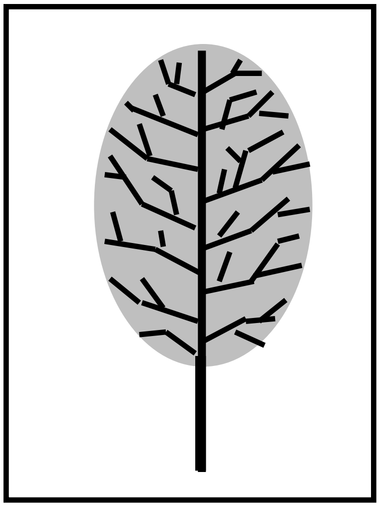
Acer palmatum	**Japanese Maple**
Cercis canadensis	**American Redbud**
Cornus florida	**White Flowering Dogwood**
Cornus kousa	**Kousa Dogwood**
Cornus mas	**Cornelian Cherry**
Koelreuteria paniculata	**Golden Rain Tree**
Syringa amurensis japonica	**Japanese Tree Lilac**
Syringa reticulata Summer Snow	**Summer Snow Japanese Tree Lilac**



Broad Upright Branching

Tall - 40 Ft. and Up

Acer platanoidesEmerald Queen	**Emerald Queen Maple**
Acer saccharum Bonfire	**Bonfire Sugar Maple**
Acer saccharum Green Mountain	**Green Mountain Sugar Maple**
Acer saccharum Legacy	**Legacy Sugar Maple**
Eucommia ulmoides	**Hardy Rubber Tree**
Fraxinus americana Autumn Purple	**Autumn Purple Ash**
Fraxinus americana Rosehill	**Rose Hill Ash**
Fraxinus lanceolata Summit	**Summit Ash**
Fraxinus pennsylvanica Marshall Seedless	**Marshall Seedless Green Ash**
Liquidambar styraciflua	**Sweet Gum**
Platanus acerifolia Bloodgood	**Bloodgood London Plane Tree**
Quercus acutissima	**Sawtooth Oak**
Quercus bicolor	**Swamp White Oak**
Quercus coccinea	**Scarlet Oak**
Quecus macrocarpa	**Bur Oak**
Quercus robur	**English Oak**
Quercus rubra	**Northern Red Oak**
Sophora japonica Princeton Upright	**Princeton Upright Scholartree**
Tilia americana Redmond	**Redmond Linden**
Tilia euchlora	**Crimean Linden**
Tilia tomentosa Green Mountain	**Green Mountain Silver Linden**
Ulmus hollandica Groenveldt	**Groenveldt Elm**



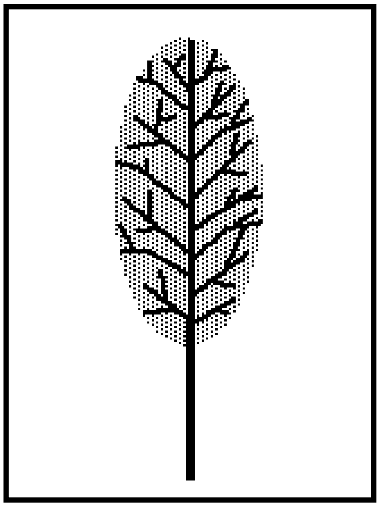
Broad Upright Branching

M edium - 30 to 40 Ft. and Up

Betula alba laciniata	**Cutleaf Weeping White Birch**
Ostrya virginiana	**American Hophornbeam**
Prunus maackii	**Amur Chokecherry**
Pyrus calleryana Aristocrat	**Aristocrat Callery Pear**
Pyrus calleryana Autumn Blaze	**Autumn Blaze Callery Pear**
Pyrus calleryana Redspire	**Redspire Pear**
Pyrus calleryana Capitol	**Capitol Pear**
Pyrus calleryana Whitehouse	**Whitehouse Pear**
Sorbus alnifolia	**Korean Mountain Ash**

Short - 20 to 30 Ft. and Up

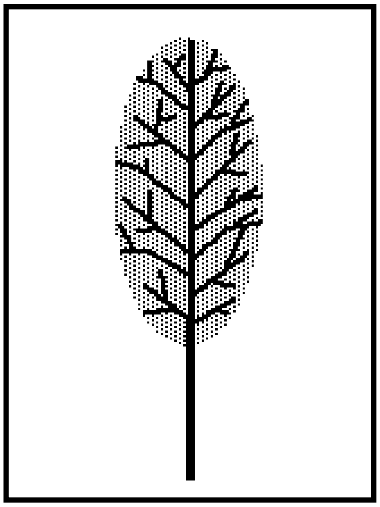
Amelanchier grandiflora Autumn Brilliance	**Autumn Brilliance Shadblow**
Amelanchier Cumulus	**Cumulus Shadblow**
Amelanchier grandiflora Robin Hill	**Robin Hill Shadblow**
Amelanchier Robin Hill Pink	**Pink Shadblow**
Crataegus Lavallei	**Lavelle Hawthorn**
Crataegus oxyacantha Superba	**Crimson Cloud Hawthorn**



Columnar or Fastigiate Branching

Tall - 40 Ft. and Up

Acer nigrum Greencolumn	**Greencolumn Black Maple**
Acer platanoides columnare	**Columnar Norway Maple**
Acer rubrum columnare Armstrong	**Armstrong Red Maple**
Acer rubrum coumnar Bowhall	**Bowhall Red Maple**
Acer saccharum columnare Goldspire	**Goldspire Surgar Maple**
Acer saccharum Monumentale	**Sentry Sugar Maple**
Fagus sylvatica fastigiata	**Pyramidal Beech**
Ginkgo biloba Lakeview	**Lakeview Ginkgo**
Ginkgo biloba Princeton Sentry	**Priceton Sentry Ginkgo**
Ginkgo biloba Magyar	**Magyar Upright Ginkgo**
Quercus robur fastigiata	**Pyramidal English Oak**



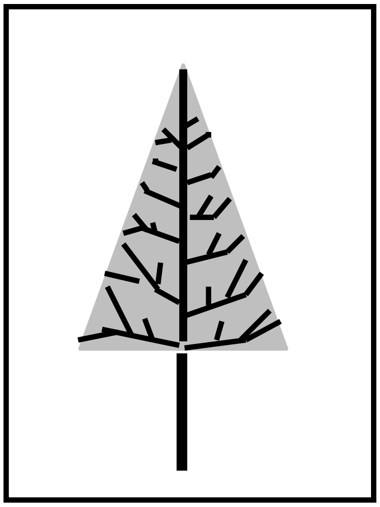
Columnar or Fastigiate Branching

M edium - 30 to 40 Ft. and Up

Betula alba fastigiata	**Pyramidal European Birch**
Carpinus betulus fastigiata	**Pyramidal European Hornbeam**
Carpinus caroliniana	**American Hornbeam**
Prunus sargenti dalumnaris	**Columnar Sargent Cherry**
Sorbus thuringiaca fastigiata	**Columnar Oakleaf Mountain Ash**

Short - 20 to 30 Ft. and Up

Malus baccata columnaris	**Columnar Siberian Crabapple**
Malus Madonna	**Madonna Crabapple**
Malus Snowdrift	**Snowdrift Crabapple**
Malus Spring Snow	**Spring Snow Crabapple**
Malus Van Eseltine	**Van Eseltine Crabapple**
Malus zumi Calocarpa	**Redbud Crabapple**
Prunus serrulata Amanogawa	**Amanogawa Cherry**



Conical Branching

Tall - 40 Ft. and Up

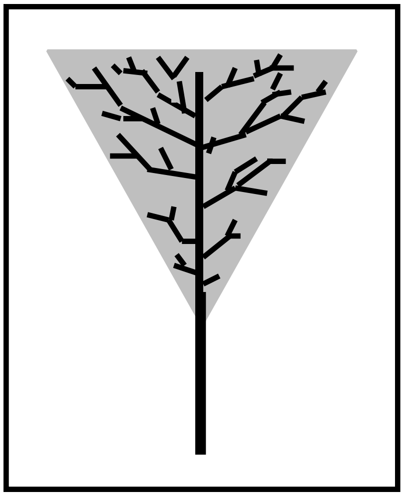
Acer saccharum columnare	**Columnar Sugar Mape**
Fraxinus americana Greenspire	**Greenspire Upright American Ash**
Metasequoia glyptostroboides	**Dawn Redwood**
Quercus palustris	**Pin Oak**
Quercus phellos	**Willow Oak**
Taxodium distichum	**Bald Cypress**
Tilia cordata Greenspire	**Greenspire Littleleaf Linden**

M edium - 30 to 40 Ft. and Up

Betula platyphylla japonica	**Asian White Birch**
Ilex opaca	**American Holly**
Pyrus calleryana Breadford	**Bradford Callery Pear**

Short - 20 to 30 Ft. and Up

Oxydendrum Arboreum	**Sourwood**



Vase Shaped Branching

Tall - 40 Ft. and Up

Celtis occidentalis	**Hackberry**
Ulmus americana Deleware	**Delaware American Elm**
Zelkova serrata Green Vase	**Green Vase Zelkova**
Zelkova serrata Village Green	**Village Green Zelkova**

Short - 20 to 30 Ft. and Up

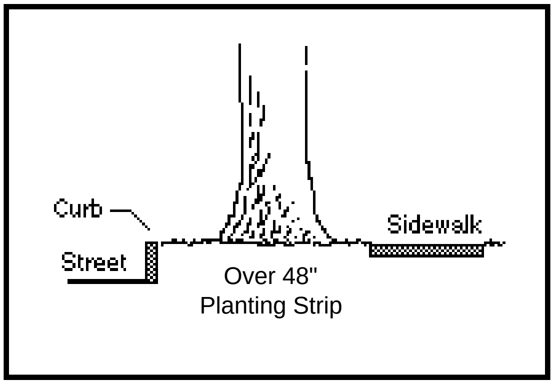
Malus theifera	**Tea Crabapple**

Plant Selection for Specific Planting Strips

Using criteria developed by the New Jersey Tree Federation (1990), the selection of tree species must also take into consideration the width of the planting strip or diameter of the planting pit available, in order to ensure that the tree roots and trunk will not damage nearby physical infrastructure.. Taking into consideration the width of available planting space is critical in order to ensure that the growth of the tree will not be inhibited while at the same time making sure that nearby sidewalks, curbs, paving and underground infrastructure is not damaged.

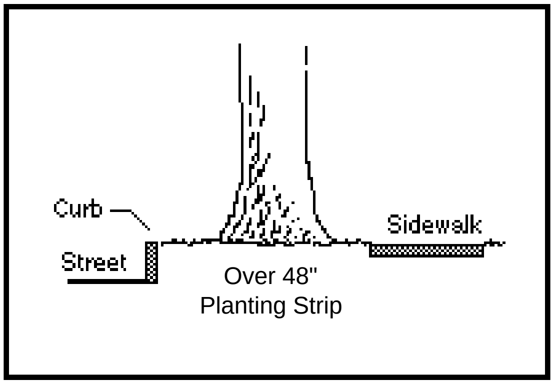
The New Jersey Tree Federation has developed a method for classification of tree selections which takes into consideration the diameter of the tree trunk after 30 years of street side growth. The previous plant list has been classified using this system in the plant lists which follow. Through careful selection of trees using the criteria of size and planting strip width, appropriate plant selections can be made.

Trees to be Planted in Planting Strips Greater than Four Feet (48") wide.



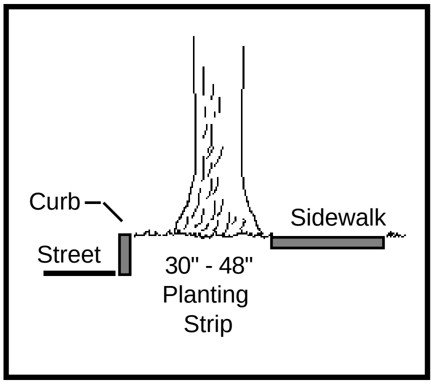
Acer nigrum Greencolumn	**Greencolumn Black Maple**
Acer platanoides Cleveland	**Cleveland Norway Maple**
Acer platanoides Crimson King	**Crimson King Maple**
Acer platanoides Olmsted	**Olmsted Norway Maple**
Acer platanoides Schwedleri	**Schwedler Norway Maple**
Acer platanoides Summershade	**Summershade Norway Maple**
Acer pseudoplatanus	**Planetree Maple**
Acer rubrum	**Red Maple**
Acer saccharum	**Sugar Maple**
Acer saccharum columnare	**Columnar Sugar Mape**
Acer saccharum columnare Goldspire	**Goldspire Surgar Maple**
Acer saccharum Monumentale	**Sentry Sugar Maple**
Aesculus carnea Briotii	**Ruby Red Horsechestnut**
Celtis occidentalis	**Hackberry**
Cercidiphyllum japonicum	**Katsura Tree**
Fagus sylvatica	**European Beech**
Fagus sylvatica fastigiata	**Pyramidal Beech**
Fraxinus americana Greenspire	**Greenspire Upright American Ash**
Fraxinus lanceolata Newport	**Newport Ash**
Fraxinus lanceolata Patmore	**Patmore Ash**
Ginkgo biloba Lakeview	**Lakeview Ginkgo**
Ginkgo biloba Magyar	**Magyar Upright Ginkgo**
Ginkgo biloba Princeton Sentry	**Priceton Sentry Ginkgo**

Trees to be Planted in Planting Strips Greater than Four Feet (48") wide.



Gleditsia triacanthos inermis Continental	**Continental Honeylocust**
Gleditsia triacanthos inermis Shademaster	**Shademaster Thronless Honeylocust**
Gleditsia triacanthos inermis Skyline	**Skyline Honeylocust**
Gymnocladus dioicus	**Kentucky Coffeetree**
Liriodendron tulipifera	**Tuliptree**
Magnolia acuminata	**Cucumber Tree**
Metasequoia glyptostroboides	**Dawn Redwood**
Nyssa sylvatica	**Sourgum**
Quercus alba	**White Oak**
Quercus borealis	**Northern Red Oak**
Quercus imbricaria	**Shingle Oak**
Quercus palustris	**Pin Oak**
Quercus phellos	**Willow Oak**
Quercus robur fastigiata	**Pyramidal English Oak**
Sophora japonica Regent	**Regent Scholartree**
Taxodium distichum	**Bald Cypress**
Tilia cordata Greenspire	**Greenspire Littleleaf Linden**
Ulmus americana Deleware	**Delaware American Elm**
Zelkova serrata Green Vase	**Green Vase Zelkova**
Zelkova serrata Village Green	**Village Green Zelkova**

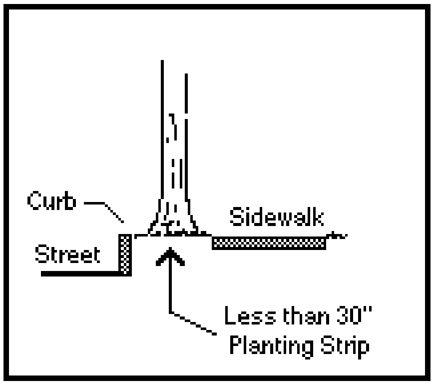
Trees to be Planted in Planting Strips 2 1/2 to 4 feet (30-48") wide.



Amelanchier grandiflora Autumn Brilliance	**Autumn Brilliance Shadblow**
Betula alba fastigiata	**Pyramidal European Birch**
Betula alba laciniata	**Cutleaf Weeping White Birch**
Betula nigra	**River Birch**
Betula platyphylla japonica	**Asian White Birch**
Carpinus betulus fastigiata	**Pyramidal European Hornbeam**
Carpinus caroliniana	**American Hornbeam**
Cladrastis lutea	**Yellowwood**
Corylus colurna	**Turkish Filbert**
Ilex opaca	**American Holly**
Ostrya virginiana	**American Hophornbeam**
Phellodendron amurense	**Amur Corktree**
Prunus maackii	**Amur Chokecherry**
Prunus sargenti dalumnaris	**Columnar Sargent Cherry**
Prunus serrulata Kwanzan	**Kwanzan Cherry**
Prunus subhirtella Autumnalis	**Autumn Flowering Cherry**
Prunus yedoensis	**Yoshino Cherry**
Pyrus calleryana Aristocrat	**Aristocrat Callery Pear**
Pyrus calleryana Autumn Blaze	**Autumn Blaze Callery Pear**
Pyrus calleryana Breadford	**Bradford Callery Pear**
Pyrus calleryana Capitol	**Capitol Pear**
Pyrus calleryana Redspire	**Redspire Pear**
Pyrus calleryana Whitehouse	**Whitehouse Pear**
Sorbus alnifolia	**Korean Mountain Ash**

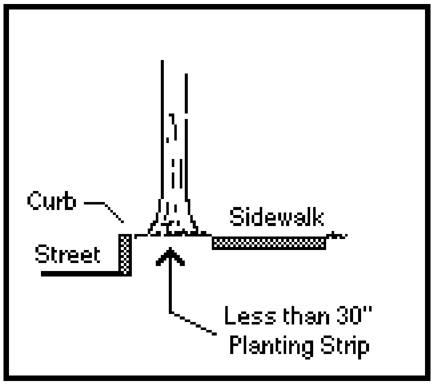
Sorbus thuringiaca fastigiata	**Columnar Oakleaf Mountain Ash**

Trees to be Planted in Planting Strips less than 30" wide.



Acer campestre	**Hedge Maple**
Acer ginnala Flame	**Amur Maple**
Acer palmatum	**Japanese Maple**
Acer rubrum Karpick	**Karpick Red Maple**
Amelanchier Cumulus	**Cumulus Shadblow**
Amelanchier grandiflora Robin Hill	**Robin Hill Shadblow**
Amelanchier Robin Hill Pink	**Pink Shadblow**
Cercis canadensis	**American Redbud**
Cornus florida	**White Flowering Dogwood**
Cornus kousa	**Kousa Dogwood**
Cornus mas	**Cornelian Cherry**
Crataegus cordata	**Washington Hawthorne**
Crataegus Lavallei	**Lavelle Hawthorn**
Crataegus oxyacantha Superba	**Crimson Cloud Hawthorn**
Crataegus Vaughn	**Vaughn Hawthorn**
Crataegus viridis Winter King	**Winter King hawthorn**
Halesia corolina	**Carolina Silverbell**
Koelreuteria paniculata	**Golden Rain Tree**

Trees to be Planted in Planting Strips less than 30" wide.



Malus baccata columnaris	**Columnar Siberian Crabapple**
Malus Madonna	**Madonna Crabapple**
Malus Snowdrift	**Snowdrift Crabapple**
Malus Spring Snow	**Spring Snow Crabapple**
Malus theifera	**Tea Crabapple**
Malus Van Eseltine	**Van Eseltine Crabapple**
Malus zumi Calocarpa	**Redbud Crabapple**
Oxydendrum Arboreum	**Sourwood**
Prunus serrulata Amanogawa	**Amanogawa Cherry**
Syringa amurensis japonica	**Japanese Tree Lilac**
Syringa reticulata Summer Snow	**Summer Snow Japanese Tree Lilac**

Improved Planting Procedure

In addition to plant selection and planting location, the use of planting specifications which are specifically designed for the urban street condition are necessary to ensure the proper growth and survivability of the street tree. The use of planting wells, as illustrated in the following drawing, (FIGURE 90) is one method that improves the conditions in which a street tree must grow. The planting method is one of the latest techniques recommended by The National Arbor Day Foundation (1990), and demonstrates the use of innovative planting specifications designed to improve the health of the urban trees. In this method a cover is added over the a portion of the planting pit, and is filled with a coarse gravel.

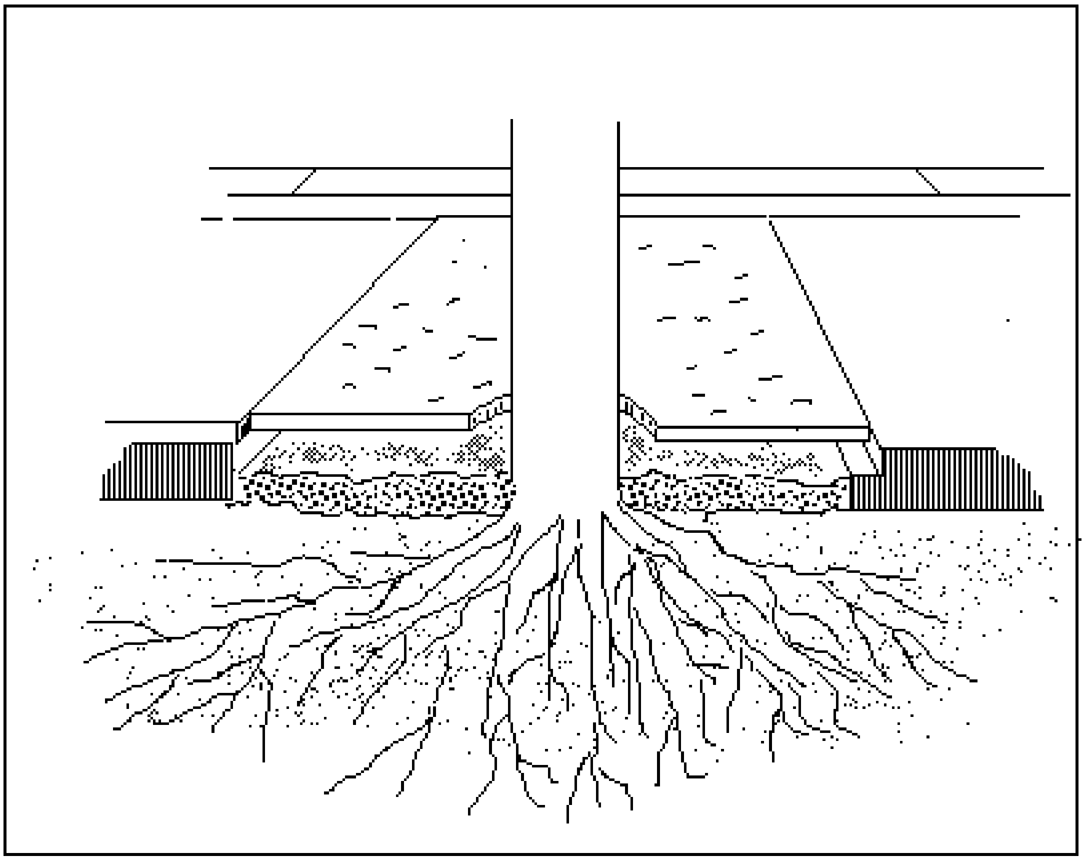


FIGURE 90 - Planting well with cover allowing for deeper rooting.
Source Valuation of Landscape Trees, Shrubs, and Toher Plants

Other planting procedures and methods can help in promoting deeper rooting or preventing damage to the physical infrastructure surrounding the tree planting location. The use of physical root barriers made of various materials is now being employed as a successful method for deflecting root growth downward and away from surface infrastructure such as sidewalks, curbs, and roadways. The following drawing (FIGURE 91) illustrates the concept behind the use of these measures.

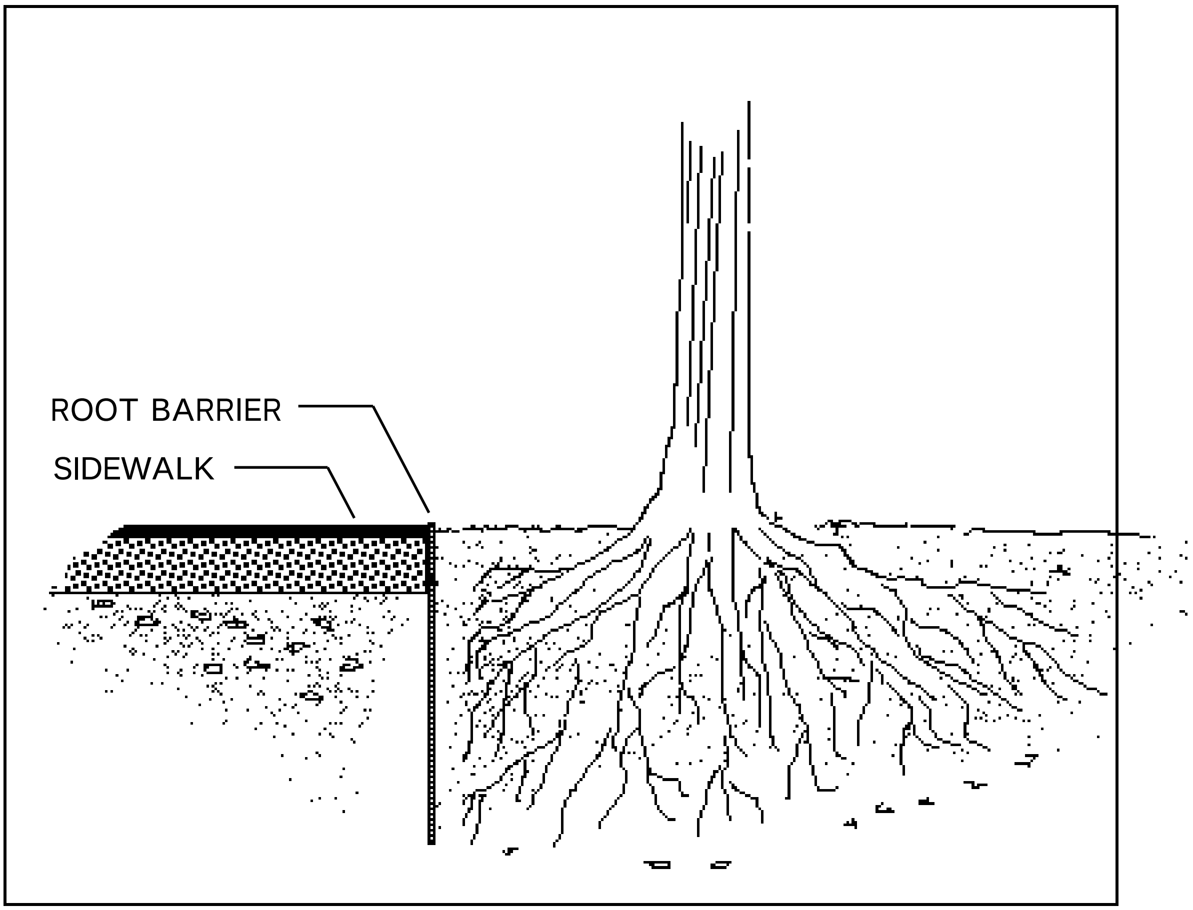


FIGURE 91 - Root barrier used to direct root growth downward away from physical infrastructure.

The use of porous paving materials which are also flexible and can withstand the expansion of tree root systems is also suggested for paving near street trees. This method can be employed on sidewalks and in the parking lanes of roadways. The following drawing (FIGURE 92) illustrates the use of this type of paving material. There are many methods which can be used to employ this useful technique, all of which can add to the aesthetic quality of the streetscape. The use of this type of porous and flexible pavement surface is suggested as an alternative to the use of concrete pavement immediately adjacent to tree planting locations. The specific materials which are used are the choice of the designer or landscape architect, but the principle of the method remains the same. The use of this method allows for a lasting solution to the expansion of street tree roots.

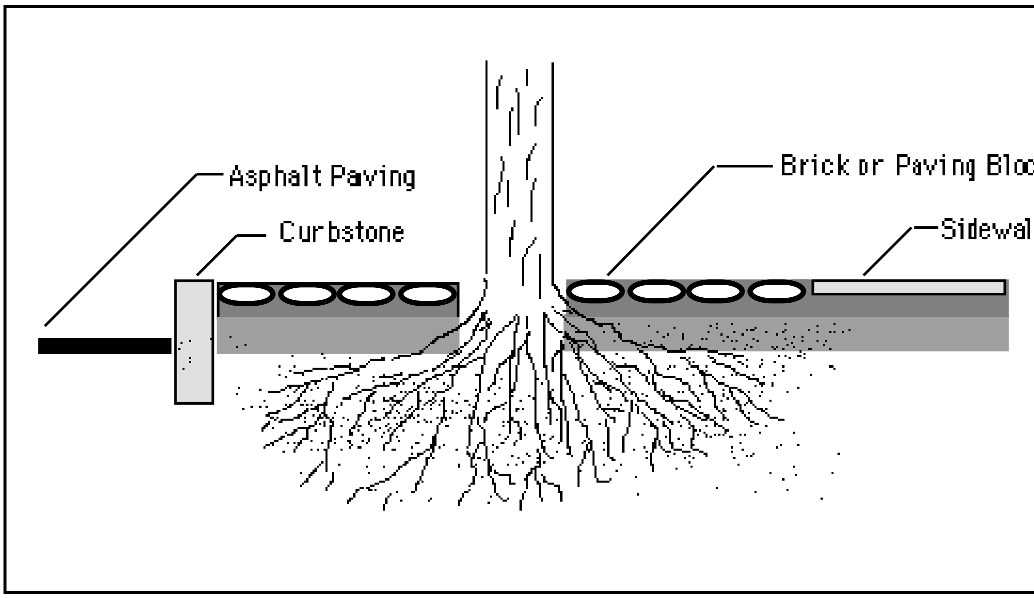


FIGURE 92 - Brick or pavers used to reduce potential damage to surrounding paving and allowing for improved permeability.

When tree roots present damaging results to underground infrastructure the use of a vault or planting container system helps to contain the root system of the tree within a specific area the concrete vaults are similar to underground planting pots, which allow for the addition of desirable soil within the planting area, protect the area from compaction through the use of a concrete lid, and protect adjacent utilities, piping, and other structural infrastructure from intrusion by tree roots. The following illustration (FIGURE 93) demonstrates the use of this type of vault system. The example shown was developed for use in Denver, Colorado Transitway Mall by I.M. Pei and Partners, Hanna/Olin, and Philip Flores Associates.(Jewell, 1981)

FIGURE 93 - Tree vault system used to retain tree roots and protect surrounding underground infrastructure.

Private Property Planting

In Massachusetts the General Laws of the Commonwealth (Chapter 87, sec.7)(See Appendix 5) allows for the planting of public shade trees on private property adjacent to the public way, up to twenty feet from the property line. This innovative approach has been used in several communities in the state, and has resulted in providing these communities with tree lined streets. One community using this provision of the General Law very successfully is the Town of Wellesley, which implemented a program of private property planting in 1948. According to the 1948 Report of the Tree Warden there were over 600 shade trees planted and "in accordance with long range planning, new trees are set out, wherever possible, on private property just off the highway. In this location the tree gets more moisture, does not interfere with overhead wiring, is not a traffic hazard, and the property owner takes a personal interest in the growth of the tree. In time this will result in a great saving in maintenance." (Town of Wellesley,1948) This approach to planting has proved to be extremely successful in the town, that now has some of the most picturesque tree lined streets in the state.

The practice of planting public trees on private property is one of the most useful methods which can be employed to fulfil the design intent of a streetscape planting, in a manner allowing for the full growth of the tree. Trees are kept away from overhead utility lines and municipal infrastructure as a result. This planting practice eliminates pruning by the utility company and protects against damage to streets, sidewalks, curbs, and other elements of the streetscape, thereby saving money for both the utility and the municipality.

The implementation of a program for planting trees on private property can be easily accomplished, by developing a permission method whereby the property owner gives permission to the tree warden to plant a tree on their private land through the use of a permission slip. This becomes a contract between the town and the property owner allowing for the town to keep control of trees placed on private property. The permission slip used by the Town of Wellesley is shown below (FIGURE 94) and serves as a model for other communities in the state.

FIGURE 94 - Permission form used in Wellesley, MA for planting fof shade trees on private property.

Conclusion

The implementation of procedures and policies which ensure that the right tree is planted in the right spot are necessary so that the trees which grow on public streets fulfil their role as an aesthetic attribute as well as one of the major components of the urban forest ecosystem. Through careful plant selection based on planting location and conditions, using appropriate planting technique to protect infrastructure, planting trees in locations which will eliminate conflict with overhead utilities, and by designing streetscapes which recognize the limitations placed on trees growing in these areas, successful street tree planting can be achieved. Failure to take into account all of the complex components of plant growth, physical infrastructure, overhead utility lines, and design intent will result in a failed street tree environment.

Chapter Five
Conclusion- A Review of the Study

Project Intent

The purpose of this project was to examine the problems associated with street tree plantings as they relate to utility lines and urban infrastructure and to develop recommendations for new plantings addressing these problems and offer feasible solutions. The use of appropriate species, the selection of proper locations for plantings, and the implementation of a program of preventative maintenance for the street trees, allows for a cost effective tree management system. Reducing the conflict between utility wires and tree plantings leads to a less costly procedure for maintenance of overhead utility lines. The appropriate use of trees along streets benefits other components of the upkeep of the urban infrastructure, including reducing the amount of damage by tree roots to streets and sidewalks. The development of an aesthetically pleasing streetscape design can benefit from the development of a program addressing the type, location, and upkeep of trees along streets and roadways. The development of recommendations that assist in the management of the street trees growing along city streets was the primary purpose for this investigation.

Background

Often times the design intent of a planted street tree is never achieved because of the problems associated with the streetscape condition and the influence of overhead utility lines. The maintenance procedures necessary to ensure the safe delivery of electricity often times lead to a change in the form a street tree achieves, thereby threatening the intended design. Through careful examination of what methods can be employed that will ensure that the right tree is planted in the right spot, eliminating the need to be trimmed away from utility lines, the design intent can be achieved. The intent of this study was to examine these methods, propose new ones, and to develop an understanding of what is required to ensure that the right tree is planted in the right place.

This study is part of an ongoing investigation into developing a management plan for the maintenance of street trees growing on the streets over which electric lines of Western Massachusetts Electric Company/Northeast Utilities travel. The utility company is interested in determining ways of reducing the cost of maintaining trees growing within the safety clearance distance of their wires. Since the trees are owned by the municipalities, any recommendations that might be implemented require approval of the local communities represented by the tree warden in the city or town. In addition to potential savings for the utilities resulting in implementing changes to their policy, the study presents recommendations protecting the physical infrastructure in the communities, resulting in a financial savings to the cities and towns which enact the recommendations.

Three target communities were examined and the findings presented will be recommended for incorporation into the management of the street trees in these communities. Streets in The City of Springfield, the Towns of Longmeadow and Agawam, Massachusetts were used as the source of street types to be examined. These communities presented a good cross-section of the community types that are serviced by Western Massachusetts Electric/Northeast Utilities.

State of the Art

The development of recommendations and presentation of specific findings necessitates a complete investigation of the problem, and this was undertaken in this study. Through site visits, literature review, personal interviews, and addtional research, an understanding of current practice in communities was achieved. By looking at successful street tree planting techniques and by researching the newest methods, the feasibility of implementing similar procedures in the target communities was deemed possible.

A careful and thorough presentation of the implications of overhead utility line maintenance on the quality of street trees was presented as part of the examination. By graphically illustrating various street tree forms, the changes that result from utility line trimming are shown, and the severity of the impact on the design intent of the trees presented.

The Procedure and Findings

In this study a series of street types were identified, representing the various kinds of streetscapes in the targeted communities. The streetscapes were identified and the characteristics of each illustrated. A careful examination of the design intent of the street trees in each street type was addressed, and the implications of overhead utility lines and physical infrastructure demonstrated. Proposed changes were suggested for planting location and tree species for each street type presented. Graphic illustrations showing the implications of suggested changes were included, allowing for a visual understanding of proposed changes. By looking at the location and type of trees planted, the implications to the original streetscape can be seen, allowing for a more informed decision to be made as to what suggested changes to adopt. Since the streetscapes looked at in the study were based on the street types found in the target communities, the changes to the samples street types can be directly related to the streets found in each of the communities

In addition to planting location and suggestions for plant types, a plant list was developed including tree species and varieties tollerant of streetscape conditions, while at the same time fulfilling the design intent and their role as streetscape elements. The plants listed are locally available and represent a wide range of shape, size, flowering, color, and texture. Also included are recommendations for the selection of plant types based on the size of available planting space in which the plant must grow. Measures to protect the physical infrastructure of the streetscape environment were presented as part of the findings and recommendations of the study.

The Contribution

The findings and recommendations found in this study can be used by several different practicing professional groups to improve the quality of the streetscape environment and to enhance the health of the urban forest ecosystem. Landscape architects and other design professionals can use the research and findings to select the proper plant for the right spot when designing new streetscapes or changes to existing ones. Municipal tree wardens can benefit from the findings, by developing a policy for new tree plantings that selects tree species that are appropriate for the planting location, and advocating the implementation of policy that includes planting of public trees on private property. In addition the tree wardens and city planners can jointly propose changing to zoning bylaws that ensure trees planted in newly developed areas will be the right species planted where it can develop fully without presenting problems to infrastructure or other landscape elements. Utility arborists can use the findings and the research materials to begin to implement policies which will increase cooperation between cities and the utilities, so that the management of the urban streetscape forest can be most economically carried out.

Landscape architects have a special role in ensuring that street trees be effectively used in streetscape design. It is critical that the designer understand the potential value that a mature and healthy tree will have on the streetscape environment. Since landscape architects are often involved in the design of new roadways or the redesign of existing streets, they have the opportunity to influence the way in which trees are selected, planted, and cared for. Therefore their role in ensuring that the aesthetic and ecological value of the street tree be maximized, is special and presents a challenge they must meet. Studies and findings such as this one begin the process of more effectively meeting the challenge of creating a functional, aesthetically successful, and ecologically viable streetscape. The knowledge gained through such study can lead to the implementation of practices ensuring the success of the street environment for everyone to experience.

Further Research

The challenge of designing the streetscape and using street trees effectively is ongoing, and the findings presented here only begin to examine the entire design and management process. There is a great need to examine existing situations more fully, and to determine the successes and failures and to use the findings to develop refined selection and planting techniques.

The development of a pro-active approach by the the utilities and other concerned parties requires that methods, policy, and criteria be developed allowing for the implementation of successful street tree plantings. The development of these recommendations requires that ongoing research continue so that the latest technology, genetic research, zoning policy, and management practices can be most effectively be undertaken.

Conclusion

This study has examined an area most landscape architects have not fully addressed sucessfully, either in study or practice. The use of trees by landscape architects as a design element is well documented, but an examination of whether or not the design intent was ever achieved does not often occur. Only by understanding the reasons for failed design, can new design reflect improvements which will eliminate the causes of the failure. Through a careful and complete examination of plant selection, planting location, planting technique, maintenance and management methods, the landscape architect can be more effective in designing successful landscapes. By understanding what the street tree looks like as it matures in the streetscape environment and realizing the conditions threatening the tree's maturity, the landscape architect can select appropriate species for planting in the right location. By specifying the latest planting technology, and recommending the most effective management practices, the landscape architect can effectively design the streetscape so that the trees fulfil their role as design element.

Today, the use of street trees has a special role in ensuring the sustainability of the urban ecosystem. This presents another challenge to the landscape architect, designer and arborist. The health of the street tree is critical not only for aesthetic reasons but more importantly for ecological reasons, presenting a special challenge to those charged with their care. It is hoped that this study will in some way assist in meeting this challenge.

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