

Landscape and Aesthetics

This chapter provides an overview of landscape planning and design, an integral part of transportation project development. The chapter provides guidance on landscape objectives, corridor considerations, design, plant material selection, and protection/preservation techniques. The chapter also describes the project documentation typically required for landscape elements.

13.1 Landscape Design Objectives

The goal of roadway landscape design is to integrate the road into the landscape context. This goal is guided by three objectives: (1) protection of natural and cultural resources, (2) restoration and rehabilitation of landscapes damaged or compromised by transportation improvements, and (3) enhancement of the corridor such that it becomes not merely a functional facility, but a community asset. Achieving these objectives involves evaluating the features of the corridor, and the corridor as a whole, to determine project impacts and how to best integrate the facility into the larger community and environmental context.

Protection and Preservation

Some features, such as wetlands, waterways, historic landmarks and districts, and parks, are protected by regulation. Yet there may be locally significant elements – pathways, architectural details, monuments, groves of trees – that may not meet regulatory thresholds, but may support adjacent ecosystems, or define the atmosphere of a village or town.

Plants, especially trees, provide climatic benefits, air filtration, erosion control and slope stability, storm water retention, and natural habitat. They also enhance the visual quality of the roadway corridor. Project planning and design should seek to preserve and protect existing plants, important cultural features, and ecosystems that make up the corridor.

Restoration and Rehabilitation

When impacts to the landscape are unavoidable, project design should, to the extent feasible, seek to restore or repair landscapes damaged by construction. For natural systems, the intent of such restoration is not merely to replace lost elements, but to replace specific lost functions. This may mean restoring habitat, water buffers, edge systems, hydrologic connections and soil functions. Streetscape restoration, like ecological restoration, involves more than simply replacing individual elements that have been lost. Therefore, the overall character of the street context must be evaluated in project planning and restored to the extent feasible.

Enhancement

Often landscaping is part of a civic improvement or a beautification initiative that has been incorporated into a transportation project. The local community is typically involved in design decisions for these projects and is committed to the future care of the streetscape elements. Project enhancements may include sidewalk improvements, furnishings, lighting, and street trees. New elements should be properly integrated with and linked to existing streetscape elements and should contribute to creating a sense of place and town identity.

13.2 Corridor Considerations

There are many requirements and considerations involved in safely accommodating the multiple uses of roadway corridors while respecting environmental conditions and meeting public expectations.

13.2.1 Public Expectations

The roadway landscape is the interface between the functional area of a road and the community through which it passes. Project planning and design must address a broad constituency with sometimes competing interests. For example, vehicles, including bicycles, require certain minimum widths for travel; neighborhood residents may desire street trees; and pedestrian accommodation requires minimum vertical as well as horizontal clearances. All of these factors will influence the streetscape opportunities for a roadway.

13.2.2 Safety

The over-riding spatial design considerations for roadway landscaping are those that address the safety of the corridor. The principle considerations are:

- **Sight Lines** must be maintained near intersections and driveways. No obstructions, such as plant material, signs, lights, signals, and other furnishings should block sight lines. Chapter 3 provides guidance as to the necessary sight distances.
- **Clear Zones** provide a recovery area adjacent to the roadway. Trees that will attain trunk diameters of 4 inches (measured 2 feet above ground) or more at maturity should not be located within the clear zone. See Chapter 5 for specific clear zone guidance.
- **Buffers** provide separation between higher speed vehicular traffic and pedestrian traffic. They serve to increase the comfort and safety of pedestrians walking on sidewalks. Measures, including landscape, to provide buffers and improve walkability are discussed in Chapters 5 and 16.

13.2.3 Environment

The environmental conditions of a site determine which plants will survive and thrive. Roadside conditions are typically harsh, limiting the palette of plants for landscape restoration and streetscapes. The following conditions should be analyzed to guide location and selection of species (See Section 13.4 for specific guidance on species selection).

- Climate and microclimate of the roadside vary from site to site and within sites. Slope angle and orientation will dramatically affect ground temperatures and water demands of plant material. Desiccating winds increase with closer proximity to the roadway.
- Soil quality of existing soils and proposed fills must be assessed as to drainage characteristics, compaction potential, organic content and fertility, as well as potential exposure to salt run-off and other soil contaminants.
- Existing hydrology will determine erosion considerations and species choices. Wetland areas will require additional protective measures, as described in Chapter 8.

- Existing vegetation should be evaluated with regard to plant communities, invasive species, native species, and the function that that vegetation serves (wetland buffer, screening, habitat area, erosion control, etc.). Indirect construction impacts on existing vegetation, such as changes in light or exposure, should also be addressed.
- Existing habitat should be assessed prior to choosing species for restoration. Habitat preservation and restoration should avoid inadvertently attracting species closer to roadway. Habitat considerations along roadways are further discussed in Chapter 14.

13.2.4 Utilities

Roadsides often serve as utility corridors. Underground and overhead wires and conduits are among the most common features. However, electric boxes, manholes, fire hydrants, lighting, and other fixtures must also be evaluated for clearance and access requirements. Underground utilities may require setbacks for the purpose of access and maintenance, although excavation of underground service is typically infrequent.

With the exception of the occasional high voltage utility corridor, overhead clearances are primarily a concern in urban and other developed areas. Utility poles, wires, and streetlights present special challenges for landscape design.

13.2.5 Roadway Maintenance

Landscape design must anticipate the type of maintenance that will be required. Responsibility for maintenance varies depending on roadway jurisdiction. Section 13.3.2.2 provides design guidance to accommodate maintenance in natural conditions. Maintenance for streetscape areas, as discussed in Section 13.3.1, is typically the responsibility of local municipalities.

13.3 Landscape Design Guidance

This section provides general design guidance. Design decisions are ultimately based on specific site conditions and may, in certain instances, require different solutions than those recommended. For this reason, this section classifies roadside landscapes into *streetscapes* and *natural sites*.

13.3.1 Streetscapes

Many of the roadway projects in Massachusetts pass through densely settled areas. These “streetscapes” are primarily pedestrian environments. This section focuses on the pedestrian landscape bound by the limits of right-of-way, and comprised of sidewalks and crosswalks. It may include decorative pavement, street trees, decorative lighting, and, where appropriate, other furnishings such as bicycle racks, benches, and trash receptacles.

13.3.1.1 Sidewalks

Occupying the border between the vehicular travel ways and private property, the sidewalk is a zone of many uses. In addition to pedestrian use, it usually carries underground and/or overhead utilities, streetlights and signs, as well as other sidewalk furnishings, including mailboxes, utility cabinets, and hydrants.

Sidewalk design must be attentive to the need for equitable access for a broad range of physical abilities, meeting the requirements of the Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG) and Massachusetts Architecture Access Board regulations (521 CMR). These requirements are discussed throughout the Guidebook and their specific influence on landscape design is summarized below:

- **Clearances.** Sidewalks must provide a clear path, a minimum of 5 feet wide. Short portions of this path may be narrowed to 3 feet to avoid fixed objects. Accommodating these clearances typically requires consolidation of street furnishings, including utility poles, lighting, and street trees to one side or the other of the walking path.
- **Gradient.** Sidewalks are allowed to follow the prevailing grade of the roadway. When other walkways are proposed, the constructed profile of walkway without a railing must not exceed 5 percent. Cross slopes should be designed to 1.5 percent, so as not to exceed the regulatory maximum of 2 percent. These cross section constraints restrict the type of materials and surfaces to those that can maintain these grades.
- **Surfaces.** Accessible surfaces should be slip resistant, with vertical deviations (such as at joints) not exceeding 1/8 inch. As with gradient thresholds, these constraints restrict the location and types of decorative pavement used.

- **Ramps at crossings.** Individual wheelchair ramps must be provided at both ends of all street crossings. They must be traversable from all approaches, and must provide level landings at top and bottom (See Chapter 6 for additional details). Landscape features such as street trees, lighting, and decorative pavement must be integrated such that they do not obstruct or hinder access to these transition areas.

13.3.1.2 Aesthetic Pavement Surfaces

Pavements for sidewalks are typically concrete or hot mix asphalt. Occasionally, decorative pavements are desired to reflect architectural materials and details in historic districts, to beautify significant downtown locations, or to highlight pedestrian zones. In general, the designer should:

- Limit irregular or rustic surfaces to non-traversable areas, such as the buffer zone, or “furniture zone” between the pathway portion of sidewalk and the street, or for non-traversed portions of medians;
- Where highlighted or decorative walks are desired, consider textured pavement and color admixtures.

Where unit pavers are used for pathways, the designer should:

- Provide a concrete or otherwise rigid base to ensure a smooth surface, and provide an adequate bituminous setting bed (minimum 3/4 inch) to ensure a durable bond.
- Avoid irregular or rustic materials such as cobble or rustic molded bricks. Use only highly durable modular units that fit together evenly and without gaps. Chamfer of pavers should be no greater than 1/8 inch.
- Apply unit paving only where pavement line is continuous. Minimize breaks requiring cutting and hand fitting of units.
- Anticipate utility fixtures and develop templates to fit whole units around fixtures without gaps.
- Wheelchair ramps should be constructed out of non-slip cement concrete. Integrate modular pavement with ramp conditions without transitional breaks and gaps.

Decorative pavement can be expensive to construct and presents challenges to maintain. Its application should be limited to projects

that have explicitly identified the enhanced treatment as a priority and where there is local municipal commitment to maintenance, including proper repairs when pavements are disturbed or damaged.

13.3.1.3 Street Trees

Compared with other investments in civic improvements, street trees are relatively inexpensive and yield substantial community and environmental benefits. The desire for and feasibility of planting trees as part of a transportation project should be identified in the early stages of project development. Street tree plantings are frequently provided as part of state highway projects, but maintenance becomes the responsibility of local municipalities. For this reason, street tree planting design must consider not only conventional traffic issues of sight lines and clear zones, but also the horticultural requirements of plant material. An assessment of the planting area must take into account soil area, volume and type, availability of water, tree species, and microclimate.

Historically, trees have often been planted in strips too narrow and pits too small to adequately support long-term growth. Do not replant in these existing sites without carefully considering whether the soil volume, soil quality, microclimate, moisture levels and other site considerations are appropriate for the species selected, as described below.

Back-of-Curb Planting

Locating trees along the traffic side of sidewalks provides a buffer between the sidewalk and the street and may provide a visual traffic-calming cue to drivers. The planning and development of streetscapes should aim to provide sufficient area for tree planting, while accommodating pedestrian and utility demands. Considerations for back-of-curb planting include:

- Due to the many demands that may need to be met within the limited corridor space available – space for utility structures, pedestrian and bicycle accommodation, parking areas, and travel lanes – there is often insufficient area left for tree planting in back of the curb. Existing or proposed overhead and underground utility lines place further constraints on planting behind the curb.
- Typical urban forestry practices recommend at least 6 feet, preferably more, for the width of a street tree lawn. However, this

amount of available area is rarely found, especially in dense urban corridors.

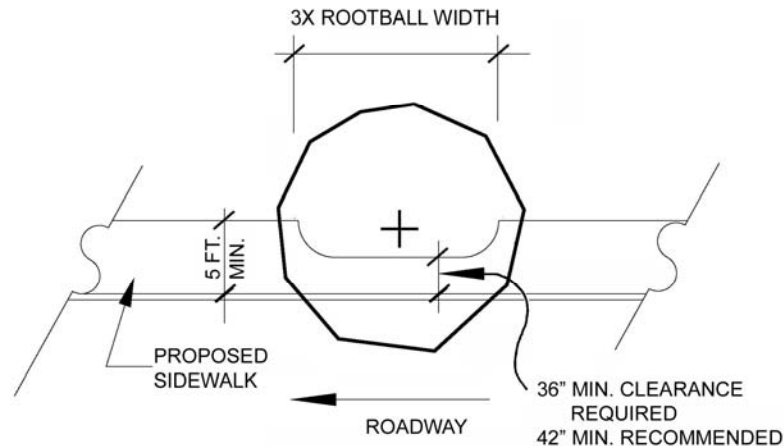
- If the width of the planting strip is less than 6 feet, or where the planting surface area is less than 60 square feet per tree, planting design should include documentation as to how species selection, soil modifications, irrigation or other designed modifications will support planting design.
- Tree strips as narrow as 3.5 feet may be viable. However, with smaller planting areas, municipalities should expect diminished tree growth and health, shorter plant life spans, and increased maintenance.
- Different species have different soil volume and moisture requirements. Choose species most likely to survive in the microclimate, site and soil conditions of the planting area.
- Shared root space provides a benefit to trees. Link tree pits or tree lawns to create spaces with greater soil area and volume.
- Municipalities may need to provide irrigation where there is insufficient soil volume to provide the moisture that the trees will require.
- In general, planting strips less than 3.5 feet wide are too narrow for trees. These strips do not contain sufficient soil volume for most species, do not provide sufficient area to protect tree trunks and roots from pedestrians, bicycles and parked cars, and, due to roots seeking soil outside the planting area, do not provide optimum long term conditions for sidewalks.

Back-of-Sidewalk Planting

Where sidewalk conditions (including accessible pathway requirements) limit the feasibility of back-of-curb planting, and where abutting land use allows, current urban forestry practices recommend back-of-sidewalk planting. Under these circumstances, the design process should include agreements with adjacent owners, especially where installation will encroach on private property.

Where right-of-way limits fall close to or on the back of the sidewalk, a portion of the sidewalk and sub-grade may be cut out to accommodate the root ball, provided there is adequate passage between the back of the curb and the back of the sidewalk, as shown in Exhibit 13-1.

Exhibit 13-1 Back of Sidewalk Tree Planting



Source: MassHighway

While planting in back of the sidewalk does not provide a physical buffer between the sidewalk and the street and may appear to compromise the conventional image of the tree-lined street, there are several significant benefits:

- Trees planted in areas with larger volumes of soil are more likely to survive and grow faster than trees in individual tree pits or strips because the roots have greater access to moisture and nutrients.
- Trees on back of sidewalk are much less likely to lift sidewalk pavement.
- Conflicts with overhead utilities along the sidewalk are avoided.
- Trees are less likely to be injured by vehicles and car doors.
- Trees will be less likely to obscure traffic signs and lights.
- Setback plantings are out of the way of future street repair such as curb resetting or installation.

Other Street Planting Strategies

Where sidewalk space is constrained and back-of-sidewalk planting is not possible, other considerations include:

- Locate trees where conditions are more favorable.

- Design subsurface planting pits that extend beneath and provide structural support to sidewalks, allowing sufficient room for root growth.
- Tree grates may help expand the tree planting area in confined pedestrian environments. There are specific ADA/ADAAG requirements for tree grates that limit the size of grate openings (and thereby limit available moisture). In general, tree grates are over-used as a decorative element. They are expensive and tend to restrict the growth of the tree over time. Uneven settlement around frames and eventual expansion of tree root mass can create trip hazards.

General Location and Design Guidelines

- The outside face of the tree trunk at its estimated mature size should be at least 1.5 feet behind face of curb.
- Locate trees and select species such that the canopy will not block signs, signals, or street lights.
- Locate trees so that trunks do not obscure sight lines at intersections and curb cuts.
- Where there is on-street parking, coordinate tree locations with parking stalls to minimize conflicts with car and truck doors.
- In commercial areas, allocate space for bicycle parking to deter people from locking bikes to trees.
- Avoid planting under utility wires. Otherwise, choose appropriate species/cultivars: low growing, columnar, or finely branched trees that can be pruned without causing major damage to the tree.
- Locate trees away from hydrants, electric boxes, lights, and other utility structures that may need to be accessed.
- Inventory subsurface utilities. In general, most tree roots are found in the top 2 to 3 feet of soil. However, excavation for sidewalks, root balls, backfill and drainage must be considered. Tree roots do not generally migrate toward underground lines, however, where soil surface area and volume is limited, roots may follow moisture and air along drainage and sewer lines underneath streets and sidewalks.

- Sidewalk pathways typically require a 7-foot vertical clearance, which may dictate species selection and/or selective pruning of trees upon or after installation.
- Vertical considerations for roadways include 8-foot clearances for bicycle traffic and as much as 14 feet clearance to avoid interference with buses. Pruning after installation may accommodate these conditions.

13.3.1.4 Median and Island Plantings in Urban Areas

Occasionally communities desire median or island plantings to enhance the visual quality of the roadway corridor. These locations are extremely challenging, particularly in high volume locations. The environmental stresses and maintenance demands are, along with safety considerations, greater than on the roadside. Clear commitment from the local community to maintain plantings is essential. General guidelines include:

- Median plantings in urban areas should be limited to areas where design speeds are less than 45 mph and where plants will not present a hazard or obscure sight distances or traffic signs and signals.
- From a horticultural standpoint, soil cross section for planted medians should be at least 10 feet for trees, 6 feet for shrubs.
- Selected trees should be upright, narrow, and high branching, in order to minimize interference with vehicles and pedestrians. Smaller tree species, including multi-stem trees tend to perform better than shade trees, but must not obstruct sight lines.
- Typically, the frequency of curb cuts and intersections will require maintaining sight lines across most, if not all, of the median, limiting shrubs and perennials to plants less than 3 feet high, including curb and earthwork height.
- Plants should be located as far from the curb as possible to prevent injury from salt, sand and snow.
- Raised earthwork on medians increases soil volume and raises plants above the roadway, providing greater protection from salt and sand.
- Where snow storage or traffic conditions may result in back-of-curb erosion, provide an 18 to 24-inch wide paved apron behind the curb.

Community commitment to maintenance is essential. Median areas are highly visible and highly susceptible to trash build up. Weeds must be regularly removed, plants watered, grass mowed, and branches routinely pruned. Planting and surfacing materials should be selected to avoid the emergence of weeds, minimizing the need for frequent manual weeding or herbicide application.

13.3.1.5 Lighting

Construction and maintenance requirements for roadways may limit the types of fixtures used. Communities are typically responsible for additional maintenance and installation costs of non-standard fixtures and lights. Aesthetic considerations include the detail and finishes of the posts and lamp housings, the post height, brackets, and the color quality of the light. The following general guidelines apply to the installation of street lighting, which is also discussed in Chapter 16:

- Top-mounted decorative lights can be obscured by adjacent street trees.
- It is advisable for light fixtures to cast the light downward to avoid obscuring the night sky and contributing to light pollution.
- Shorter lights are more to human scale, but provide a reduced spread of light. To provide adequate lighting, they must be installed at closer intervals. This increases installation, operation, and maintenance costs.
- In determining compatibility of illumination and planting, consider pole heights, light cones, the shape of the tree, and the horizontal location of poles relative to tree trunks.

13.3.1.6 Bicycle Racks

Bicycle racks are an integral part of accommodating bicycle transportation. Bicycle racks should be located where they are convenient to the users and where they will not interfere with pedestrian and vehicular traffic. Providing bicycle racks helps discourage users from locking bikes to railings, street trees, and other furnishings. General guidelines are presented below and additional references are provided in Section 13.7:

- The appropriate number of spaces needed should be assessed with respect to the associated building or land use.

- Ideally, the rack area should be protected from the elements
- Typical inverted “U” or post and ring systems are preferred, but any rack that meets the following criteria may be used:
 - Rack must enable the frame and one or both wheels to be secured, preventing the bike from tipping over.
 - The rack should be anchored so that it cannot be stolen with bikes attached.
 - For parallel storage, arrange rack elements 30 inches on center to allow space for two bicycles to be secured to each rack element.

13.3.1.7 Benches

When appropriately sited and properly constructed, benches create more attractive and comfortable human environments. Their design and construction should be appropriate to the character of the site. Backless benches allow two viewing perspectives. Benches should be located where people are likely to sit to wait, people-watch, rest, or look out at scenic views. They should not block pedestrian movement or impede wheelchair access. Avoid placing benches where they will not be used.

13.3.1.8 Trash Receptacles

Municipalities desiring receptacles must consider quantity and placement if they have limited resources to empty the receptacles. A period of monitoring may be necessary to determine the appropriate number of receptacles needed. In addition, receptacle design should consider capacity needs, security, weight, and vandalism, as well as lids to limit litter and rodent problems.

13.3.1.9 Information Signs

Information signs are necessary to guide people unfamiliar with the local area. Local zoning regulations are valuable in controlling the appearance, size and location of signs. Signs should be visible and conveniently located, but should not interfere with vehicular or pedestrian circulation. Less signage is better than excessive signage, which creates clutter and tends to be ignored.

13.3.2 Natural Site Landscape Treatments

Natural sites, as distinct from *streetscapes*, are those locations (urban and rural) where the principal objectives and concerns involve natural systems. Landscape design for natural sites encompasses surface stabilization of cuts and fills; containment and filtration of storm water

runoff; tree replacement and reforestation; buffering of roadside ecosystems and habitats; screening views to and from the road; mitigating wind and snow drift; and habitat enhancement. Typical landscape conditions at natural sites are illustrated in Exhibit 13-2. In general, design for natural sites is primarily comprised of appropriately selecting and placing plant material. See Section 13.4, regarding plant selection.

13.3.2.1 Design Constraints

The principal constraints governing plant placement in natural sites are clear zones and sight lines, maintenance considerations, frequently dry and windy microclimate conditions, and relatively poor soil conditions along the roadside.

Planting in Clear Zones

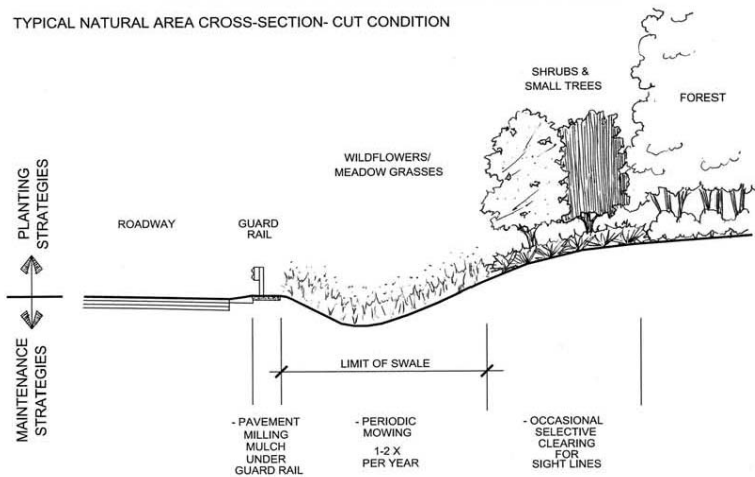
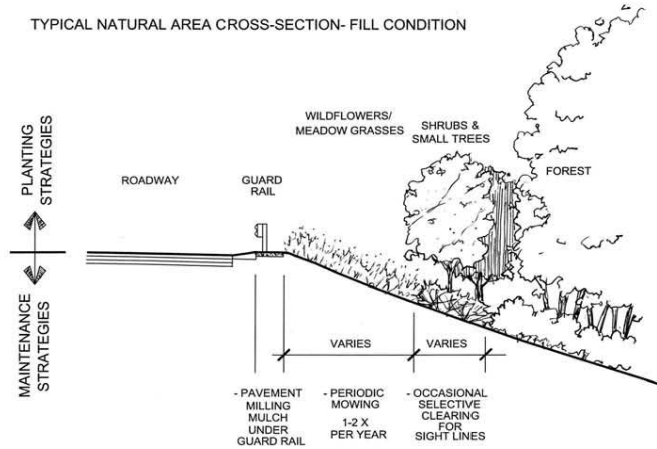
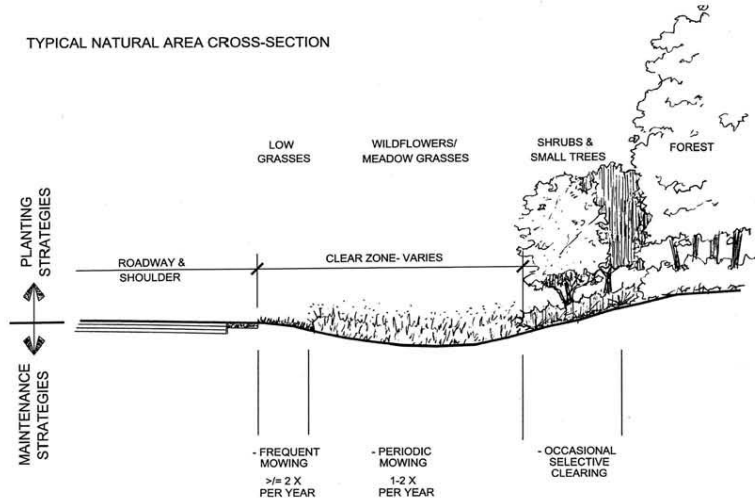
Technically, shrubs may be planted in the clear zone, although shrub masses are susceptible to successional growth of larger trees over time. Native grasses and perennials are good options for clear zone areas that are infrequently mowed.

Maintaining Sight Lines

Sight distance requirements on curves, and at interchanges and intersections limit the placement, height, and spread of plant material used. Sight distance requirements will depend on design speed, road geometry, and traffic controls. As with clear zones, low shrubs are technically feasible, but over time larger trees will have to be removed from shrub beds. Shrubs and perennials must be low growing. Larger trees should be set back to prevent branch encroachment and prevent blocking of traffic signs and signals, particularly for interstates and heavily traveled arterials.

Exhibit 13-2

Typical Landscape Cross-Sections at Natural Sites



Source: MassHighway

13.3.2.2 Design to Accommodate Roadway Maintenance

Successful integration of the road into the natural landscape requires anticipating typical maintenance practices. General planting guidance for maintenance of natural sites includes:

- Clear zones are typically mowed at least once a year, while 8- to 10-foot maintenance strips adjacent to the pavement may be cut more frequently. Grasses provide the typical groundcover. Native grasses and wildflowers are ideal where mowing is limited to once per year in the fall.
- In general, in natural areas, avoid planting woody material within 8 to 10 feet of the roadway edge, even behind barriers. This area is typically mowed more frequently and may also be used for snow storage.
- Slopes steeper than 3H:1V are typically protected by guardrail. These slopes will not be mowed except for the area immediately behind the guardrail and may be planted with grasses, wildflowers, shrubs or trees.
- Plantings along the roadside must be able to tolerate salt runoff and salt spray from de-icing operations. Runoff tends to reach about 5 to 10 feet. While salt spray effects have been measured over 100 feet from interstates, the most noticeable impacts are on evergreens within 30 to 40 feet of the pavement on higher speed roadways.
- Locate large trees away from the road and use appropriate shrub and understory edge species in areas that are closer to the roadway.
- Avoid locating evergreen trees on the south side of east-west tangents to reduce potential roadway icing due to shade.
- Plant in groups to facilitate mowing and use perimeter mulching to help suppress weed growth during establishment.
- Locate plantings to ensure easy and safe access by maintenance teams.
- Reduce mowing areas by planting or allowing naturally occurring woody species to grow in expansive open areas.
- Use pavement milling mulch with weed barrier to suppress vegetation under and within 3 feet of the back of traffic barriers.

13.3.2.3 Buffers and Screening

Landscaping can provide a buffer between the road and adjacent land. Frequently this buffer is intended as a visual and aesthetic screen, either of the highway itself, or of undesirable views from the highway.

Earthwork landforms and berms can provide sound attenuation and add variety and shape to the landscape, but may require as much as 5 feet of cross section width for every foot of elevation. While trees and shrubs offer very little sound attenuation compared to structures, they provide substantial visual and psychological relief from traffic impacts.

When designing vegetative screening, use a diverse palette of plant material rather than a continuous wall of one species and size. Where space is adequate, provide a mix of evergreens and deciduous trees and shrubs, creating a mixed woodland strip. Where space is narrow, screening should be a mix of evergreen species and sizes.

- **Habitat Edge/Buffer** - In natural sites, a vegetated roadside edge provides a buffer for forests and other habitat areas. Plantings provide edge cover, screen wind and snow, and filter air and trash from roadway traffic. The vegetated edge also provides habitat for edge species and food and cover for wildlife movement along the roadway corridor, as further discussed in Chapter 14.
- **Water Resource Protection** - Plants are a critical part of water protection. They function as a physical barrier, protecting water from litter and other pollutants as well as slowing the flow of water to allow it to gradually filter through the soil, preventing erosion and flooding. Plants immediately along the water edge shade and cool waterways, protecting the habitat of fish and other wildlife.
- **Shading and Screening** - Trees on a rural roadway provide shade and reduce glare, lessening driver fatigue. Shrubs in the medians help screen headlights of opposing traffic. Trees can also be used to screen undesirable roadside views such as landfills, scrap yards, and other industrial uses. Evergreens provide winter screening.
- **Wind and Snow Breaks.** - Trees can prevent snowdrift and serve as windbreaks. Evergreens and dense deciduous shrubs are best for this use.
- **Framing Views.** Planting trees in rows or clusters focuses views and defines corridors. Plantings can also be used to draw attention to scenic views or historic landmarks.

- **Aesthetic Interest** - Shrubs and wildflowers provide visual accents, and large swaths of plantings create visual impact. A variety of plantings with seasonal interest and irregular plantings diversify roadway edges and reduce the monotony of a continuously forested edge. Reducing mowed areas and mowing times allows wildflowers to grow creating more interesting clear zones and open areas.

13.3.2.4 Medians in Natural Sites

In addition to the safety requirements of preserving clear zones and sight distances, medians in natural sites have many of the same environmental constraints as those in urban areas. However, they offer some additional design considerations.

- Shrub plantings and berms in the medians provide visual interest and screen headlight glare from opposing traffic. They also help reduce snow drifting.
- Rural medians provide an opportunity for storm water storage, conveyance and filtration. Plant selection and location should anticipate these functions. The *MassHighway Storm Water Handbook* and Chapter 8 of this Guidebook provide more information on these topics.

13.3.2.5 Steep Slope Conditions

Steeper slopes tend to be dryer due to increased run-off and (if south-facing) increased solar exposure. Planting recommendations, including maintenance considerations, include:

- Specify slope plant material in smaller sizes to facilitate transplanting.
- Plant in close groups on slopes to decrease wind damage to plants and to enhance root shading.
- Locate trees and shrubs away from channel bottoms and slope toes to avoid areas of flooding, poor drainage, and salt accumulation.
- South facing slopes require heat and drought tolerant species. North facing slopes require species that thrive in shade and a cooler microclimate.

13.3.2.6 Reinforced Slopes

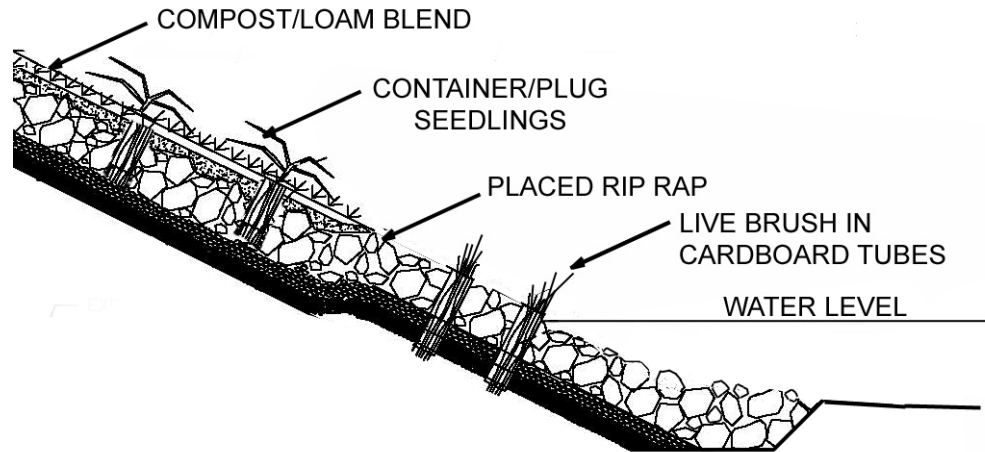
Protected resource areas and narrow right-of-way areas often require retaining walls or specially reinforced slopes to limit the area of impact. There are a variety of geotechnical solutions using wall unit systems and geotextiles to help stabilize steep slopes. Geotechnical evaluation of fills and cuts is necessary when considering alternatives.

Biotechnical stabilization integrates plant material with layered geogrid reinforced systems, riprap, and/or gabion systems. This method provides the benefits of bioengineered vegetative systems with the more predictable benefits of non-living structures and measures. The addition of deeply rooting plant material to the stabilization system can lead to longer term stability than is provided by strictly structural solutions. Further, the addition of vegetation provides ecological/habitat value, improves aesthetics, and reduces heat, glare, slope runoff amounts and rates, ice buildup and potential movement of structural elements over time.

To incorporate plants with geogrid systems, the facing of these slopes will require wrapping the slope face with rolled erosion control materials to ensure surface stability during plant establishment. Plants must be sufficiently drought and heat tolerant to withstand the steep slope conditions. In a similar fashion, gabion terraces may be interplanted with seedlings or dormant plant material. A diverse palette of rapidly growing nurse (cool season) grass species mixed with durable native (warm season) grasses and wildflowers species, and rooted and dormant tree, shrub and vine species should be considered for any slope reinforcement site. The solar orientation (slope aspect) should guide the selection of appropriate plant species.

Where placed stone or riprap is used for steep slopes or bridge abutments, loam pockets and tube plantings can provide vegetative cover and wildlife habitat. When planting in pockets, potential dislodgement of plants and soil can be avoided through various preventative measures. Techniques can include tying woody stems to embedded rocks or other structural members and wrapping soil surface with sturdy, biodegradable erosion fabric, as illustrated in Exhibit 13-3.

**Exhibit 13-3
Bioengineering Stabilization with Stone**



Source: MassHighway

13.3.2.7 Bio-engineering and Stream Bank Stabilization

Bioengineering is the combined use of plant material and various natural and manufactured structural materials to stabilize, restore and/or reconstruct slopes, stream banks and shorelines. Because bioengineering seeks to mimic natural slope stabilization processes, rocks, boulders, logs, and dead brush may be used in combination with plantings. Existing soils may be enhanced with placed topsoil, marsh base and/or compost or leaf mulch. Biodegradable fabric is frequently used to hold soil in place prior to installation of plants. The term bioengineering covers a broad range of stabilization techniques, and therefore, allows for more site-specific treatment than strictly structural/conventional solutions. In some instances, bioengineering can provide more long-term stability than conventional solutions than structures alone.

As plants establish, the slopes become increasingly stabilized. However, there are some factors which must be considered:

- Bio-engineering depends on the performance of living material, which is difficult to predict, particularly during the initial establishment stage.
- Availability of water for irrigation, particularly in upland sites, may be limited.

- Bio-engineering tends to be labor-intensive, requiring hand placement of numerous plant stems at regular intervals.
- Some methods of bio-engineering require planting of dormant cuttings, which can only be implemented during certain seasons (usually very early spring).
- Proper stream bank repair requires an understanding of the specific stream type and stage of morphology.
- Bioengineering for stream stabilization is generally limited to bank slopes of 2:1 or flatter and has varying effectiveness depending on the morphology of the stream.
- Because they are constructed of living material, bioengineered systems must be monitored and maintained for at least a year or more following installation to ensure proper establishment of desired plant material and the control of invasive plant species.

Specifications on stream bank stabilization in the vicinity of bridge abutments and other critical slopes is provided by FHWA Highway Engineering Circular 23 (*HEC 23 Bridge Scour and Stream Countermeasures*).

13.3.2.8 Storm Water Management Facilities

Consistent with the goal of preservation, roadside design should pursue storm water management strategies that minimize the disturbance of existing vegetation and encourage vegetated filtration areas. However, standards for water quality may still require the construction of “Best Management Practices” in the form of filtration channels, detention/retention basins, and other storm water management practices. The *MassHighway Storm Water Handbook* provides guidance for the evaluation of storm water management demands and appropriate designs for roadway projects.

While constructed basins and channels improve filtration of runoff, they frequently become a dominant part of the highway terrain and substantially shape the roadside landscape. Basins should be designed to minimize disturbance to existing vegetation and topography, with a natural curvature that blends into the surrounding context. Planting can help integrate basins into the landscape. Configure basins to allow for appropriate screening and buffering of adjacent areas, particularly in residential locations. Avoid locating woody plants where sediment will accumulate, or on constructed retaining berms where planting may

compromise the structure. Design should anticipate access for maintenance including sediment removal. Woody plants are not recommended in the basin area or on constructed embankments holding water.

13.3.2.9 Wetland Replacement

Thorough guidelines for wetland replacement are beyond the scope of this Guidebook. There is substantial guidance within the regulatory literature as to the performance objectives of wetland replacement. Basic guidelines include:

- Proposed replacement areas must fulfill the intent of replacing lost resources and functions.
- In addition to typical wetland requirements for adequate hydrology and proper soils, replacement areas in highway environments must be designed to anticipate additional environmental stresses and pressures from invasive plants associated with the roadside environment.
- Soils need to be evaluated as to potential seed content, including invasive plants. New soils should be manufactured from seed free components.
- Selected plant material must be self-sustaining and tolerant of salt and wind. Plant material may need to be planted in greater quantities and smaller sizes to compensate for transplant conditions.
- Plant selection should be based on a survey of existing material, should seek to restore native plant communities, and should not include any invasive or potentially invasive species.
- Grading, plant selection, and location must integrate and blend with upland conditions and existing hydrologic conditions.
- Wetlands are very susceptible to invasive species. Replacement projects must be inspected and managed after planting to ensure plant establishment and to control invasive material.

13.3.3 Noise Walls

Noise walls are installed where traffic noise exceeds or is expected to exceed established threshold levels. The introduction of these structures along the roadway can substantially depreciate the visual quality of the roadway corridor and become a mixed blessing to abutting land uses. Noise walls can particularly exacerbate the climatic stresses on roadside plants since the flat surfaces can substantially

increase reflected solar gain, desiccating winds, and snow throw and salt spray accumulation. Design considerations for noise walls include:

- Provide noise walls only where they are needed, and consider terrain and abutting land uses.
- Typically, noise wall location is dependent on optimizing sound attenuation while minimizing wall height and construction cost.
- Where other factors do not prevail, wall should be sited such that it blends into the terrain and with existing vegetation.
- As setback from the highway increases, the opportunity for providing a sustainable planted roadside buffer also increases. Walls may also be constructed so as to weave through existing vegetation. Walls with more vegetation on the highway side are less susceptible to graffiti, however, the large scale of sound walls presents an imposing structure near residential areas.
- Walls within 20 feet of the traveled way will be limited to hardy vines and groundcovers on the roadway side.

13.3.3.1 Wall Design Aesthetics

Sound attenuation specifications control the materials, proportion and geometry of sound walls. Materials and installation costs further limit the alternatives available for the design. Aesthetic treatment lies in mitigating the effects of the large surface area, as described below.

- Architectural design that emphasizes and articulates posts can break up the surface of the wall and provide the appearance of a more decorative wall.
- Modular construction that breaks the surface into smaller units can relieve the monotony of continuous wall surfaces
- Using natural materials or simulated natural materials provides visual relief. The natural appearance and the layered pattern of the lumber makes wood an attractive option.
- Composite masonry units can be molded into a variety of forms that mimic stone masonry walls. However, where the reveal of the “grout” lines is shallow, shadow lines can disappear and the visual effect is lost to views from the road.

13.3.4 Bridges

Chapter 10 provides an overview of bridge design considerations. This section pertains to plant material around bridges and interchanges. Whether bridged interchanges are in predominantly natural or urban settings, the grade separation typically creates slope areas that benefit from landscaping. However, access to these areas can be limited, making maintenance difficult.

13.3.4.1 Interchanges

- Where bridges occur over roadways, plantings can blend the mass of the bridge into its environment. Plants also serve as ornamental features that enhance the interchange. In general, plant material should be selected and located to enhance the architectural lines of the bridge, rather than to screen the bridge.
- Locate plant material so that branches and stems do not obscure sight distances to and from ramps. Depending on interchange geometry, bridge abutments may govern available sight distances.
- Plant locations should allow access for periodic bridge inspection.
- Locate shade trees to avoid branch encroachment over bridge deck and locate plant material away from walls to allow for snow storage.
- Avoid over-planting or filling interchanges with trees and shrubs. These areas are frequently used as future construction staging areas and may be used for storm water storage.
- Planting hedges in interchange open space (outside of sight line and clear zone limits) can provide screening of headlights and reduce snow drifting.
- Planting materials should be diverse and massed to complement the design of the interchange. An irregular grouping of trees and shrubs with open spaces for wildflowers and grasses allows views and creates a more diverse and dynamic landscape.

13.3.4.2 Waterways

Where bridges carry traffic over waterways, landscaping may also be used to blend the bridge into the natural context and to restore adjacent areas used for temporary bridges and staging areas. Where existing patterns dictate, wildlife passages may be warranted, and surface treatment and landscape materials should integrate these passages with existing pathways, as described in Chapter 14.

Slope stabilization, including protection against scour, should be installed to look as natural as possible. This can be achieved by tapering armored stone aprons from bridge abutments out toward the bank so that they blend into the existing stream bank, rather than constructing abrupt edges that are perpendicular to the contour of the bank. Bio-stabilization techniques can further blend the armored surface with the natural riverbank form and habitat.

13.3.5 Traffic Barriers

As described earlier, traffic barriers are often used in steep slope conditions. They are also used in many other roadway settings to separate high-speed traffic flows and to shield other hazards. Barriers are described in more detail in Chapter 5 and options are available to increase the compatibility between the visual appearance of traffic barriers and the qualities of the setting. The designer needs to select a barrier system that meets the necessary safety requirements, can be obtained within the project budget, and can be effectively maintained. For additional information on aesthetic barrier treatments, the designer should refer to the 2002 AASHTO *Roadside Design Guide* and FHWA's *Flexibility in Highway Design*.

13.4 Plant Material Selection

Selecting the appropriate species is an essential part of creating a successful roadside landscape. Plants should be selected based not only on how they will thrive in that particular site, but also on how they may interact with and impact surrounding ecological systems. Good plant selection will create sustainable plant communities and transition areas, benefiting human and ecological systems. Poor selection can lead to plant failure which can result in soil loss, compromised highway structures, and the encroachment of invasive species, causing long-term negative impacts to surrounding as well as distant ecological systems.

13.4.1 General Plant Material Selection Guidelines

General guidance for species selection includes:

- **Hardiness** - Plants should be hardy to the region in which they will be planted. Roadsides have extremes of microclimates: south facing slopes get full sun and heat, north facing slopes are cool and shaded, areas close to the road have high wind conditions and salt spray. In urban environments, asphalt, building masses,

automobiles, and reflective surfaces generate radiant heat, creating a microclimate hotter and drier than the general climate.

- **Existing Plant Species and Communities** - Surrounding vegetation should be assessed to determine what species are doing well in the site's general soil and climate conditions. Determine whether there are invasive species in the surrounding area that may out-compete new plantings. Surrounding vegetation can also be used as a clue to pH and moisture levels when selecting new species.
- **Soil Quality** - Soil should be evaluated for texture, pH, moisture and soil biology. Most soils close to the road are infertile, dry, compacted, and contain salt and other pollutants. New soils brought in after construction have better soil quality in terms of texture and density, but they tend to lack necessary soil organisms. The designer should select plant species appropriate to anticipated conditions.
- **Diversity of Species** - A diverse selection of plants, including native species that are already existing in the landscape should be used. Mixing different sizes and types of plants (i.e., shrubs, evergreens, deciduous trees, and groundcovers) helps create an interactive plant community. While the diversity opportunities are much more limited on streetscapes than in naturalized areas, diversity of species remains important. There are many benefits to choosing a variety of species, including pest or disease resistance within the population. Choosing cultivars that are more tolerant of drought and more resistant to pests and diseases is also important.
- **Plant Sizes and Densities** - Plant sizes (in age) should be relatively small. Quantities and spacing (particularly for reforestation type plantings) should be close due to the stresses and mortality during establishment. Varying ages prevents all trees from maturing and having to be replaced at the same time, thus maintaining general canopy cover at all times. Where conditions permit, smaller species can be planted between or in front/back of larger shade trees. The following general species selection considerations apply:
 - ❑ Do not use invasive and potentially invasive species.
 - ❑ Use native species, particularly in ecologically sensitive areas, when possible.

- ❑ Choose trees that are low maintenance (no spraying, pruning, fruit litter).
- ❑ Choose trees that are tolerant of specific site conditions (narrow spaces, overhead wires, salt, compacted soil, low soil volume, pollution).

13.4.1.1 Native Species

Native species are defined as species that occur in a region as result of natural forces rather than as having been brought in by humans, either intentionally or accidentally. A species may be native to a large area, such as North America, or may be native only to a small area, such as Cape Cod. The plant's native range, or region, is typically associated with environmental factors such as climate, soils, and topography. When choosing native species, it is recommended to choose plants as locally "native" as possible.

In an effort to restore native plant communities and retain native wildlife, planting of native species is recommended. The 1994 *Executive Memorandum on Environmentally Beneficial Landscaping* directs federally funded projects, to the extent practical, to use regionally native plants for landscaping and to minimize adverse effects on natural habitats, including reducing the use of fertilizer and pesticide.

In addition to environmental benefits, native species reflect the region's ecological characteristics. For instance, sugar maples or New England Asters along a New England roadside give a sense of place and identity to the roadway or streetscape. In general, native species are better adapted to the native climate and soils of a region. However, roadsides and other developed or exposed areas may not have typically "native" conditions. Therefore, species should be chosen with regard to the specific site conditions.

Special attention should be paid to sensitive areas and efforts should be made to plant native species in ecologically sensitive areas along waterways, wetlands, and areas noted for rare and endangered species.

Less common native species may not be available at the nurseries. Some native plants are not commonly used and therefore not readily available. When specifying native plants for a project, choose species

and sizes that are available to avoid substitutions with non-native species at planting time.

13.4.1.2 Invasive Non-Native Species

Exotic or non-native species are those that have been introduced into a region by humans. Many early introductions came from European settlers who brought plants with them for human and animal consumption, for medicine, to make products, and for ornamental use. Some non-native species were accidental introductions, arriving with ships, in packaging, or with cattle. Many new weed species continue to enter the United States as seed contaminants.

Executive Order 13112 on Invasive Species requires Federal agencies to the extent practical to prevent the introduction of invasive species, respond to and control populations in a cost-effective and environmentally sound manner, to monitor invasive species populations, and to restore native species and habitat conditions in ecosystems that have been invaded.

Invasive species are common along roadsides because they survive and thrive in harsh climates and poor soils. Traffic, construction, and roadside vegetation management, including mowing, also contribute to the spread of these species along the roadway corridor. Invasive species have not only spread along the roadways, but have also spread into minimally managed environments and are displacing native species. Managing invasive species for roadside visibility, safety and general maintenance has proven expensive and difficult. While no longer planting these species will not eliminate them from the environment, it may help to contain the population. See Exhibit 13-4 for list of invasive species.

No invasive species should be planted. The most commonly planted invasive species that should no longer be used include: Burning Bush (*Euonymus alatus*), Barberry (*Berberis thunbergii*), and Norway Maple (*Acer platanoides*). Cultivars of these species have been found to revert back to the species and should not be used. Existing vegetation should be identified and measures taken to prevent the spread of invasive plants during and after construction.

13.4.1.3 Potentially Invasive Plants

Plants that have been found to be potentially invasive should be avoided, particularly in sensitive areas such as near waterways. In

particular, species that spread by seed should be avoided as highway traffic, wind, and maintenance activities provide means for seeds to travel. Also, many roadways are along rivers and waterways, allowing for further spread of these species.

Exhibit 13-4 Selective List of Invasive or Potentially Invasive Ornamental Plants

Invasive Species (Do Not Use)

<i>Acer platanoides</i>	Norway maple
<i>Acer pseudoplatanus</i>	Sycamore maple
<i>Ailanthus altissima</i>	Tree of heaven
<i>Berberis thunbergii</i>	Japanese barberry
<i>Celastrus orbiculatus</i>	Oriental bittersweet; Asian or Asiatic bittersweet
<i>Elaeagnus umbellata</i>	Autumn olive
<i>Euonymus alatus</i>	Winged euonymus, burning bush
<i>Frangula alnus</i>	European buckthorn, glossy buckthorn
<i>Hesperis matronalis</i>	Dame's rocket
<i>Iris pseudacorus</i>	Yellow iris
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lonicera x bella [morrowii x tatarica]</i>	Bell's honeysuckle
<i>Lythrum salicaria</i>	Purple loosestrife
<i>Phalaris arundinacea</i>	Reed canary-grass
<i>Phragmites australis</i>	Common reed
<i>Rhamnus cathartica</i>	Common buckthorn
<i>Robinia pseudoacacia</i>	Black locust
<i>Rosa multiflora</i>	Multiflora rose

Likely Invasive (Do Not Use)

<i>Berberis vulgaris</i>	Common barberry; European barberry
<i>Euphorbia cyparissias</i>	Cypress spurge
<i>Ligustrum obtusifolium</i>	Border privet
<i>Lonicera tatarica</i>	Tatarian honeysuckle
<i>Miscanthus sacchariflorus</i>	Plume grass; Amur silvergrass

Potentially Invasive (Avoid)

<i>Lonicera maackii</i>	Amur honeysuckle
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Source: "The Evaluation of Non-Native Plant Species for Invasiveness in Massachusetts," Massachusetts Invasive Plant Advisory Group, 2005

13.4.2 Plant Selection for Streetscapes

Vegetation and individual street trees play an important role along streetscape corridors. They enhance the ecological environment, which in turn enhances the environment for the community by improving microclimate, air quality and aesthetics. While more sparsely located, street trees and shrubs should also be considered as part of a larger system in that they function as links for animals migrating or seeking food within a larger habitat corridor.

As discussed in Section 13.3.1, streetscape environments are complicated by having multiple users, utilities, intersections, sidewalk accessibility requirements, and limited planting areas. Microclimate conditions on streetscapes are often harsh due to heat radiation from light reflected from buildings, windy conditions, or heavy shade from buildings. Soil conditions are generally poor. Soil volume in tree pits may be inadequate for healthy growth of most tree species and existing soil compaction or potential soil compaction due to pedestrian traffic are typically problems. Urban activities also create limitations: car doors opening, bus/truck clearance, and sign and safety visibility requirements. Overhead wires, utility poles, hydrants, mailboxes, and light fixtures further restrict the types of trees that can be used.

13.4.2.1 Recommended Species for Urban Conditions

General species guidelines for urban areas include:

- Use a variety of species, rather than just one or two species.
- Columnar cultivars should be considered for narrow areas.
- Trees that reach mature heights of 25 to 30 feet are better for areas where there are overhead utilities. The small upper branches of these trees may be pruned, but the heavy limbs, capable of breaking wires, remain well below the wires.
- Where soil conditions and overhead clearances allow, larger shade trees that can be limbed up may be preferable to smaller trees.
- Avoid species and cultivars that drop fruit or have excessive leaf litter, species that require frequent pruning or irrigation, and species with thorns.

Specific species recommended for streetscape environments are presented in Exhibit 13-5.

Exhibit 13-5 Suggested Street Trees

Botanical Name	Common Name	Cultivars	Size	Characteristics
Large Trees (mature size more than 40')				
<i>Acer rubrum</i>	Red Maple	'Red Sunset', 'Armstrong', 'Bowhall', 'Columnare'	40-75'	Does not tolerate heavily polluted areas, dry soils. Prefers acid soils.
<i>Celtis occidentalis</i>	Common Hackberry		40-60'	Wind tolerant, salt and drought resistant. Subject to pests and disease.
<i>Fraxinus pennsylvanica</i>	Green Ash	'Marshall's Seedless', 'Summit'	50-60'	Tolerant of heat, cold, wet and dry soils. Subject to borers and scale. Select male cultivars.
<i>Ginkgo biloba</i>	Ginkgo	'Autumn Gold', 'Princeton Sentry'	50-80'	Tolerates extremes of soil, heat and pollution. Choose male clones only.
<i>Gleditsia triacanthos var. inermis</i>	Thornless Honeylocust	'Skyline', 'Shademaster'	30-70'	Very adaptable to soils and tolerant of salt, drought, and soil compaction. Over-used. Subject to pests and disease.
<i>Platanus x acerifolia</i>	London Planetree	'Bloodgood', 'Columbia', 'Liberty', 'Yarwood'	70-100'	Tolerates wide range of soils. Select anthracnose resistant cultivars. Best where has large space.
<i>Quercus palustris</i>	Pin Oak	'Crownright', 'Sovereign'	60-70'	Fairly tolerant of city conditions. Intolerant of high pH soils. May need to be limbed up.
<i>Quercus robur</i>	English Oak	'Fastigiata'	40-50'	'Fastigiata' is good for restricted areas, but red and pin oak are better choices where space allows. Mildew can be a problem.
<i>Quercus rubra</i>	Northern Red Oak		60-80'	Tolerates range of soils, withstands pollution. Intolerant of high pH.
<i>Tilia cordata</i>	Littleleaf Linden	'Corinthian', 'Glenleven', 'Greenspire'	60-70'	Tolerates pollution and pruning. Susceptible to salt, as well as aphids and Japanese beetle.
<i>Ulmus americana</i>	American Elm	'Princeton', 'Valley Forge', 'New Harmony'	60-80'	Withstands extremes of soil conditions, salt tolerant. Subject to pests and decay. Select Dutch elm resistant cultivars.
<i>Ulmus parvifolia</i>	Chinese Elm	'Allee', 'Athena', 'Milliken'	40-50'	Adaptable to wide range of soil, tolerant of urban conditions. Resistant to Dutch elm disease, elm leaf beetle and Japanese beetle.
<i>Ulmus sp.</i>	Elm hybrids	'Frontier', 'Regal', 'Homestead'	40-50'	Tolerant of urban conditions. Select resistant cultivars. Susceptible to elm leaf beetle.
<i>Zelkova serrata</i>	Japanese Zelkova	'Green Vase'	50-80'	Tolerant of soils, wind, drought, pollution. Good resistance to Dutch elm disease, elm leaf and Japanese beetle.

Source: MassHighway

Exhibit 13-5 (Continued)
Suggested Street Trees

Botanical Name	Common Name	Cultivars	Size	Characteristics
Medium Trees (mature size approximately 30-40')				
<i>Acer campestre</i>	Hedge Maple		25-35'	Very adaptable, tolerant of dry soils, soil compaction and air pollution. Withstands severe pruning.
<i>Koeleruteria paniculata</i>	Golden Raintree	'Fastigiata'	30-40'	Tolerant of heat, drought, wind, compacted soils, and air pollution. Possibly weak
<i>Pyrus calleryana</i>	Callery Pear	'Aristocrat', 'Chanticleer'	30-35'	Adaptable to soils, tolerates dryness and pollution. Overplanted. Use only disease/pest resistant cultivars, narrow cultivars for restricted space.
Small Trees (mature size less than 30')				
<i>Acer ginnala</i>	Amur Maple		15-20'	Adaptable to wide range soils, tolerant of wind and drought. Select single stem. May need to be limbed up.
<i>Amelanchier sp.</i>	Serviceberry	'Autumn Sunset', 'Cumulus'	15-25'	Adaptable to soil, not pollution tolerant. Subject to insects and diseases. Select resistant cultivars and single stem.
<i>Malus sp.</i>	Crabapple	'Donald Wyman', 'Cardinal', 'Prairifire', 'Snowdrift', 'Zumi'	15-30'	Tolerant of drought, salt, air pollution. Wide variety of sizes and shapes. Select disease/pest resistant cultivar. Fruit litter. Low branching.
<i>Syringa reticulata</i>	Japanese Tree Lilac	'Ivory Silk', 'Regent', 'Summer Snow'	25-30'	Adaptable to difficult sites. Resistant to mildew, borers and scale.
*List is not a comprehensive urban tree list. Trees in list may not be appropriate for all conditions.				

Source: MassHighway

13.4.3 Plant Selection for Natural Sites

Generally, natural sites involve larger expanses of land, more extensive vegetation and associated wildlife, and significant water bodies. There is a wider range of species that can be selected for these areas, however, plants located close to the roadway must be able to tolerate climate conditions of exposure, high winds, salt spray, and full sun. Unless new soil has been brought in, soils close to the road are typically infertile, very dry or fluctuating between wet and dry, and often contain salt and other contaminants. Typical of naturalized roadside environments, there is little maintenance either to get plants established or to ensure their survival once established. The following functions and restoration goals should be considered when choosing plant species:

- **Erosion Control** - Deep-rooted species, such as warm season grasses and perennials are recommended for erosion control. They hold soil in place, can absorb run-off, and help water infiltrate the soil. Quick growing species are good for immediate erosion control.
- **Water Protection** - Using plants to benefit hydrologic systems is important to protect water bodies, wetlands, and aquifers. Deep-rooted species in particular, including native grasses and perennials, help water infiltrate through the soil and absorb excess nutrients.
- **Habitat Restoration** - All plants provide habitat. However, different species offer different kinds of habitat. Shrubs offer different forms of cover and food than trees, and evergreens offer different habitat environments than deciduous plants as well as providing winter cover. Consider a variety of types of plants (trees, shrubs, groundcovers) to provide a range of food and cover throughout the year. Planting native species helps support habitat for native wildlife. Edge conditions, such as where forest meets open areas, provide cover and a protective buffer from the road. When restoring roadway edge conditions it is important to consider species in terms of horizontal layering and vertical layering. This means choosing plants that fill all layers: trees which provide food, shade, and viewing posts; understory trees and shrubs which provide food and cover for small animals; grasses and perennials which provide food and cover for insects, birds and small animals; and groundcovers which protect creatures that move along the earth surface.
- **Pioneer Plants** - The roadside conditions after construction may be significantly disturbed and altered such that native species or species established in the surrounding environment will not thrive in the newly constructed roadside environment. In such cases, imitating typical succession patterns by using a mix of the surrounding species with fast growing, pioneer species that thrive in infertile soils - such as cherries, poplars, sumac, birches, and silver maples - helps create a forest type microclimate. These pioneer species grow fast, providing shade and cover for those species that are more difficult to get established.

13.4.3.1 Cultivating Grasses and Wildflower Meadows

Natural sites along the road offer an ideal opportunity for cultivating wildflowers. Clear zones within the roadside right-of-way must be maintained as grassland, ensuring the long-term establishment of grasses and perennials. Reducing mowing and incorporating more native grasses and wildflowers provides more food and shelter along these corridors than the traditional, continually mowed areas.

Wildflowers and grasses not only benefit insects and wildlife, but they create a more visually interesting and attractive roadside throughout the seasons, helping to alleviate driver fatigue. Wildflowers, either perennial or annual, can also be used to accentuate certain areas and to mark gateways. There are basically two strategies for cultivating wildflowers along the roadside: reducing areas that are mowed and by seeding. Both methods require reducing mowing to a once-a-year mowing schedule. This is important not only so that the blooms can be enjoyed throughout the seasons, but also to allow the wildflowers and grasses to set seed for the following year.

Benefits of cultivating grass and wildflower meadows include:

- Mowing less will also reduce air pollution and mowing expenses.
- Flowers and seeds provide a greater source of food attracting insects and birds.
- The diversity of herbaceous species will likely increase due to a reduction in mowing. This in turn may encourage greater diversity of wildlife.
- The reduced mowing cycle will encourage the growth and dispersal of New England natives such as goldenrods, asters and milkweeds, all of which provide an important food source for native wildlife.
- Taller herbaceous material provides better cover for birds and small mammals that nest and move along the highway corridors. Mowing later in the season allows many species of grassland birds and mammals to nest and to successfully raise their young.

Seeding Native Grasses and Perennials

Roadsides are an excellent place to begin re-vegetating by seeding perennials and native warm-season grasses. Highly disturbed areas or areas with new soil provide an ideal site for establishment since there is less competition from weeds and cool season grasses. It is also

easier to control what competition there is until the warm season grasses are established.

Native warm season grasses tend to be more aesthetically attractive than cool season grasses because, unlike the cool season species whose flower stalks topple in summer, the stems and seed heads of these later-flowering grasses persist well into winter, maintaining their ornamental appeal.

Perennials and native grasses have several benefits over annuals and cool season grasses, but are more difficult to get established. Unlike annuals and cool season grasses, which usually spread by rhizomes, native perennials and warm season grasses tend to grow very deep root systems, sometimes down to 12 feet deep. However, in order to establish the initial root system, they partition more energy to the roots, resulting in slow aboveground growth of perhaps only 2-3 inches after the first season. It is because of this deep root system that once established, perennials and warm season grasses are longer lasting and more drought tolerant. The deep roots also provide additional benefits such as:

- Erosion Prevention—the deep fibrous root systems hold the soil.
- Improved water quality—deep roots absorb more water than sod and help to prevent runoff, which might result in less fertilizers and pollutants ending up in the water supply.
- Improve soils—the greater root bio-mass provides increased organic matter in soils and more rapid infiltration rates.

Due to establishment of extensive root systems, perennials and warm season grasses can take three to five years before they flower. Native and perennial species should not be chosen if the goal of the seeding project is quick cover and/or quick color.

In order to prepare the site to eliminate competition from existing species or seeds in the soil, a site will need to be sprayed with herbicide or repeatedly tilled to eliminate as many weeds and dormant seeds as possible. Soils generally do not need to be amended and no fertilizers are necessary.

Seeding Annual Wildflowers

Annuals typically have a very showy display in year one and maybe year two, but generally need to be reseeded in order to maintain such a display. Annuals are best used as a short-term means of accentuating “gateways” and other highly visible locations. They can also be incorporated with perennials in order to get blooms in the first and second years, before perennials typically bloom.

Restoration by Reduced Mowing

Medians and roadside areas should be mowed according to clear zone and sight line requirements and to maintain a neat and cared-for look. As part of a program to reduce mowing costs and to create beneficial aesthetic and ecological changes along the roadways, expansive open areas and areas where sight distance is not a concern can be designated for no mowing at all. In these areas, native trees and shrubs should be allowed to establish and over time, through succession, reforest that area.

13.5 Plant Protection and Preservation

During initial project development, existing vegetation should be assessed as to whether it should be preserved and if so, what steps should be taken to protect it. All vegetation should be assessed, not only trees. For instance, a dense stand of native grass not only serves a highly important function in terms of habitat and erosion control, but such a stand takes considerable time to become established, and therefore should be protected. Vegetation should be considered as to how it fits into the larger landscape and larger ecosystem: groups of trees or vegetation are often important parts of a larger forest or vegetated corridor.

Not all vegetation should be preserved. In some cases, the vegetation is not desirable: it may be overly mature, diseased, damaged or may be an invasive species. In such cases, the vegetation should be removed and replaced.

13.5.1 Trees

Trees are the most noticeable vegetation along roadways, particularly in the urban/suburban streetscape environment, and their removal usually has the biggest impact—both ecologically and visually. In assessing whether a tree should be preserved or removed, it is

important to understand the basic structure of trees and how they function, as illustrated in Exhibit 13-6.

Roots

Trees get their water, oxygen, and most mineral nutrients through their root systems. Roots are therefore absolutely critical to the health of the tree. Roots also anchor the tree, preventing it from toppling. Most of tree preservation should focus on protecting the roots of the tree.

Tree roots typically grow along the top 18 inches of soil and extend well beyond the canopy of the tree. They tend to grow along the surface of the soil because that is where they have access to oxygen and water.

In order for oxygen and water to penetrate the soil and for roots to be able to grow and obtain oxygen, water and nutrients, the soil must have good structure. Good soil structure is characterized by the amount and size of pore spaces created by soil particles and organic matter. These pore spaces allow water, air and microbes to penetrate and move through the soil. Vehicular traffic, pedestrian traffic, tillage (especially when wet) and the storage of heavy equipment will ruin the soil structure, compacting the pore spaces and damaging tree roots. Most trees will die in compacted soil because they cannot get the oxygen, water and nutrients required for survival.

Trunk/Stem

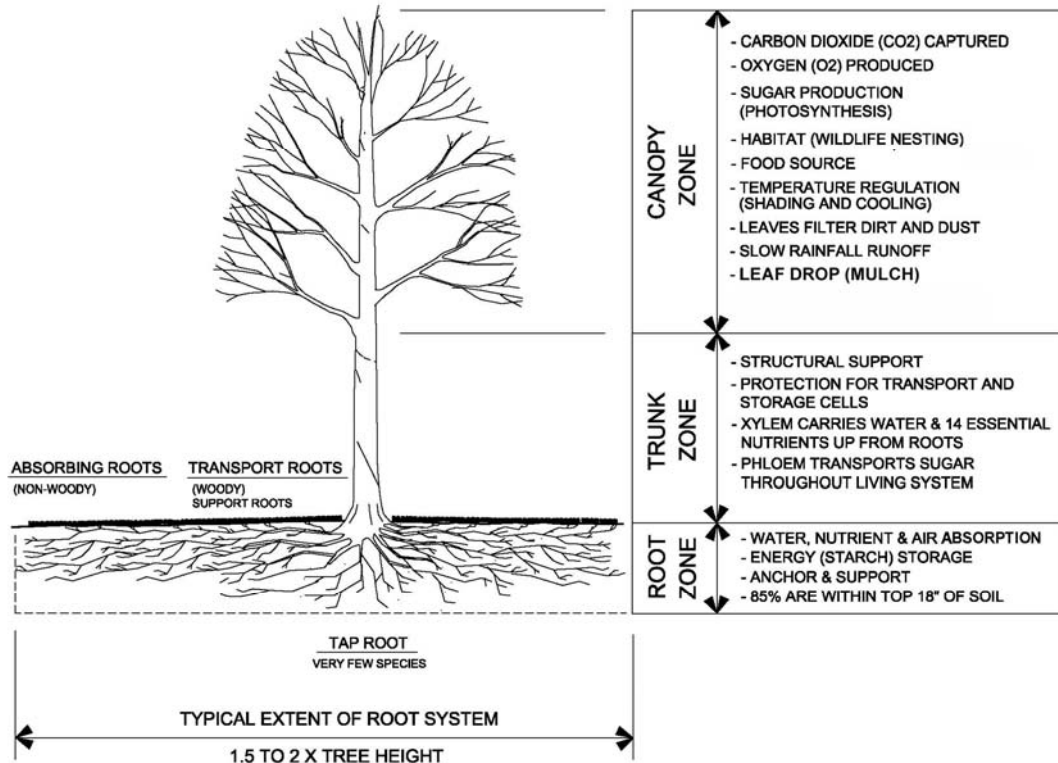
The trunk of a tree serves two functions: it provides the means of transporting mineral nutrients, sugars and water between the roots and the canopy of the tree, and provides the structural support to hold the tree. The bark of the trunk protects the transport and storage cells. Protecting the bark and the trunk is important for protecting the means of transporting nutrients and water so that the tree can grow and survive. Wounds to the bark, the trunk, or major stems that do not close properly can cause decay.

Canopy and Branches

The tree canopy, through the process of photosynthesis, converts, water, CO₂ and nutrients into energy to support the growth of the tree. Significant damage to the canopy can compromise this conversion process. Substantial loss of limbs, either through damage, pests, or

poor pruning practices, can also leave the tree prone to decay and failure.

Exhibit 13-6
Tree Structure and Functions



Source: MassHighway

13.5.2 Evaluation of Construction and Project Impacts

Construction impacts should be evaluated as to how they will affect the long-term health of the surrounding vegetation, particularly with regard to trees as they have the most extensive root systems. The following construction impacts should be avoided:

- **Changes in grade** - As little as 2 inches of soil placed on top of the root zone can smother roots by preventing the flow of water and oxygen into the soil. Removing soil may damage and expose root systems.

- **Damage to a significant portion of the root system** - If more than one-third of roots will be removed or otherwise significantly impacted, the tree should be considered for removal.
- **Soil compaction** - Vehicle and excessive foot traffic, as well as equipment or materials storage, will destroy soil by compacting it and closing soil pore spaces. This prevents water and air from moving through the soil, destroying roots and vital soil microbes. Protective measures should be taken to protect soil during construction. Storing equipment or material over root zone areas can cause moisture or aeration deprivation.
- **Damage close to tree trunk** - Removal or damage to the large roots close to the base of the trunk will have a significant impact on the tree. Damage to the trunk will interfere with the flow of nutrients and leave the tree susceptible to disease and decay.
- **Improper or excessive pruning** - Loss of too much tree canopy will interfere with photosynthesis and nutrient uptake, weakening the tree. Excessive loss of canopy also reduces the visual quality of trees and lessens its value in terms of providing shade and screening.
- **Excavation outside of tree root zones that alters subsurface water availability** - Changes to the surrounding area may cause changes in moisture levels creating conditions that no longer are appropriate to the existing tree species.
- **Increased exposure from unavoidable clearing** - Trees in a forested area typically have small canopies (low live crown ratio) and few lower limbs (i.e., pines). Once surrounding vegetation is removed, they may become structurally unsound. Such trees are also not aesthetically appealing.

13.5.3 Assessing Vegetation for Preservation

Accurate site information is essential in determining which plants, particularly trees, can be preserved and which will require removal. Project planners and designers should take measures to anticipate impacts from both construction activities and the project itself by visiting the site during the early stages of planning. Survey information is helpful in providing plant locations, but it does not replace a site visit. For instance, survey information often does not show the diameter of the tree trunk and therefore does not necessarily show the extent of impact the tree will suffer from changes in sidewalk

or street re-alignment. Survey information also does not relay information about the health, age or structure of the tree.

During the project planning process, designers should identify on plans trees that might be affected and determine whether to protect or remove and replace existing vegetation. Trees and other vegetation should be evaluated for preservation in terms of the following considerations:

- **Species characteristics** - All species have characteristics that allow them to adjust to change or tolerate damage to different degrees. Some species are much more tolerant of disturbance and tolerate a much wider range of conditions. Some species are short lived and are not worth putting extra effort into preserving. Consideration should be taken as to:
 - ❑ life span
 - ❑ how well the species adapts to disturbance
 - ❑ resistance to decay and compaction
 - ❑ tendency to fail when exposed to wind
 - ❑ habitat value
 - ❑ invasiveness
 - ❑ historic or cultural value
- **Size** - The larger the plant size, the larger the area of root zone requiring protection.
- **Age** - Older plants may be less tolerant of construction impacts and will require larger protection zones.
- **Overall health of tree or community of plants** - Healthy plants will withstand removal of more roots, provided there are no stabilization problems. Plants that are diseased, damaged, or have pests should be considered for removal and be replaced.
- **Structure of plant** - Plants that show signs of decay or potential for decay, have been improperly pruned, or street trees that are poor specimens should be considered for removal.
- **Live crown ratio** - This is the ratio of the length of the live crown to the height of the tree. Trees with live crown ratio greater than 50 percent are the best candidates for preservation. Tall trees with

small crowns are structurally unstable. Many forest trees have low live crown ratios due to closer proximity of other trees. Forest pine trees in particular, have low live crown ratios.

- **Crown integrity.** Crown should have healthy foliage, which typically signifies a healthy tree.
- **Pruning history (cut leaders, topped).** Improperly pruned trees are susceptible to decay.

13.5.4 Plants Requiring Removal

In some cases there may be instances where tree or plant removal may be desirable, such as:

- When plants are weed species or invasive, as described in Section 13.4.1.2.
- When trees are structurally unsound, show signs of decay, have small crowns, and/or have small root systems.
- When plants are diseased or pest ridden since they will be more susceptible to failure under stress.
- When construction impacts are too significant for species to survive, or species has low tolerance of impacts.

13.5.5 Determining Tree Protection Zone

If it is desirable to retain a tree, there are several guidelines to determine the tree protection zone that will be required. These limits will indicate boundaries for permanent protection measures, such as walls, as well as temporary construction measures, such as fencing. Trees should be protected to the edge of tree canopy, or 1.5 times the drip line for narrow-canopied trees. Using trunk diameter is another method that may be more appropriate: for every inch of trunk diameter at 4.5 feet above grade, allow 1 to 1.5 feet of space from the trunk. This method is not dependent on the tree canopy, which may be small or irregular and not reflect the root zone area. In general, a minimum of 6 feet should be protected around a tree regardless of its diameter.

Other factors (determined as part of the plant evaluation) should also be considered. For instance, older trees may be more likely to die due to root loss and should have a larger root zone protection area. Some species are more likely to fail due to root loss and these should also

have larger root zone protection area. In general, to determine tree protection zone:

- Evaluate species tolerance of the tree: good, moderate, or poor.
- Identify tree age: young, mature, or over-mature.
- Estimate distance from trunk that should be protected based on canopy size or trunk diameter.

13.5.6 Design Measures to Preserve & Protect Trees

If a tree is to be preserved, design measures should focus on preventing injury to trees, particularly to the root zones, during construction and after construction. Design strategies include:

- Shifting sidewalk or roadway geometry or reducing cross section to avoid the tree.
- Narrowing sidewalk to minimum accessibility thresholds in immediate vicinity of existing trees.
- Adjusting the profile (up to accessibility constraints) such as raising the sidewalk to existing grade rather than excavating to construct the walk.
- Using retaining walls and/or steepened slopes to minimize cuts or fills over existing root systems. For example, one can steepen the grade as it gets closer to the tree root zone area. Not only does this reduce the impact to the tree, but will also reduce the amount of cutting or filling in that area and reduce associated costs.

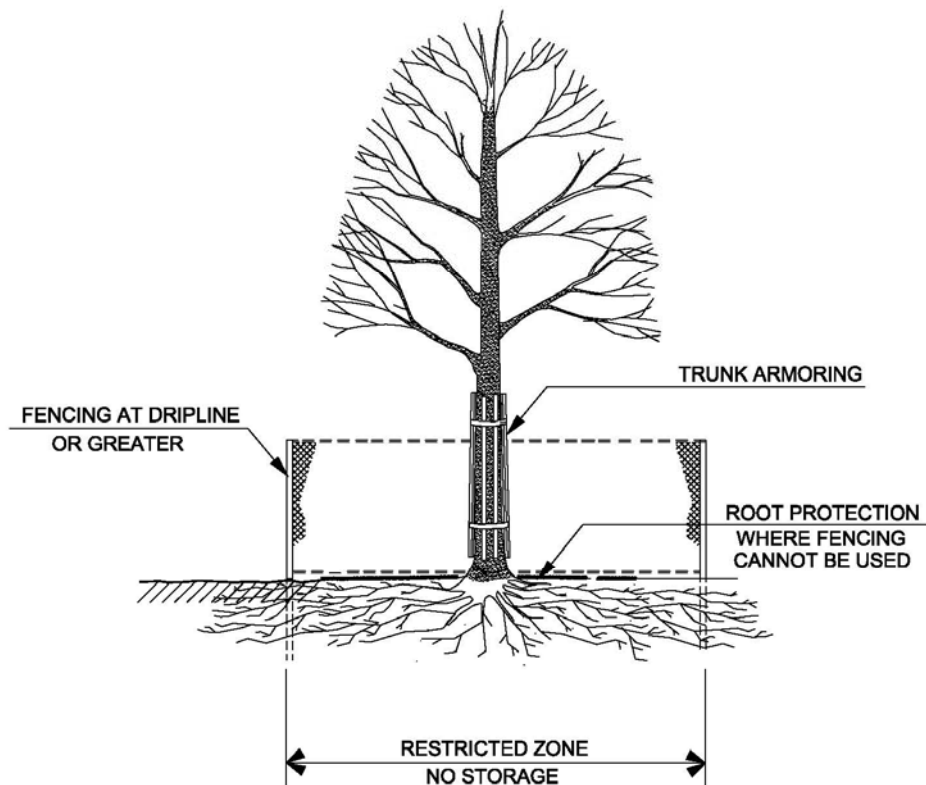
13.5.7 Construction Measures to Preserve & Protect Trees

Protecting plants is an important part of construction staging and operations. The following measures can be employed to protect plants during construction, as illustrated in Exhibit 13-7:

- Fencing should protect as much of the root zone area as possible. Fencing should enclose the entire root area of the plant or groups of plants to the edge of canopy. No activities should be allowed within this zone including no vehicular or foot traffic and no storing of machinery or supplies.
- Pruning of broken branches or roots by a certified arborist.
- Irrigation of disturbed roots.

- Avoiding staging areas around trees and protect tree roots close to staging area.
- Providing trunk armoring along with fencing if construction comes close to tree trunk.
- Mulching root zones to keep soil moist and protect roots.
- Providing wood chips where storage or foot traffic cannot be avoided: A layer of 4 to 12 inches of wood chip mulch can help prevent compaction of soil in the root zone.
- Bridging the root zone area when it cannot be fenced off. Plywood or steel plates supported by railroad ties or on top of wood chip mulch to cover the root zone area can be used so that the weight of a vehicle or equipment is distributed over the sheeting, not the ground.

Exhibit 13-7 Tree Protection



Source: MassHighway

13.6 Plans and Documentation

Documentation of projects is essential and additional information on project planning and design is provided in Chapters 2 and 18. Not all of the documentation recommended below is required for all projects. The type of project, its complexity, and the extent of change to the landscape will determine the extent of documentation.

From the standpoint of landscape and context analysis, photographic documentation is the most useful, simplest, and least expensive form of documentation. In addition to publicly-available orthographic aerials, digital photography has made the cost of collecting and distributing images negligible.

A further benefit of digital photography is the ability to readily edit and illustrate, in either elaborately rendered or simple diagrammatic form, the type and extent of changes for a given proposal.

13.6.1.1 Preliminary Development

The following are recommended design considerations during project planning and at the preliminary design stage:

- Aerial orthophotos.
- A comprehensive site photo documentation set.
- Large or complex projects should be superimposed on corresponding aerial orthophoto.
- Additional diagrammatic information may be included on aerial photograph to annotate graphic data for better understanding of context.

13.6.1.2 25 Percent Submittals

The following activities should be completed in preparation for the 25 Percent submittal:

- Early environmental coordination.
- Overlay of project on environmental layers.
- Digital site photo documentation.
- Narrative of site changes and estimated impacts.
- Photo documentation of existing structures (i.e., bridges).

- For Design Public Hearings, plan superimposed on aerial orthophoto, including approximate limit of impacts, such as grading.
- For complex or controversial projects, visual simulation showing changes.
- For projects where landscape is integral to the purpose or is substantially affected, a narrative of impacts and proposals.
- For streetscape/enhancement projects, approximate locations and type of landscape materials, including preliminary species list.

13.6.1.3 75 and 100 Percent Submittal

The following activities should be completed in preparation for the 75 and 100 Percent submittals:

- Construction drawings showing location and specific species of plants and other features.
- Tree protection shown on construction plans. Landscape plans shall show locations with symbol tags of proposed plants.
- Include a Summary plant list with botanical and common names, plant sizes and item numbers. Include a Comments column indicating, (as required) height to lowest branch, cultivation (container size, b&b, bare root, cutting, etc.), or other information.
- All planting sheets shall include key showing symbols and names of plants on that sheet.
- Where different types of seeding are used for different areas, call out non-typical locations on construction plans, landscape plans, or area detail, as appropriate.
- Estimate of landscape materials including quantities and sizes.
- Special provisions as required.
- Plans and CAD files as described in Chapter 18.

13.7 For Further Information

- AASHTO. 2004. *A Policy on Geometric Design of Highways and Streets: 2004*. Washington, D.C.: American Association of State Highway and Transportation Officials.
- AASHTO. 1990. *A Guide for Highway Landscape and Environmental Design*. Washington, D.C.: American Association of State Highway and Transportation Officials.
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- NRCS. 1992. National Engineering Field Handbook, Chapter 13, *Wetland Restoration, Enhancement, or Creation*; Chapter 16, *Streambank and Shoreline Protection*; Chapter 18, *Soil Bioengineering for Upland Slope and Protection and Erosion Reduction*. Washington, DC: USDA Soil Conservation Service.
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- Bassuk, Nina L. and Trowbridge, Peter J. 2004. *Trees in the Urban Landscape: Site Assessment, Design, and Installation*. New York: John Wiley and Sons, Inc.
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- www.nps.gov/plants/alien
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