URBAN FORESTRY

Trees and Construction

USING THIS MANUAL

The Urban Forestry Manual has been developed by the Southern Group of State Foresters and the USDA Forest Service, Southern Region as an educational manual for the employees of State forestry agencies. This manual provides the scientific, technical, and practical information needed to work with communities on urban forestry. Each of the 16 units (listed below) addresses a specific topic in the practice of urban forestry. These units have been developed as a series, each building upon the information in previous ones. The units may also be used individually to gain information about a specific topic.

Trees and Construction is an introduction to the relationship between construction activities and trees. It explains the importance of getting involved during the construction process. The focus is on the impact of construction activities on trees and the protection of trees before, during, and after construction.

Benefits and Costs of the Urban Forest

State Forestry Agency's Role in Urban Forestry

Tree Biology

Dendrology

Urban Soils

Site and Tree Selection

Tree Planting

Tree Maintenance

Tree Diagnosis and Treatment

Trees and Construction

Hazard Trees

Urban Wildlife

Urban Ecosystems

Urban Forestry Planning and Management

Urban Forestry and Public Policy

Working with the Public

USING THIS UNIT

The Urban Forestry Manual consists of 16 units to provide you with the technical and practical information that will be useful for your work. Each unit is organized as follows:

Table of contents
Lists major topics that are included in the unit.

Unit overview
Presents goals and objectives for the unit.

Before You Begin
Consider how your current activities and experiences relate to this topic.

Content
Presents specific material about this subject under several headings.

Next?
Think about how you can use the information in your daily responsibilities and in developing your career in forestry.

For More Information
Lists other sources of information about this subject as well as the literature cited in the unit.

Appendix
Some units have an appendix that may include checklists and other information.

In addition, each unit has two sections that will help you assess your learning of the information:

Checking Your Understanding
At the end of major sections in the unit there are short-answer questions about the information you have read. After you have written the answers, you may compare your responses to the answers provided at the end of the unit.

Case Study
These are stories based on the real experiences. The questions at the end of the case study challenge you to use the information you learned to solve a problem similar to what you will be facing when working. You will be asked to analyze an actual urban forestry problem and offer your solutions. There are no right or wrong answers -- only what you decide is the best course of action after considering all the information.

TREES AND CONSTRUCTION

Table of Contents

Trees and Construction

Overview

Land development and construction are having a major impact on the urban forest. Key to minimizing this impact is to work with developers, local government, and citizens to plan for tree protection, maintenance, and replacement during these activities. This unit first discusses how important it is to get involved in the land-development process. Then it reviews how construction activities damage trees. Methods of protecting trees before, during, and after construction are then discussed, with emphasis on tree-protection techniques. The last section discusses how site plans can be used as a tool for tree protection.

A "Beech" House In the Piedmont

Good Intentions

Here was a perfect setting for an apartment complex, and the developer knew the trees on the land would be an asset. In particular he liked the old American beech tree near the center of the property, and he decided to nestle an apartment building next to it. Decks were built around the tree, giving the apartments a "beech" outside their back doors. But the developer didn't realize the double whammy he was facing -- an old tree is more sensitive to changes and the American beech is even more sensitive than most species. His best intentions were not enough to keep the beech alive. Deterioration began early in the construction and each action just added one more "nail in the coffin." First, the tree was side-pruned to make room for the apartments, and roots were cut on one side when the foundation was excavated. Construction equipment was parked under the shade tree, compacting the soil on its "good" side and an irrigation system was installed. For a tree that liked moist, but well-drained soil, this beech was now getting a daily dip from the sprinkler system. Six weeks after construction was finished the beech died. The tree, because of its location within the apartment complex, had to be removed piece by piece; a costly procedure. The apartment may have come to the beech, but the beech couldn't survive its new neighbors.

We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.

Aldo Leopold, Sand County Almanac

Before You Begin

This unit addresses ways you can help others understand the relation between trees and construction. Before you begin reading, take a few minutes to think about some of the current construction practices that affect trees in your community.

- What types of construction practices have you observed that impact trees?

- Have you driven through a community and seen land cleared of all the trees and other vegetation for a construction project? What were the effects of this on the surrounding land? Have you seen just the opposite, where trees were protected on the construction site?

- Have you or someone in your office tried to explain to a homeowner that the tree in their yard is dying because the roots were damaged when the home was built 3 - 5 years ago? What was their reaction?

Using this page, note how you think this information about trees and construction will assist you in your job.

Getting Involved

Getting involved in the land-development or construction process is essential to protecting and maintaining an urban forest. Protecting trees on the site should be considered and discussed throughout the land development or construction project – from the early design stages through completion. Getting involved in the beginning, during the design phase, usually allows more options for tree protection. To help you get involved and provide assistance, this unit will focus on these three areas:

- How construction activities impact trees
- Protecting trees before, during, and after construction
- Site plans – how they can be used as a tool

Opportunities for providing assistance

Many construction professionals, such as developers, engineers, architects, and road- building crews, may not be aware of how their actions can damage and kill trees**.** And natural resource professionals are not always aware of the concerns and issues of those in the construction profession. Understanding these different perspectives and issues associated with protecting trees on construction sites is important to successful tree protection. There are many ways to provide assistance related to trees and construction (table 1).

Table 1. Examples of ways to provide assistance, and potential recipients

Technical/Educational	Planning	Community
• Trees most suitable to save, remove, or transplant • Tree response to construction damage • Hazard trees • Site and tree selection • Tree diagnosis and treatment • Tree protection techniques • Incorporate natural resources into land development • Minimize impact to trees • Workshops and publications	• Construction plans • Land development plans • Government ordinances and regulations • Reviewing site plans • Ecological impact from site changes	• Developers • Builders • Engineers • Architects • Landscape architects • Contractors • Other sub-contractors • Homeowners • Neighborhood associations • Road building crews • Garden Clubs • Chamber of Commerce

How Construction Activities Impact Trees

Knowing how construction activities impact trees is critical to understanding tree protection, recommending tree-protection techniques, and communicating with people involved in the construction process. This section will begin by briefly describing how trees can be damaged above and below ground, as well as symptoms and signs of construction damage. However, the main focus of this section is on the different types of construction activities and how they affect trees.

Important point icon: Construction activities can impact established trees on a site, as well as trees planted after construction.

Above-ground and below-ground damage

Trees can be damaged both above and below ground by construction activities. The above-ground damage, such as bark wounds, is usually visible. Below-ground damage to the soil and root system is not always visible, and therefore is often overlooked or undetected.

Construction activities can impact trees in various ways:

Important point icon: Construction activities typically cause more damage below ground than above ground.

- Trunk and crown damage
  Construction vehicles and activities often cause trunk and crown damage, such as split trunks, broken limbs, stripped bark, and burned branches and leaves. Wounds to the trunk and branches become entrance points for insects and disease.
- Direct root damage
  Roots can be damaged both directly and indirectly. Direct root damage includes
  tearing, stripping, crushing, severing, and exposing roots. Trees that suffer direct root damage may lose their ability to absorb and transport water and mineral nutrients and can be prone to windthrow and insects and disease**.** Examples of construction activities that frequently cause direct root damage include clearing, grading, paving, and trenching for utilities.
- Indirect root damage
  Indirect root damage refers to changes in soil conditions that affect the roots. Indirect root damage often occurs when the normal exchange of gases in the soil atmosphere is interrupted resulting in a deficit of soil oxygen and increases in toxic levels of carbon dioxide and other gases. Other causes of indirect root damage include soil compaction, changes in soil moisture conditions and drainage patterns, soil contamination, changes in soil fertility and pH, sedimentation, and deposition of soil fill material. Construction activities that may cause indirect root damage are grading, vehicle parking and traffic, storage of materials, chemical leaking, and carelessly located concrete washouts.

Interesting point icon: Most tree roots are within the top 18 inches of soil and extend well beyond the spread of the tree canopy.

- Changes in exposure
  When trees are removed from a construction site, the remaining trees (which are either standing alone or on the outside edge of a stand) will likely have increased exposure to direct light and wind. Trees that receive more direct light for long periods may have sun-scorched leaves or wilt from dehydration. These trees are also more susceptible to broken limbs and wind throw.

Photo 1: Construction site showing damage to trees.

For More Information Icon: For more information on how to minimize the impact of these construction activities, refer to the "Tree Protection Techniques" section later in this unit.

Symptoms and signs of construction damage

Symptoms and signs of construction damage may not be noticeable for several years. Insects, diseases, and other causes are often blamed for the death of a tree, even though construction damage initially started the decline. How trees react to construction damage depends upon species, age, health, extent of damage, season, and site factors. The first visible symptom of construction damage usually occurs in the leaves, although each part of the tree eventually shows symptoms and signs of damage (table 2).

Action Icon: Find out how species in your community react to construction damage.

Table 2. Symptoms and signs of construction damage

Tree part	Symptoms and signs of damage
Crown	Slow rate of growth, staghorns, or dieback
Leaves	Wilted, scorched, sparse, undersized, distorted, chlorotic, browning leaf margins, premature autumn color, or premature leaf drop
Trunk	Wounds, bark removed, crown rot, absence of buttress flares, adventitious sprouting , suckering, and severe insect damage and disease
Branches	Dieback, slow growth rate, wounds, adventitious sprouting, or suckering
Fruits and flowers	Abnormally large crop or absence of fruit, flowering out of season

Different types of construction activities

The construction activities described in this section include:

- Clearing
- Grading
- Trenching
- Vehicles, pedestrians and materials
- Paved areas
- Concrete washouts
- Leaks and spills
- Bury pits and fires

Clearing

Site clearing is the removal of all unwanted trees and vegetation from the construction site. Because tree roots spread extensively, clearing with heavy equipment, such as a bulldozer, usually tears the roots of the remaining trees. The heavy machinery used to clear sites can crush roots and compact the soil. Trees being removed from the site may also fall and break branches or damage the trunks of the remaining trees. The remaining trees will also be more exposed to light and wind.

Removing vegetation from a site can change drainage patterns. Higher rates and volume of water runoff can cause soil erosion and sedimentation. The soil erosion that may result can undermine the roots of the remaining trees. And the sediment from the erosion, which is usually fine soil particles, can cause anaerobic soil conditions. Sediment can also affect water quality in nearby rivers, streams, and lakes.

Photo 2: Site clearing and grading.

Grading

Grading generally refers to moving soil. When soil is removed it is called "cutting" and when soil is added it is called "filling." Grading can alter the natural shape of the land, which may change the drainage pattern. The water table may also be lowered or raised by grading. Vehicles used for grading, such as graders, bulldozers, and backhoes, can compact the soil and injure the trunk and break branches of trees.

Interesting point icon: The redirection of runoff water toward constructed drainage ditches, drainage pipes, or impoundments can change soil moisture conditions.

Lowering the grade (cutting)

Often lowering the grade begins with removing topsoil, which may be stockpiled for later use or trucked to another site. Rough grading and excavation follow, and fine grading is done near project completion to improve site drainage and provide top dressing for landscaping. Direct root damage will most likely occur when soil is being removed from a site, such as leveling a piece of land for a building or excavating for a foundation. Removing topsoil can completely eliminate absorption roots and reduce soil fertility. Leaf litter is also often removed before installing formal landscaping. Lowering the grade can also inhibit nutrient cycling.

For more information: Refer to the "Tree Biology" unit for more information on roots.

Raising the grade (filling)

Raising the grade at a site can be permanent or temporary. When the grade or site elevation is raised permanently, such as a graded slope or behind a retaining wall, it is referred to as "permanent fill." When soil is stock-piled or stored for later hauling or use, it is called "temporary fill." Often temporary fill is stored around or near trees because it is convenient. Fill material can smother tree roots by limiting the normal exchange of gases between the soil and the atmosphere. The fill material may be of questionable quality depending on where it came from.

Fill material can be soil from the construction site or it can be trucked in from other locations.

Photo 3: Avoid placing permanent or temporary fill material around trees.

Trenching

Trenching is digging a ditch for the installation or maintenance of underground utilities such as gas, electric, water, sewer, and irrigation. A trench may also be dug for installing a silt fence (fencing material used to limit soil erosion). In housing developments, main utilities are generally placed beneath the roads, while service utilities to the home are located along the shortest and most direct path from the main utility to the home. Most damage to tree roots occurs during the installation and maintenance of service utilities. Root damage from trenching is not unique to newly developed areas, but also occurs in more established communities as a result of maintenance or the installation of utilities, such as fiber-optic line. Trenching can tear, crush, and sever roots. This not only reduces the water and nutrients a tree is able to absorb, but also decreases the tree's stability in high winds or wet soils.

Interesting point icon: A ditch as little as 2 inches deep in heavy clay soils can damage roots.

Photo 4: Trenching

Vehicles, Pedestrians, and Materials

Many construction sites have compacted soils because of the weight of heavy construction machinery, stored construction material, or repeated vehicle and pedestrian traffic. Compaction can also result from vibration caused by large grading equipment and pile drivers. Compaction can crush and tear fine roots, reducing the ability to absorb necessary water and nutrients. It can also cause indirect root damage by reducing soil pore space, which then diminishes the ability of the soil to absorb water and reduces the natural exchange of gases. Any mechanical equipment can also gouge the trunk or break branches.

For more information icon: Refer to the "Urban Soil" unit for more information on soil compaction.

Photo 5: Avoid storing construction equipment and materials under trees.

Paved Areas

Installing and maintaining paved areas, such as roads, parking lots, sidewalks, and curbs, can cause both above-ground and below-ground damage to a tree. Examples of how the construction of paved areas can injure trees include:

- Roots can be severed as soil is excavated for the paved area.
- Roots can be crushed when the soil is intentionally compacted under the areas to be paved.
- Roots can be killed if herbicides are used on the paving area.
- Soil moisture conditions can change if drainage patterns are altered, such as redirection of water flow and change in volume and rate of runoff.
- Soil pH may change due to concrete debris left in the soil.
- Soil temperature can be increased by reflected heat from pavement.

Concrete Washouts

Soil pH can dramatically change in locations where concrete contractors wash their concrete chutes after making deliveries. Mortar and cement, which are calcium based and therefore alkaline, raise the soil pH. A high soil pH can cause chemical reactions with nutrients in the soil, rendering some nutrients unavailable to the tree.

Leaks and Spills

Fuel, grease, paint, and other chemicals may leak or spill from storage tanks on the construction site. Field offices and trailers for subcontractors, such as painters, are often placed near or under trees. Spills of any toxic chemicals that kill the tree roots are fatal to the trees. Soil pH can also change because of leaks and spills.

Bury Pits and Fires

On some sites, construction debris, such as tarpaper, drywall, and paint cans, is buried. This debris may contain toxic materials that change the soil structure or alter pH. Also, if burn holes or debris fires are located too close to trees, flames and heat from the debris fire can scorch the trunks, leaves, or roots or even consume the tree in flames.

Checking Your Understanding of How Construction Activities Impact Trees

On a separate sheet of paper, list or write as short answers the important points you need to remember for each of these questions:

1. How can trees be damaged by construction activities? List the most likely causes for the each type of damage.

2. What problems may result from root damage?

3. Describe how clearing, paved areas, and concrete washout areas impact trees?

Answers are on page _____ at the end of the unit.

Protecting Trees Before, During, and After Construction

The most successful way to protect trees before, during, and after construction is through prevention. This can often be done by getting involved at the beginning of the construction project and providing on-site protection for the trees. This section addresses five subjects important to protecting trees on a construction site:

- Key players and their roles
- Land development process
- Site and tree evaluation

- Site plans
- Tree protection techniques

Key Players and Their Roles

Some of the key players involved in construction activities include the property owners, developers, general contractors and sub-contractors, architects, engineers, surveyors, landscape architects, natural resource professionals, local government, and the community. One of the best ways get involved is to talk with these people. Communication can be challenging due to the number of different people and professions involved in the construction process and the terminology used by the different professions. Find out what challenges they face related to working with trees and the natural landscape. Also talk with them about how construction activities impact trees. They may even be interested in a presentation, workshop, or field trip.

Important Point Icon: To have a successful project, tree preservation has to be a goal shared by everyone.

Property owner

The role of the property owner varies depending upon why he/she owns the property. For example, the property owner may be a couple building their first home or it may be a corporation building a large office complex. Typically, the property owner has the ultimate authority to determine what construction activities occur on the site.

Developer

The developer may be the property owner or his/her representative. The term "developer" usually refers to the person or business that has a financial investment in the property and whose primary goal is often to ensure that the project is a financial success. The developer may invest in the construction of large projects, such as shopping malls, or, if it is a small project, such as one home, the developer may be referred to as the builder. The developer will typically hire consultants, such as engineers and landscape architects, to develop construction site plans (drawings that show the layout of a proposed project) for the project and to facilitate getting permits from the local government. The developer may oversee all construction activities at the site or he/she may hire a general contractor or other consultants to oversee construction. Although many developers realize that trees add value and beauty to the property, the cost of protecting and preserving trees is often their immediate concern.

Interesting point icon: Inclucing tree protection clauses in construction contracts is one way to increase the level of awareness and compliance.

General contractor and sub-contractors

A general contractor coordinates the construction activities, such as land clearing, erosion and sediment control, grading, paving, utility installation, framing, landscaping, parking lot striping, fence installation, concrete installation, and painting. The general contractor is typically concerned about getting the project completed on time and within budget. General contractors hire and supervise "sub-contractors" that specialize in specific areas of work, such as

painters and electricians. Sub-contractors report and get paid by the general contractor. The general contractor is usually responsible for any communication with the sub-contractors.

Architects

Architects design buildings guided by what the property owner or client desires, as well as by local government standards and building codes. Architects may be concerned about how the tree will affect the building, such as view, sun and shade, or design.

Engineers – civil and structural

Civil engineers design roads, sidewalks, utilities (water, sanitary sewers, and storm sewers), and retaining walls. They are usually concerned about storm-water management, soil erosion, roadways and intersections, site distances (clear views for seeing traffic, traffic signs and pedestrians), grading and drainage, and steepness of slope. Civil engineers can also prepare preliminary plats (simple drawings of property boundary or outline) for industrial, commercial, and residential subdivisions, as well as overall site plans for various types of developments. Structural engineers design retaining walls, bridges, structural framing plans, and foundations for buildings and large utility poles and signs.

Surveyors

Surveyors are responsible for title, deed, and easement research, boundary surveys, topographic surveys, and construction-phase staking and layout services. Surveyors can also design and prepare preliminary plats for industrial, commercial, and residential subdivisions.

Landscape architects

Landscape architects plan the entire arrangement of a site, including the location of buildings, plazas, streets, parking lots, open spaces, grading, storm drainage, utilities, storm-water management areas, natural/undisturbed areas, and buffers. They may design many of the same features as engineers. The landscape architect often develops the project's site plans, in cooperation with the other design and engineering professionals. A landscape architect usually develops landscaping and tree protection plans.

For more information icon: Refer to the section on "Site Plans" later in this unit for more information on landscaping and tree protection plans.

Natural resource professionals

Natural resource professionals, such as soil scientists, arborists, wetland ecologists, biologists, archeologists, urban foresters, and timber management experts, can be involved in the construction process. They may consult on issues related to the natural resources on the site, such as site conditions, tree health, wetland delineations or mitigation, threatened and endangered species, and historical or cultural artifacts. Soil scientists are the most commonly utilized natural resource professional. They conduct soil surveys for septic system planning and design; many are also qualified to delineate wetland areas. Soil surveys and wetland delineation are usually required by local, state, and federal regulations.

Local government

The local government often has a role in the construction process. This role varies, depending upon the community, because each local government has their own regulations for land development and construction. To work effectively with local government, find out the following information.

- How the local government regulates land development and construction activities by contacting the administration, planning, building inspection, public works, public utilities, or other departments. What is the land-development or construction process that the local government requires a property owner or developer to follow? How does the process for construction activities differ between private property and public property? Refer to the following section on *Land Development Process* for more information.
- What role does each local government department, such as planning, public works, and public utilities, play in construction activities that impact trees?
- What permits, such as a land-disturbance permit, does the local government require?
- What local ordinances regulate activities that effect trees? Get copies of the ordinances and become familiar with the terminology and the regulations.

FMI Icon: Refer to the "Public Policy and Urban Forestry" unit for more information on local government and the land development process

Community

The community plays a key role in the development of a project. What are the community's needs and what is its reaction to the project? Communicating with community residents can help anticipate reaction to a project and also help create a positive public image for all those involved in the development.

Interesting point icon: Trees can be a "hot button" item for communities.

Land Development Process

The land development process is different in every community – drastically different in some communities. The best way to become familiar with this process is to get involved and talk with the key players, especially the property owner/developer and those in the local government. The local government typically has mandated a process that ensures compliance with local, State and federal regulations. Even though the process is different in every community, two steps common to the land development process are 1) project team is formed and develops construction documents, and 2) construction documents reviewed for by local government.

Action icon: Identify where there are opportunities are for getting involved in the construction process.

Project team is formed and develops construction documents

The property owner and/or developer assemble the project team, usually consisting of the property owner, developer, general contractor, architects, engineers, surveyors, landscape architects, and natural resource professionals. When the project purpose and scope are identified, the project team starts gathering site data, conducting site analysis, and developing preliminary design alternatives. From those alternatives the property owner/developer selects a final design. Based on this final design, the site master plans and other construction

documents are developed. When the project team completes the required formal applications for permits and construction documents, they are submitted to the local government for review.

If the project is going to require rezoning (changing the land-use classification of the property), variances (an appeal to change existing zoning requirements), or other modifications to local ordinances, the project team may have to go through other processes, such as the rezoning process, to obtain approval from the local government. Refer to the *Urban Forestry and Public Policy* unit for more information on the rezoning process.

Construction documents reviewed by local government

The formal applications for permits and site plans are reviewed by the appropriate local government departments, such as planning, public utilities, public works, transportation, building and inspections, fire, and engineering. The local government may require permits for land-development activities include building/construction, grading, sewer and water, soil erosion and sedimentation, land disturbance, and certificate of occupancy. During the review process, the local government looks for a variety of factors, such as compliance with local, State, and federal regulations, as well as impact on soils, drainage, topography, wetlands, capacity of public facilities, stormwater runoff and adjacent properties. Sometimes State government, such as the department of transportation or division of natural resources, and the federal government, such as Corp of Engineers, are also involved in the review. After the review process, the local government either approves or sends the application back for revision. This part of the process, revision, generally involves negotiation and compromise between the developer and local government. When approved, the local government will issue permits, as appropriate, and make site visits during construction and a final inspection to assure compliance to the approved plans and local codes and standards.

Interesting fact icon: A land disturbance permit may authorize clearing, dredging, grading, excavating, transporting, and filling, as well as overall site development.

Site and Tree Evaluation

The primary purpose of the site and tree evaluation is to identify trees at the construction site to save, remove, and/or transplant. Ideally this should be done at the very beginning of the project, when the project team is gathering site data, conducting site analysis and developing design alternatives. Look for opportunities to incorporate existing natural resources on the site into the design of the project. However, if site plans or construction drawings have already been developed, use the information from the site and tree evaluation to determine how construction activities will affect trees and look for ways to minimize that impact and modify the construction drawings.

A site and tree evaluation will describe the characteristics of the trees as well as site conditions. With this information it will be easier to select good quality trees that have the best chance of surviving after construction. Because it costs money to protect trees on the construction site, as well as to remove them after

construction, it is important to select trees and design a project that will foster tree survival. Some things to be considered when evaluating the trees and the site include:

Tree age

Large, mature trees afford instant canopy, but young trees are usually more resilient to construction disturbance. For young trees selected to remain, ensure adequate space, both above and below ground, for growth. It is also generally recommended to save trees of various ages.

Tree value

Why are these trees important to this site and what benefits do they provide? Look for trees that have significant value, such as specimen quality, unique characteristics, historic significance, or ecological importance. Sometimes a tree has special sentimental value in a community.

Tree health

Select trees that are growing vigorously, have good structure and form, and no show severe insect or disease problems. Healthy trees have a better chance of surviving construction disturbances than unhealthy ones. If the tree has deadwood, thinning crown, leaning trunk, split trunks, root damage, and/or severe insect or disease problems, it may need to be removed.

Tree species

Different tree species react to construction damage in different ways (Coder 1996a). Look for those species that have the best chance of surviving after construction is completed. Try to save a diversity of species so the site will be more resilient to future insect and disease problems.

Critical root zone

The best way to protect trees on construction sites is to avoid disturbing the roots within the critical root zone. Generally, the critical root zone of a tree extends well beyond the spread of its branches. The critical root zone is a function of tree size, health, and how the species responds to construction damage. For example, the critical root zone of a young, vigorous red maple (tolerant to construction damage) is much smaller than that of an old, declining yellow poplar (low tolerance for construction damage). The size of the critical root zone should be adjusted according to the specific tree and site factors.

Groups of trees

Preserving stands of trees or "tree save" islands is encouraged because groups of trees often tolerate construction disturbance better than individual trees.

Transplanting trees

If a good quality tree needs to be removed because it is located where construction activities are planned, look for opportunities to transplant it to another location on the site. This works best for small trees, less than 10 inches diameter at breast height. Be sure that the appropriate equipment is used to transplant the tree.

Photo X (We have photos of tree spade – if we need it.)

Site conditions

What are the site conditions and how will they change during and after construction? Examples of factors to consider when evaluating the site include:

- Soil characteristics
- Wind and light patterns
- Slopes
- Drainage
- Rivers, creeks, and streams
- Structures and pavement
- Utilities

Site Plans

Site plans, also called construction documents, provide detailed information about existing conditions at the site and proposed plans for the project. These plans are drawings used during the construction process to visually illustrate project design and construction activities scheduled at the site, such as clearing and grading, control of erosion and sedimentation, water management and drainage, location of utilities, traffic engineering, hardscape (such as buildings and roads), and landscape. The site plans should also include information on trees to save, remove, and transplant, as well as location, species, and critical root zones of trees that remain on the site. They are the most important source of information for the major players in the project. Because site plans illustrate the planned changes at the site, they can be used to predict the impact those changes will have on trees and identify ways to prevent or minimize the impact. Things to do while site plans are being developed and reviewed include:

- Design the project to incorporate the existing natural landscape. Identify those natural areas that offer the most environmental and economic benefits to the project design and the site. Also, look for ways to minimize damage to natural features that can be assets to the project, such as using a wetland area as a storm retention pond.
- Determine what construction activities will impact trees and identify ways to minimize these impacts.
- Identify the critical root zone on the site plans to define the limits of disturbance for the tree protection areas. If it appears that some of the construction activities will impose on the critical root zone, suggest ways to modify the site plan. For example, a sidewalk may be moved to protect nearby trees.
- Similarly, modify the design, for example, by moving a parking lot to save a significant group of trees. The costs for the modifications need to be weighed against the value of the trees to be saved.
- Decide if it would be more cost effective to remove and replace a tree rather than saving it.

For more information icon: There is more information on site plans later in this unit.

Tree Protection Techniques

Various techniques can be used to protect trees from construction damage. Some of these techniques can be incorporated into the design while others can be applied on-site. Communicating with the property owner, developer, and general contractor about the significance of protection measures before, during, and after construction can foster acceptance. As mentioned earlier, identify the key players and their roles and look for opportunities to increase awareness and understanding of the relation of trees to construction. Refer to the Appendix for a checklist, *Minimizing Impact of Construction Activities,* which can be copied and used as a quick reference.

The following section discusses some of the common measures used for tree protection:

- Organize site activities
- Minimize land disturbance
- Trench before clearing and grading along limits of disturbance
- Account for underground utilities
- Adapt to pavement
- Install protective tree fencing around the critical root zone
- Mulch in the critical root zone
- Insure quality of fill material
- Prune branches for vehicle clearance
- Maintain trees
- Restore site

Important point icon: The best tree protection technique is prevention.

Organize site activities

Specific areas for construction activities, such as those listed below, should be identified and located outside, and sometimes far away from, the critical root zone. These areas can be identified on the site plans and marked on-site with signs.

- Vehicle and equipment parking areas
- Material storage areas
- Debris burn holes and bury pits
- Temporary offices, such as trailers
- Grease and fuel stations
- Concrete washout areas
- Temporary fill areas
- Chemical disposal

Important point icon: Avoid nailing building permits and other related signage onto the trunks of the trees.

Minimize land disturbance

Look for ways to minimize the amount of land-disturbing activities, such as clearing and grading.

- Leave natural areas and groups of trees

Leaving some of the site as a natural area and saving groups of trees can reduce the amount of clearing and grading.

- Tight grading contours and terracing
  Any grade change, either cut (reduce grade) or fill (increase grade), affects root and tree survival. A rule-of-thumb is that the steeper the grade the less area will be disturbed. Tightening grade contours and terracing are both techniques that can be used to make a slope steeper and decreasing the land that has to be disturbed. An engineer can recommend the best way to make the steepest slope possible while maintaining stability.

Photo 6: Terracing - Comparison illustration/photograph of how more trees were saved with these techniques.

- Retaining walls
  Retaining walls allow for a change in grade without any sloping. They can also be used to maintain a natural grade where a cut or fill is required. Some things to consider about retaining walls include the cost of construction, possible root damage to remaining trees, and potential changes in drainage patterns.

Photo 7: Retaining wall.

Trench before clearing and grading along limits of disturbance

Roots of trees to be protected trees are often fused or tangled with those of other trees that are being cleared from a property. Removal of the latter trees can damage the remaining ones by tearing and breaking these fused roots, jeopardizing the survival of the remaining trees. Cutting a 2-foot deep trench along the edge of the clearing will insure a clean cut of the roots and minimize the damage. Ideally, this trench should be outside the critical root zone of the protected trees. These trenches should be back filled with loose fill material and mulch to encourage new root development for the protected trees.

Account for underground utilities

Trenching for underground utilities (sewer, gas, water, cable, and electrical lines and pipes) may tear and cut roots of trees. Trenching may even be done after the tree protection fences have been removed from the site, cutting the roots of trees being saved. During the design phase of a construction project consider different options for accommodating underground utilities to minimize damage to trees.

- Relocate utility line
  If the utility line or trench is located too close to the critical root zone, recommend that the line be moved farther away.
- Use one trench
  Sometimes several utilities lines can be placed in the same trench rather than digging a separate trench for each utility line. However, this practice may be limited by local code.
- Tunneling
  Instead of trenching for utilities, tunneling beneath tree roots is another option. Tunneling involves using boring equipment to tunnel, bore, or push

pipes and conduit underneath the roots of the tree. Some of this equipment can even bore through solid rock. Tunneling can minimize the impact on the critical root zone.

Photo 8: Tunneling & excavation

- Hand excavation
  In some instances, the value of the tree justifies hand excavation for utility lines. With hand excavation try to dig beneath any root exceeding2inches in diameter. While this method is labor intensive, the value of the tree may warrant it.

Adapt to pavement

Sometimes site plans or site limitations require the installation of pavement near or within the critical root zone of trees. Although this is not recommended, there are several things to consider when attempting:

- Pavement location
  Look for opportunities to re-locate the pavement outside the critical root zone. For example, curve the sidewalk around the tree instead of going straight through the critical root zone.
- Sub-grade compaction
  The soil underneath any pavement needs to be compacted before installing the pavement. Compaction prevents the soil from settling, which may cause the pavement to crack. The amount of soil compaction depends upon the load-bearing requirement of the pavement. For example, a road requires more sub-grade compaction then a sidewalk. If compaction is expected near or within the critical zone of trees, try to use a minimum amount of sub-grade compaction in that area.
- Permeable pavement
  Most paved or poured surfaces are not permeable. However, porous pavement allows the natural exchange of gases, nutrients, and water between the soil and the air and reduces the depth of disturbance. Porous materials available include interlocking blocks, bricks, porous cement and hollow brick pavers filled with soil and planted with grass.
- Soil modifications
  Researchers are currently developing new soil mixes that are load-bearing yet still allow for root penetration below the pavement surface.
- Herbicides
  Sometimes herbicides are used under the pavement to prevent vegetation from growing. Make sure the herbicide is not sprayed near the critical root zone of protected trees.

Install protective tree fencing around the critical root zone

Physical barriers, such as fencing that separates trees from construction activities, can protect trees on sites. Barriers are most useful when they are highly visible, sturdy enough to withstand the natural elements, and have signs to identify the tree protection area. These barriers should be installed outside the

critical root zone. Protective tree fencing can be purchased from forestry and building suppliers and catalogs.

Photograph 9: Trees surrounded by protective tree fencing.

Mulch in the critical root zone

Parking of construction vehicles, contractor traffic, and material storage under trees can be anticipated in wooded areas on construction sites. To minimize soil compaction and root damage from these activities, spread a minimum of four-inch thick layer of wood-chip mulch over the critical root zone. Additional mulching may be warranted in heavy traffic areas. A good source for mulch is the natural debris generated from clearing vegetation from the site. In addition to preventing compaction, mulching conserves moisture, reduces erosion, moderates soil temperature extremes, increases fertility, reduces runoff, and reduces competition from grasses and weeds.

Important point icon: Mulching is one of the most important ways to prepare trees for construction.

Insure quality of fill material

If fill material is going to be stored near the critical root zone and the source of the fill material is unknown, it may be worthwhile to test the fill material for contaminants.

Prune branches for vehicle clearance

Pruning branches can increase the clearance between the trees and any proposed structure or construction equipment, preventing unnecessary damage to branches.

Maintain trees

Several tree maintenance activities can minimize the impact of construction activities.

- Fertilizing

  Fertilizer applications before construction begins can enhance the trees' vigor and ability to withstand stresses. It also helps the trees resist insects and diseases that result from site disturbances. Fertilization after construction can help a tree recover its vigor if it has suffered damage; however, use caution with the amount and timing. For construction-damaged trees, a slow-release organic form of nitrogen fertilizer is recommended because a quick-release fertilizer can create burst of vegetative growth that a damaged root system cannot support. The use of high-pressure, soil-injection fertilizer may be recommended on sites with compacted soils.

For more information icon: Refer to the "Tree Maintenance" unit for details on fertilization applications, methods, and rates.

- Pruning

  Pruning of dead, diseased, or broken branches may be desirable before construction. Avoid pruning live plant tissue from a construction damaged tree because this can accelerate the tree's decline. However, if the roots have been severed, pruning may be recommended to reduce the possibility of windthrow. Pruning deadwood is recommended only when all of the deadwood is evident, which may take from one to several years.

- Watering
  Before, during, and after construction, monitor soil moisture conditions and water as necessary.
- Aerating
  Vertical mulching is recommended for trees in preparation for construction to improve their vigor. Holes, 1 to 2 inches in diameter, may be drilled in the compacted soil and filled with such porous material as sand, perilite, vermiculite, or other material. After construction, compacted soils and areas of fill or sedimentation in the critical root zones of trees should be aerated to allow for exchange of air between the soil and the atmosphere (refer to the *Urban Soils* unit). These practices may help supply adequate oxygen to the soil essential for growth of the tree. However, it is best to prevent soil compaction through project planning and on-site protection.

Restore site

When construction is completed, try to restore natural conditions within the critical root zone of protected trees.

- Remove erosion sedimentation and fill material
- Remove construction and concrete washout debris
- Remove contaminated soil
- Improve site drainage
  Site drainage can be improved by removing minor fill and correcting any interrupted or redirected flow of water.
- Installing landscaping
  It is important to consider pre-existing site conditions when installing final landscaping. For example, trees that were once in natural areas do better with a natural forest ground cover than with turf or other plant materials that may be natural competitors. It is also important to consider how the site's exposure to sunlight may have changed.
- Install irrigation systems with care
  When irrigation systems are installed, the trenching can cut tree roots and kill the trees. This can be avoided during the design phase by locating the irrigation system outside the critical root zones. Also, soil-moisture problems for the trees can be caused by irrigation systems that are timed for the landscaping located beneath the trees, such as turf and flowers.

Site Plans

Site plans are an important tool for tree protection. As mentioned earlier, site plans are drawings that illustrate the design and construction activities for a project. Site plans are drawn to visually communicate the written information that is in the specifications (specifications are written instructions that explain construction activities; they can be a separate document or included in the site plan). A site plan can include information on the existing and proposed features and structures at the construction site. A review of the site plans will reveal

construction activities that can impact trees. Information found on site plans can include:

- Property lines
- Structures
- Roads, parking lots, sidewalks, and other paved areas
- Retaining walls, fencing, light poles, park benches, and other such features
- Topographical features, such as contour lines and drainage swales
- Natural resources, such as bodies of water and trees
- Plant material
- Tree protection areas
- State water buffers
- Grading areas and drainage
- Utility locations
- Recreational areas
- Parking and building setbacks
- Easements and rights-of-way
- Erosion and sedimentation treatment

To maximize tree protection in the planning and development process, you must know how to read a site plan. Refer to the Appendix, *How to Read a Site Plan*, for information on the basic elements of a site plan.

Important point icon: Site plans reflect standards and requirements, such as soil erosion control treatment, that the local government requires for its review and permitting process.

Types of site plans

Different types of site plans are used to illustrate specific parts of a construction project. The types and number of site plans usually depend upon the complexity of the project; complex projects will typically have more than one type of site plan. These plans are all interrelated and they are the primary communication tools used by developers, builders, and subcontractors. Also, the information in site plans sometimes overlaps. Reviewing site plans helps ascertain the impact of construction activity on trees. Site plans can be modified as needed, although changes may increase the cost of the project. The next section briefly describes and illustrates the different types of site plans:

- Master plan
- Base sheet or existing site plan
- Demolition plan
- Layout plan
- Grading and drainage plan
- Erosion and sediment control plan
- Utility plan
- Planting or landscape plan
- Tree protection plan

Interesting point icon: There is no standard method for labeling site plans and there may be different names for the same plans.

Important point icon: Several types of site plans may be combined on one plan sheet, especially for small or less complex projects.

Master Plan

The master plan shows how the site will look when the project is finished (figure 1). (Some of the other common names used to describe the master plan are general site plan, final master plan, final site development plan, illustrative site master plan, and preliminary plat.) Typically, the master plan is on one sheet, showing the overall design of the project. For large or complex projects, the details are drawn on separate site plans for each component, such as the grading and drainage plans. The master plan may show the general location of existing and proposed trees, including their relation to each other and to structures. However, more detailed information from other site plans is needed to protect trees from construction damage.

Interesting point icon: For most subdivision projects, there will be a preliminary plat, which is similar to a master plan in that it shows overall design but also proposed lot lines, easements, setbacks, and roads.

Figure 1. A master plan for a housing development. (Courtesy of Rick Raymond and Associates, P.C.)

Base Sheet or Existing Site Plan

The base sheet or existing site plan includes information on existing features of the site as well as features of the adjacent property that may affect the site (figure 2). This plan usually includes topography, property lines, setback lines, easements, trees, structures, utilities, and drainage. It may also include information on existing trees on the site, such as species, size and condition. This plan can help determine which trees are to be saved or removed.

Figure 2. This is a base sheet or existing site plan that shows the location of trees. (Courtesy of Rick Raymond and Associates, P.C.)

Demolition Plan

The demolition plan shows existing features that are to be removed. Demolition work can endanger trees, especially since heavy equipment is usually involved.

Layout Plan

The layout plan illustrates the existing plus the proposed features of the site, such as property lines, easements, setback lines, structures (size and location), and plant material (figure 3). Layout plans can show the distance between existing and proposed structures and existing trees. This information can help determine if there is a suitable distance between the trees and the structures, and if the trees may be affected during and after construction.

Figure 3. Sometimes the demolition and layout plans are combined into one plan. (Courtesy of Rick Raymond and Associates, P.C.)

Grading and Drainage Plan

The grading and drainage plan shows the existing and proposed grade and drainage changes on the site (figure 4). On the grading plan it is critical to note how the grade changes may impact trees that will be protected. When drainage and grading activities are complicated, there may be a separate plan for each.

Grading and drainage plans furnish important information related to tree protection:

- Grading limits
- Location of retention ponds
- Spot elevations, including all proposed buildings and site improvements
- Direction of water flow
- Grade changes
- Areas and amounts of cuts and fills
- Location of storm drain structures and pipes
- State waters and floodplain

Figure 4. Grading and drainage plan. (Courtesy of Rick Raymond and Associates, P.C.)

Erosion and Sediment Control Plan

The erosion and sediment control plan shows the proposed structural and vegetation treatments that will be used to control and prevent erosion and sedimentation (figure 5). The types of information usually found on these plans, such as notes, construction schedules, soil types, limits of clearing and grading, existing drainage patterns and topography, and proposed grading, are helpful in developing tree protection measures.

Figure 5. Erosion and sediment control plan. (Courtesy of Rick Raymond and Associates, P.C.)

Utility Plan

The utility plan often shows the proposed and existing utilities or service lines, such as water, gas, electric, telephone, cable, sanitary sewer, and storm drainage (figure 6). It should also show the connection of these utilities to the main service lines off the site. The legend on this plan is critical because each utility has its own symbol. The general contractor usually contacts the individual utility owners to arrange the installation of service lines. Location, grouping, and routing of private utility service lines should be pre-planned and coordinated with all utility owners and the site designer before beginning any site work.

The utility plan is useful in identifying which trees may be affected by utility installation and in deciding whether the utility companies need to tunnel under the roots of trees. Utility lines should be located on the tree protection plan or planting plan. There should be a warning note on the plan to contact all utilities before digging or bringing in heavy and/or tall equipment or planting trees.

Figure 6. This utility plan illustrates proposed locations for gas (G), water (W), power (P), and fire hydrant (FH). (Courtesy of Rick Raymond and Associates, P.C.)

Planting or Landscape Plan

The planting or landscape plan shows the existing and proposed plant material (figure 7). It includes a legend or key to the plant list (common and scientific names), size, spacing, mulch, and special instructions, such as plant installation requirements and any special soil amendments. This plan can be a guide to the suitability of the tree species for the site and the proper planting space needed by the trees relate to structures and other trees. It should also provide a maintenance plan for the trees.

Figure 7. Planting or landscape plan. (Courtesy of Rick Raymond and Associates, P.C.)

The planting plan may also include irrigation plan to show the layout and size of the irrigation lines, types of sprinkler heads, back-flow preventers, timing box, and the water and electrical sources. The irrigation plan can also help determine the effect of the system installation on existing trees.

Tree Protection Plan

The tree protection plan should contain all the information necessary to protect the trees on the site (figure 8). This plan can help ensure the survivability of existing trees on a site, reduce future maintenance requirements, and prevent the development of hazard trees. A tree protection plan may include:

- Locations of critical root zones, specimen trees, and stands of trees, as well as tree species, size and health
- Trees to be removed
- Locations of structures, streets, driveways, sidewalks, parking lots, and utilities
- Methods of tree protection (details of tree fencing, signage, erosion control, retaining walls, tunneling for utilities, limits of amount of fill, aeration systems, trenching, transplanting, staking, pruning, fertilizing, and mulching)
- Designated areas with signs for parking, materials storage, concrete washouts, equipment fueling and servicing, debris burn areas, and debris burial holes
- Construction limits of clearing and land disturbance
- Notes detailing specific conditions set in the contract, such as fines for any damage to trees to be saved

Figure 8. Tree protection plan. (Courtesy of Rick Raymond and Associates, P.C.)

Interesting point icon: Some projects will have an As-Built Plan which illustrates how the project was actually built.

Checking Your Understanding of Protecting Trees Before, During, and After Construction

On a separate sheet of paper, list or write as short answers the important points you need to remember for each of these questions.

1. How can site plans be used most effectively to minimize the impact on trees during the construction process?

2. How can grade changing, utility line placements, and paving be planned to minimize the impact on the trees at the site?

4. What are some of the points you think would be helpful to communicate in a discussion with those involved in a local construction project?

Answers are on page _____ at the end of the unit.

Case Study

Planning a Grand Entrance

Jimmy, a forester in the local office, was contacted by two brothers, owners of a development company, who had questions about plans for a subdivision, Three Oaks, they were going to build. They were concerned about the impact the entrance road would have on a stand of trees. Jimmy set a meeting for two weeks before clearing and grading were scheduled to begin.

The master site plan showed a narrow, 12-acre tract, zoned for 1/3-acre lots (figure 9). At the proposed entrance there were five large oaks situated around an old home site. Three of these trees formed a triangle near the entrance while the other two were farther away, closer to the main road. The developers told Jimmy that the two trees closest to the road would be removed because the main road was being widened and a turn lane into the development was being added. The brothers' main interest was to find a way to route the entrance road through the middle of the triangle of trees without damaging them.

The trees they wanted to leave were two southern red oaks about 20 inches in diameter and one water oak about 24 inches in diameter. These trees were mid-size and had good form and sound structure.

Figure 9. Three Oaks Subdivision Master Plan.

In the Planning Triangle

Put yourself in Jimmy's place and think how you would respond to the developers. Can you offer a solution that will satisfy them and help the trees survive? On a separate page, write your answers to the challenge questions below, explaining how you will handle this situation. See how your answers compare with the recommendations that Jimmy actually made in the *Rest of the Story*.

- What options for constructing the road would you offer? Is it possible to construct the entrance and save the trees?
- What type of construction activities might the site plans show that would occur in the entrance area?
- How would you evaluate the trees suitable for preservation?
- If the trees were to remain, what steps would you suggest to avoid direct root damage?
- Are there steps you would suggest to protect the trees before and during construction?
- What should be done after the entrance is completed?

The Rest of the Story

Keeping His Fingers Crossed While Hoping for the Best

Using the site plans that had already been developed, Jimmy gave them a list of actions they could take to insure minimum tree damage from grading the land for the road, placing utility lines, and using construction equipment in the area. He suggested that a loop road around the trees (a single lane in on one side of the triangle and a single lane out on the other side) at least 40 feet away from the base of the trunks would minimize the impact on the trees. He also recommended that they look into using porous pavement for the loop road and he gave them brochures on different types that are available. Changes in some of the site plans, primarily the utility and landscape plans, would need to be made. While the main utility lines could be trenched and laid under the entrance road, this area would need electricity for the sign and security lights. Jimmy suggested that for the short distance from the main power line to the center of the trees it would be preferable to tunnel under the roots of the trees. He also gave them instructions for preparing the trees for construction, including mulching and fertilizing to improve the vitality of the trees. Site restoration was also discussed and it was suggested that leaving the entrance as a natural area would be best for the trees. The developers told Jimmy that because the space for the entrance was so narrow, building the loop road would "cost" them two lots for building homes. Jimmy suggested that perhaps the lots could be rearranged so that only half a lot on each side of the entrance would be "lost". After some more discussion, the meeting ended.

Jimmy did not have any further contact with the developers after that meeting. However, about a year later he happened to be in the area and drove by the subdivision to see how the entrance had been built (figure 10). The triangle of trees appeared to be doing well. The entrance sign for Three Oaks was placed just forward of the trees and a park bench was in the shade in the center of the triangle. While this may seem like a win-win situation for the forester, developers, and homeowners, the planned long-term care of these trees will be the real success story.

Figure 10. Three Oaks Subdivision As-Built Plan

Being Pleasantly Surprised

- Were your suggestions similar to the ones Jimmy made? Were there other options that could be considered?
- If you suggested a different solution, what advantages did it offer?
- If the developers had not been willing to change their minds about building the road through the trees, how would you have responded?
- What could Jimmy have done differently?
- What have you learned from the experience Jimmy had with these developers?

Next?

Trees that have been damaged or died because of construction activities present one of the most common problems found in urban forestry. With the basic information offered in this unit, think about how you will be able to help resolve some of these problems in the future.

- What are some of the specific benefits and costs associated with protecting trees during construction you have observed in your community? How can you use this information in talking with developers, builders, and homeowners in the future?

- How can your knowledge of the construction practices in your community help you to better address the issues concerning urban forestry?

- What are some of the ways you can communicate information about construction activities and the impact on trees to people in your community and help them use it in their planning?

- What other sources of information are available on protecting and caring for trees during construction activities?

For More Information

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Checking Your Answers

Checking Your Answers about How Construction Activities Impact Trees

1. **How can trees be damaged by construction activities? List the most likely causes for the each type of damage.**

- Trunk and crown damage
  While it is often unintentional, careless actions on a construction site may may damage trunks and crowns. These activities can include mechanical equipment hitting the trunk or breaking branches of a tree, using tree trunks as signposts, improper pruning of branches for equipment clearance, and locating burn pits too close to trees.
- Direct root damage
  Roots may be cut, torn, or stripped, when the land is cleared and graded and when trenches are dug for utility lines.
- Indirect root damage
  Some construction activities do not actually touch the roots, but can still cause damage to the root system of a tree. Some causes of indirect root damage include fill material or sedimentation that smothers the roots, concrete washouts and bury bits that change the chemical properties of the soil and changes in drainage patterns that alter soil moisture conditions.
- Exposure
  The trees that remain on a construction site are often exposed to different sunlight and wind patterns than they had been before, particularly if they had been located within a large stand of trees. They may receive more sunlight, causing wilting or sun-scorched leaves and increasing their need for water. They may also be more susceptible to windthrow since they are no longer protection from the wind. Trees that are now on the edge of a tree stand, because nearby trees were removed, may also have root damage.

2. **What problems may result from root damage?**

Root damage can -

- Limit the roots' ability to absorb water and nutrients from the soil and therefore cause slow growth rate or dieback
- Increase the risk of insect and disease damage
- Increase potential for windthrow
- Kill the tree

3. **Describe how clearing, paved areas, and concrete washout areas affect trees?**

- Clearing all unwanted trees and vegetation from the construction site, which is done with heavy equipment, can tear and crush roots, and damage branches and trunks of remaining trees, and compact the soil. Removing of vegetation often increases water runoff, causing soil erosion, sedimentation, and changes in drainage patterns.
- The installation and maintenance of pavement can crush, cut, and kill roots and change soil moisture conditions, pH, and temperature.
- Soil pH can dramatically change where concrete contractors wash their chutes after making deliveries. Cement, which is calcium-based and therefore alkaline, raises the soil pH. A high pH may cause chemical reactions with nutrients in the soil, rendering some soil nutrients unavailable to the trees.

Checking Your Answers about Protecting Trees Before, During, and After Construction

1. How can site plans be used most effectively to minimize the impact on trees during the construction process?

Site plans can be used most effectively before and during construction to plan and provide protection for the trees on a project site. Because they present information on existing conditions and proposed plans for the site, they are an important resource. The different types of site plans offer a variety of information that is helpful in tree protection, such as where clearing and grading will occur and where utilities will be installed. Site plans need to be reviewed and modified, if necessary, to minimize the impact on trees. A tree protection plan is important because it provides all the necessary information for tree protection and removal. Identifying the critical root zone on site plans is one way to define the limits of disturbance.

2. How can grade changing, utility line placements, and paving be planned to minimize the impact on the trees at the site?

- Reducing the amount of grading on the site is one of the best ways to prevent damage to trees. If grading near the critical root zone is necessary, options include using steep, narrow contours, and terracing. Both of these techniques can create a steep but stable slope or grade. Retaining walls may also be used to maintain the natural grade behind the wall, while making the necessary grade changes or cuts in front of it.
- The placement of underground utility lines is subject to several options. These should be explored when a problem is first identified on the site plan and before construction begins. The possibilities include relocating the utility line, placing several utility lines in one trench, tunneling beneath the roots of the tree, and, in cases of valuable trees, digging the trench by hand to lay the utility line.

- The best way to avoid pavement problems is to locate the pavement outside the critical root zone of trees. Other options include changing the area of pavement, using porous paving materials, and using soil modifications under the pavement.

3. What are some of the points you think would be helpful to communicate in a discussion with those involved in a local construction project?

Each construction project is different. The location and features of the land, the type of building project, and the people involved all contribute to the uniqueness of any construction project. Communicating with the people involved in the project is of primary importance. This includes property owners, developers, local government, community, and others associated with land development and regulations. The actual conversations that you have with these people depend on characteristics of the project, but certain points that may be helpful to include are:

- The need for early involvement of representatives from urban forestry in the planning process
- The importance of advance planning to maximize the benefits of the natural features, including trees, and lower the costs
- The necessity for each group (developers and builders, community, and local government) to understand the needs, goals, and values of the other groups as well as the values and role of urban forestry
- Development of a site and tree protection plan that allows reasonable and thoughtful decisions about which trees to save, which ones to remove, and which ones to be replaced during site restoration
- The importance of developing a tree protection plan that can be included in the site plan
- The types of problems that can occur before, during, and after construction that may affect a tree's health and the steps that can be taken to alleviate them.

Appendix – Minimizing Impact of Construction Activities

These are examples of different techniques that can be used to minimize the impact of construction damage to trees. However, remember that communicating with the key players and knowing their roles, conducting a site and tree evaluation, and reviewing and modifying site plans are essential to successful long-term tree protection.

Clearing

- Organize site activities – identify areas for debris-burn holes and parking
- Reduce amount of land disturbance – leave natural areas and groups of trees
- Install protective tree fencing around critical root zone
- Trench along limits of disturbance
- Apply mulch in critical root zone
- Prune branches for vehicle clearance
- Maintain trees

Grading

- Organize site activities – identify areas for temporary fill and parking
- Minimize amount of land distrubance – leave natural areas and groups of trees and use tight grading contours, terracing and retaining walls
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone
- Trench along limits of disturbance
- Insure quality of fill material
- Prune branches for vehicle clearance
- Maintain trees
- Restore site

Trenching

- Install protective tree fencing around critical root zone
- Locate trench outside critical root zone
- Place all utilities in same trench
- Tunnel beneath tree roots
- Hand excavate around roots
- Apply mulch in critical root zone
- Prune branches for vehicle clearance
- Maintain trees
- Restore site

Vehicles, Pedestrians and Materials

- Organize site activities – identify areas for parking and material storage
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone

- Prune branches for vehicle clearance
- Maintain trees
- Site restoration

Paved Areas

- Organize site activities – identify areas for parking, material storage, concrete washouts, and debris bury pits
- Minimize amount of sub-grade compaction
- Locate paved areas away from critical root zone
- Install pervious pavement
- Use soil mixes that are load bearing yet allow root penetration
- Keep herbicide sprays away from critical root zone
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone
- Maintain trees
- Restore site

Concrete Washouts

- Orgnize site activities - identify specific areas for concrete washouts and parking
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone
- Maintain trees
- Restore site

Leaks and Spills

- Organize site activities - identify specific areas for chemical disposal
- Dispose of hazardous chemicals properly
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone
- Maintain trees
- Restore site

Bury Pits and Fires

- Organize site activities - identify specific areas for bury pits and fires
- Dispose of debris properly
- Install protective tree fencing around critical root zone
- Apply mulch in critical root zone
- Maintain trees
- Restore site

Appendix – How to Read a Site Plan

A site plan provides visual information about the development and construction plans at a particular location. This appendix explains the different parts of a site plan and some of the terms that are commonly used in a plan. Learning to read site plans takes time and experience, but becoming familiar with some of the common elements in site plans is the place to start. Figure 11 is an example of a site plan for a construction project.

Figure 11. A typical site plan. (Courtesy of Rick Raymond and Associates, P.C.)

Standard Format

Most site plans have a standard format, such as size, title, page numbers, and symbols. This same format should be followed for all the sheets in the project. Most site plans are printed on 24" x 36" paper.

Title Bar or Title Block

The title bar or block, usually located on the bottom, right-hand corner or edge of the plan, lists the important information about the project (figure 12). The title bar may include:

Figure 12. Title bar or block. (Courtesy of Rick Raymond and Associates, P.C.)

Project title and location

The project title and location are always listed in the title bar.

Contracting company's name

The name of the company developing the site plans and the professional responsible for the site plans are listed in the title bar.

Interesting point icon: The client's name, address, and phone number may also be located near the title bar or in the site plan notes.

Version and dates

Check to see if the site plan is the draft or final version. Final site plans must be signed and sealed by the appropriate registered professional as required by each State. This could be an engineer, landscape architect, and/or surveyor. Site plans are often revised; the last revision date indicates the correct version.

Scale

Always check the scale on each drawing. The scale used for the drawing reveals the size of the project. The scale should be consistent from sheet to sheet within the site plan; however, sometimes one or more of the sheets will have a different scale. Scales can also be checked with field measurements because the scale may not be exact on the plan. Different types of scales used on a site plan include an engineering scale, architect scale, and not-to-scale (table 2).

Interesting point icon: A large scale has a small number (1"=10') and a small scale has a large number (1" = 100').

Table 2. Different types of scales.

Type of Scale	Description

Engineering scale	An engineering scale may involve increments of 10 feet, for example 1"=10' (one inch equals 10 feet), 1"= 20' (one inch equals 20 feet), 1"=50' (one inch equals 50 feet), or 1" =100' (one inch equals 100 feet), depending on the size and detail of the particular site. This type of scale also includes decimals of a foot on the drawings.
Architect scale	Building plans and detailed site plans may use an architect scale. This scale typically ranges from 1/8" = 1' - 0" (one-eighth inch equals one foot and zero inches) to 1-1/2" = 1' - 0" (One and one half inches equals one foot and zero inches). The architect scale shows fractions of an inch on the drawings.
Not-to-scale (NTS) or No scale (NS)	Some plans may not list a scale. If this is the case, it should read "scale = NTS" or "scale = NS." On some plans where there is no scale, the distance between two or more items may be written on the drawing.

North arrow

Before reading the plan, use the north arrow to orient it and yourself to the site. If the north arrow is pointing to the top of the plan, then orienting the plan is usually easier than if it points to the left, right, or bottom of the plan. The north arrow may be located somewhere else on the site plan and not in the title bar or block.

Sheet number

Sheet number refers to the number of sheets (drawings) in the project plan. Some project plans consist of one sheet that illustrates the project design. Large or complex projects usually have several sheets. Each sheet illustrates a specific part of the project, such as the grading plan. The cover sheet of the project plan should show the project title, site location, index of sheets, and other important information.

Legend or Key

The legend or key defines symbols or lines on the plan (figure 13).

Figure 13. Site plan legend or key. (Courtesy of Rick Raymond and Associates, P.C.)

Match Lines

Match lines may be found on each sheet of a multiple-sheet project and are used to help match the sheets with each other. They are located on the edge of each sheet.

Note Area

The note area is a place for notes or additional information related to the site plan. Examples of information in the note are:

- Call the utility company before digging.
- No tree shall be removed without the written approval of the landscape architect or city arborist.
- Prune all broken branches before planting.

Limits of Construction or Development

Limits of construction are often on the site plan to separate construction areas from adjacent areas. For example, the limit of construction may follow a property line. Or there may be grading limits on the site plan that indicate the soil cannot be disturbed by either cut or fill beyond a certain limit. Usually, the erosion and sediment control and tree protection plans include a symbol for the limits of construction.

Contour Lines

Contour lines show the topography or terrain at a site. All points on the same contour line are at the same elevation. The contour lines reveal the location of slopes, depressions, ridges, cliffs, and other topographical features on the site. Existing contour lines are usually dashed and proposed contour lines are solid. In most cases, contour lines are numbered, indicating the height above sea level. Each fifth contour line is usually drawn darker than the rest and is called the index contour. Numbered contour lines make it easier to determine the contour interval.

Interesting fact icon: A contour line of a given elevation will close on itself, but not necessarily on the site plan.

Key point icon: To read contour lines correctly you need find the contour interval.

Contour interval

The contour interval shows the vertical distance between contour lines. The contour interval is generally 1, 2 or 5 feet and is usually noted on the plan. When the interval is not given, the interval can be determined by reading the contour line numbers and referring to the scale of the plan. The contour interval usually remains the same throughout a site plan; and variations should be noted on the plan. It is essential to determine the correct contour interval to avoid mistakes.

Reading contour lines

Correctly reading the contour lines on a site plan reveals the changes in the terrain and the effect of these changes on the existing trees. Contour lines divulge information about drainage patterns, the grade around a tree, the amount of cut or fill around a tree, flood planes, steep grades, sinkholes, and potential areas for directing retention or drainage flow. Here are contour characteristics to look for in a site plan (figure 14):

Figure 14. Contour lines. (Courtesy of Rick Raymond and Associates, P.C.)

- Uniform slope
  If the contour lines are evenly spaced, the slope will be uniform in shape.
- Steep slopes
  The closer the contour lines the steeper the slope. Contour lines that are close together or converging to form one line indicate a steep slope, wall, or cliff.
- Spot elevations
  Spot elevations, indicated by a "x" sign in front of the number, are critical elevation points that indicate high and low points on the site. Knowing these numbers assists in determining how water flows across the site.

- Depressions
  Hatch lines across a contour line indicate some type of depression, such as a burrow pit or sinkhole.
- Stream valleys
  Contour lines point up stream valleys.
- Ridges
  Contour lines point down ridges.

Baselines

Baselines, which you will sometimes find on layout plans, are thick, horizontal or vertical lines that are starting or reference points for staking and surveying purposes. They are usually determined from the property line or centerline of road or corner of an existing building. The baselines can be used to find other features on the site, such as the location of a specimen tree**.**

Road Centerlines

Existing, and sometimes proposed, road centerlines can also be used as a baseline or reference point for other locations on a site plan.

Detail Sheet

Detail sheets are enlarged or exaggerated drawings to illustrate parts in a plan that require more detail. Detail sheets can show the location of tree roots and the directions for tunneling drainage pipes beneath the roots. A planting detail can describe the placement and installation of a tree. Some of the different types of detail sheets are:

Sections

Sections on a detail sheet typically show the cross section view of sidewalks, underground utilities, retaining walls, and other structures (figure 15). A cross section detail is a good way to illustrate what is being impacted both above and below ground.

Figure 15. Cross section view of a road right-of-way with utilities. (Courtesy of Rick Raymond and Associates, P.C.)

Elevations

Elevation detail sheets illustrate the above ground side or vertical view of the site or specific part of the site (figure 16).

Figure 16. Elevation view for lake access steps. (Courtesy of Rick Raymond and Associates, P.C.)

Profiles

Profile sheets allow the site to be visualized from a vertical perspective or scale. The vertical scale is often exaggerated to show even minor grade changes. They are used primarily in road and utility construction.

Road profile

The road profile illustrates how the roadbed will be cut or filled to meet its finished grade (figure 17). The road profile is a cross section view, but it is the view of the entire road, not just one part of the road. This information helps determine the impact of the construction on trees located near the road.

Figure 17. Road profile. Note the areas where cut and fill have to occur because the finished road grade is different from the existing road grade. (Courtesy of Rick Raymond and Associates, P.C.)

Utility profile

The utility profile illustrates the locations, heights, and depths of the utilities, both above and below ground. This information can be used to show tunneling under the tree roots (figure 18).

Figure 18. Utility profile. (Courtesy of Rick Raymond and Associates, P.C.)