A GUIDE TO

Preserving Trees in Development Projects

PENNSTATE

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College of Agricultural Sciences
Agricultural Research and Cooperative Extension

Contents

Why Preserve Trees?

By their very nature, trees and green space provide benefits and add value to developments. The ability of trees to improve and maintain the quality of water, soil, and air and to remove pollutants from the air is well known. Trees also provide shade and help lower temperatures during hot weather. Trees enrich people's lives and beautify landscapes. Preserving trees has positive effects on the image and attractiveness of developments and enhances developers' reputations and profits.

Figure 1. Preserving historic, landmark, and suitable ornamental trees adds value to developments.

Preserving trees in developments increases a project's attractiveness, monetary value, and marketability by providing aesthetic and functional values. Lots where trees are preserved can be sold more quickly and at higher prices. Research has shown that mature trees increase the worth of a property up to 12 percent. Developers who understand these values realize that it is in their best interest to encourage the preservation of trees and green spaces.

Developers can take advantage of different opportunities when considering the preservation of trees. Individual historic, landmark, and ornamental trees are all good choices for preservation, as are native trees in groves and woodlots. Opportunities differ from one development to another, but many of the recommendations for preserving trees remain the same.

Various people, such as arborists, engineers, architects, planners, and municipal officials, may become involved in preserving trees. Properly preserving trees in development takes time, good design, communication, and money. However, the results are worth the effort.

This publication provides helpful information to those who want to preserve trees, but know little about tree preservation techniques. Tree preservation starts with a basic understanding of the health of trees and the soils that support trees.

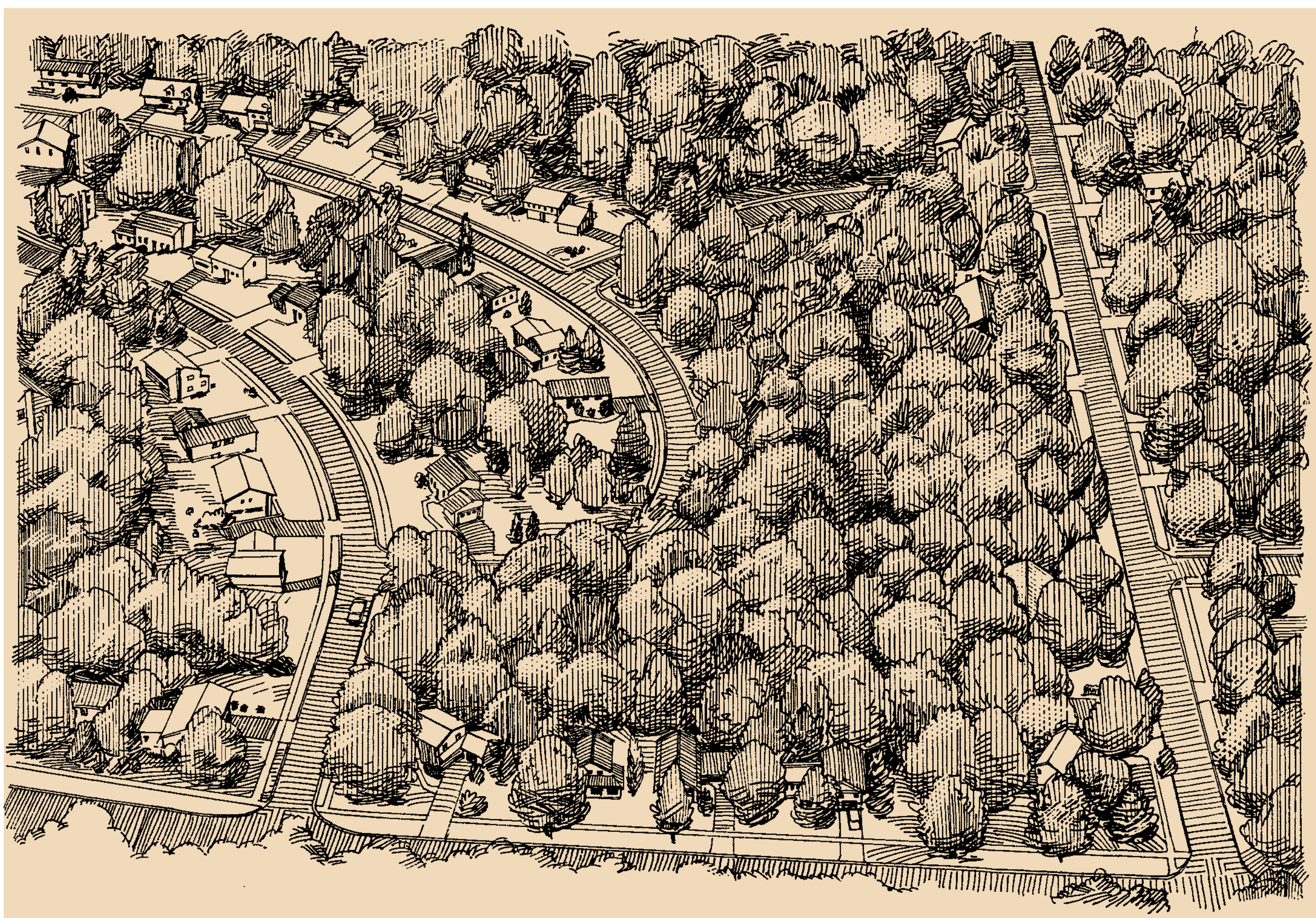


Figure 2. Preserving native trees in groves and woodlots provides economic and environmental value to developments.

Tree Health

Preserving trees is not very complicated if you understand how they function and what they need to grow. Trees are living organisms that respond to what is done to them and to the environment that they occupy. To stay healthy and vigorous, trees need air, water, and soil nutrients. They need a pollution-free and compaction-free soil that allows unhampered movement of water and air. Trees also need protection from insects, disease, and physical damage. Trees have roots, bark, a trunk, branches, and foliage, and they will thrive only if these organs remain healthy and undamaged.

Roots are essential to tree health. They support tremendous weight, store food, and take up water and nutrients from the soil. Tree roots need to be well anchored into a soil to hold the tree safely erect. Although the large, woody roots that support the weight of a tree and resist strong winds may reach deep into the soil, most roots that absorb water and nutrients can be found in the upper 12 to 18 inches of the soil. Roots are not confined to the area beneath a tree canopy—in fact, some roots can grow to more than three times the spread of the tree's branches.

Bark serves as a living barrier to insects, disease, and water loss, and as a transport system. On the inner side of the bark is the cambium, a single layer of cells that produce a new layer of xylem (wood) and phloem (bark) each year. Together, the xylem and phloem make up the circulatory system of the tree. Water and soil nutrients move upward in the wood, while manufactured food (carbohydrate or sugar) and growth substances (such as hormones) move downward and outward in the phloem.

A tree trunk provides height to the canopy of the tree, space for storing food materials, and support for the branches and leaves.

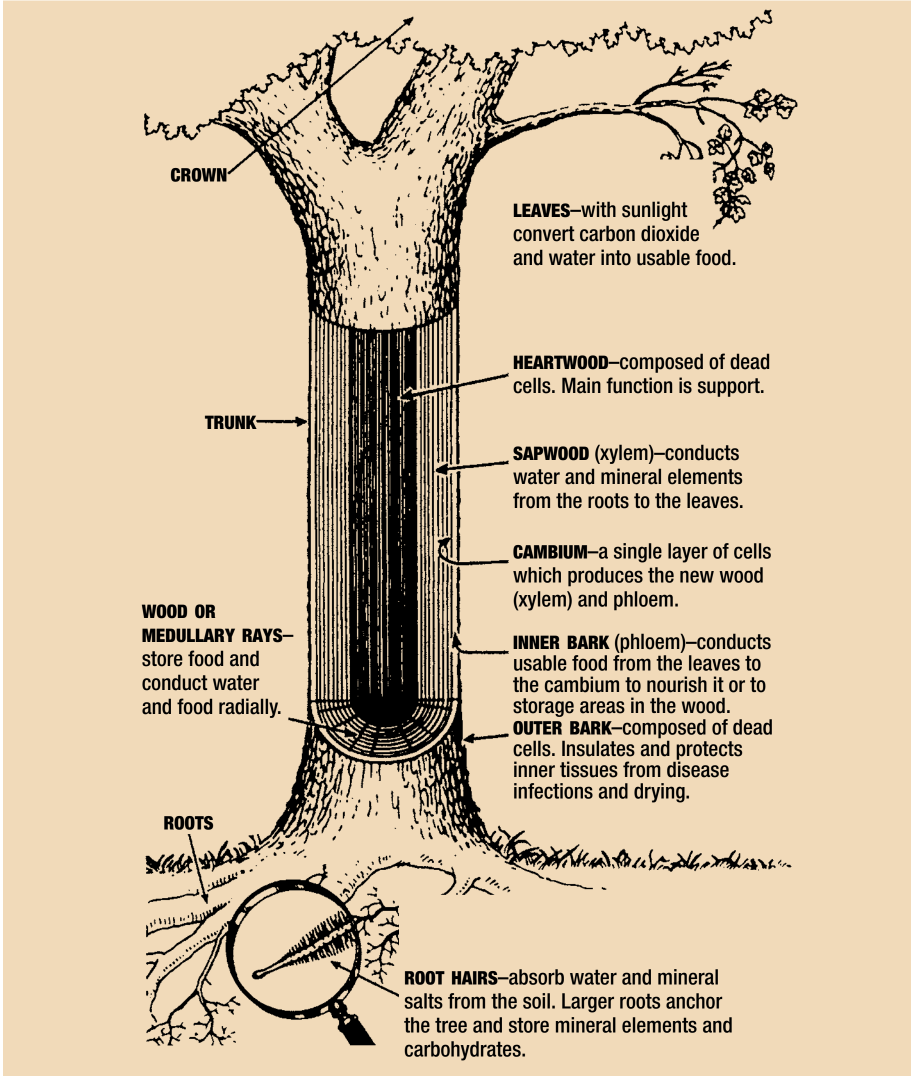


Figure 3. All of the important parts of a tree must be kept healthy for a tree to thrive.

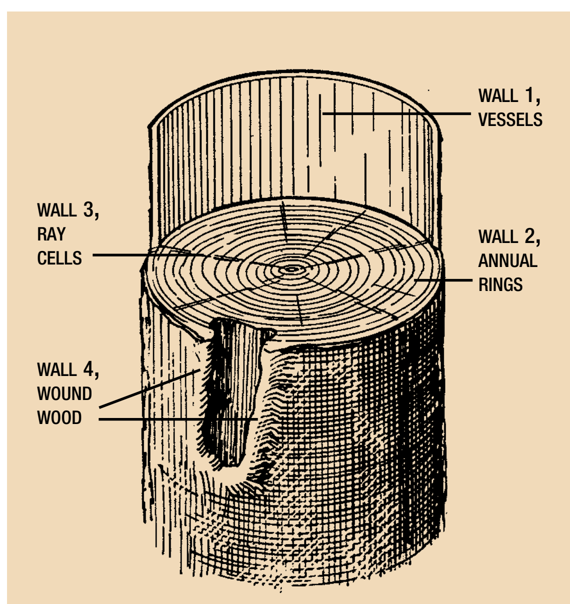


Figure 4. Trees do not heal wounds, but their "walls" resist the spread of decay by the process of Compartmentalization of Decay in Trees (CODIT). Wall 1 is the vessels in the xylem; Wall 2 is the annual rings; Wall 3 is the rays; and Wall 4 is the new wood cells of wound wood. Wall 1 is the least resistant to decay. Wall 4 is the most resistant.

Tree limbs, branches, and twigs support leaves, where most of a tree's food is produced in a process called photosynthesis. The green chloroplast cells in a tree's leaves combine carbon dioxide, water, and radiant energy absorbed from the sun to produce oxygen and carbohydrates. Through the process of respiration, living cells in buds, leaves, roots, and other structures consume oxygen and convert the carbohydrates into other chemicals and energy the plant can use for growth, reproduction, and defense against decay. The production, or use, of energy in a tree is affected by a number of factors, including temperature, the amount of stored and available carbohydrates, the concentration of oxygen and carbon dioxide in the air, the amount of water in tree tissues, light levels, and whether the tree is injured. Tree injuries increase the rate of respiration and the use of stored carbohydrates. Repeated depletion of stored carbohydrates because of injury can threaten the tree's health at the time of injury and in the future.

Wounds that penetrate through the bark into the wood enable insects and fungi that cause decay or diseases to pass through the outer defenses of the tree. There is a misconception that trees are able to "heal their wounds." A tree does not heal, or fill, a wound. Instead, it defends against decay and discoloration by compartmentalizing the wound. Compartmentalization of decay in trees is a process that protects the unwounded part of a tree from decay through the development of physical and chemical boundaries that resist the spread of disease into surrounding wood.

If a tree is damaged by equipment or workers, it can be marred for life or killed. Wounds and pockets of decay do not fill, but are compartmentalized and covered by wound wood. As a result, pockets of decay never disappear, even if they are covered by new wood. Some trees decline slowly over a number of years because of construction injury, while others may die quickly. During construction, trees can be damaged by soil compaction, grade changes, root crushing and pruning, damage to the bark, improper pruning of branches, incorrect storage of construction materials, and dumping of construction wastes.

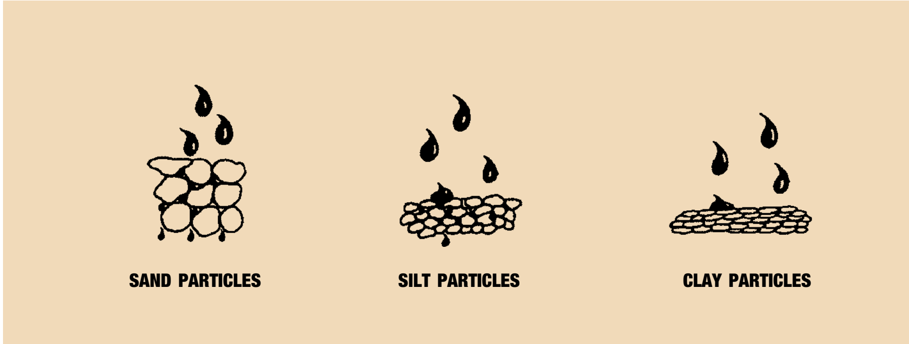


Figure 5. The amount of sand, silt, and clay particles found within a soil make up a soil's texture. Structure is how these particles are grouped together.

Soil for Healthy Trees

Soil means different things to different people. To engineers and contractors, soil is the material that supports foundations, roads, and other structures. To horticulturists and foresters, soil is the medium in which plants grow. Soil can be a few inches deep in some places and several feet in others. Soil supports tree establishment, growth, and reproduction. To remain healthy, trees need soil for water, nutrients, and structural support.

Each soil type has unique characteristics of *texture* and *structure*. Soil *texture* is the relative proportion of the individual particles of sand, silt, and clay found within a soil. Sand particles are the largest and range from 0.05 to 2.0 mm in diameter. Silt particles are intermediate in size, ranging from 0.002 to 0.05 mm. Clay particles, the smallest soil particles, are less than 0.002 mm in diameter. Construction activity will not change soil texture unless new soil or debris is brought to the site, but it can change soil *structure*.

There are many types of soils (see Figure 6). Soil *structure* is determined by the way in which individual particles of sand, silt, and clay are combined into aggregates over time. *Structure* is important because the fine spaces between soil particles hold water and air, which support plant growth, while the larger pore spaces between aggregates allow for the infiltration of rainfall and air.

Sandy soils consist of relatively large particles with large pore spaces between them and can have granular or crumb aggregates. Sandy soils are well drained and aerated, but have poor water- and nutrient-holding capacity. *Clay soils* consist of small particles with little pore space between them and can have blocky aggregates. They have a high water- and nutrient-holding capacity, but may be poorly drained and aerated unless the soil has a well-developed structure. Because of their high water- and nutrient-holding capacity, clay soils can be highly productive, but they are easily compacted.

In addition to inorganic particles of sand, silt, and clay, decaying matter shed by plants (leaves, bark, branches, and decaying roots) forms a loose organic layer, or mulch, on the soil surface, which is gradually incorporated into the soil. This layer promotes the infiltration and retention of water, supports populations of beneficial soil organisms, reduces the risk of erosion, increases the development of soil structure, and provides a slow release of nutrients.

A good soil for plant growth is a mixture of clay, sand, and silt called a "loam." The ideal soil for tree growth is a loam that is well drained and aerated, contains 1 to 5 percent organic matter, has a covering of leaves and other organic material, and has an established population of living organisms such as fungi, bacteria, and earthworms.

Healthy trees need healthy roots and healthy roots need good soil structure. *Care must be taken during construction to protect the structure of soil.* Compacting soils harms trees by decreasing the ability of their roots to take up water, oxygen, and nutrients. Compacting soil with heavy equipment or stored materials destroys good structure of the soil by crushing and closing the pore spaces. Even foot traffic beneath trees in parks and around buildings can compact soils enough to be detrimental to tree health. Soil compaction slows or stops rainwater from infiltrating and also increases runoff, which reduces the amount of water available for plant growth. Compaction also interferes with the aeration of the soil, which lowers oxygen levels and raises carbon dioxide levels around tree roots. In areas where trees are to be preserved, soil should be protected from compaction by using the techniques discussed in later sections.

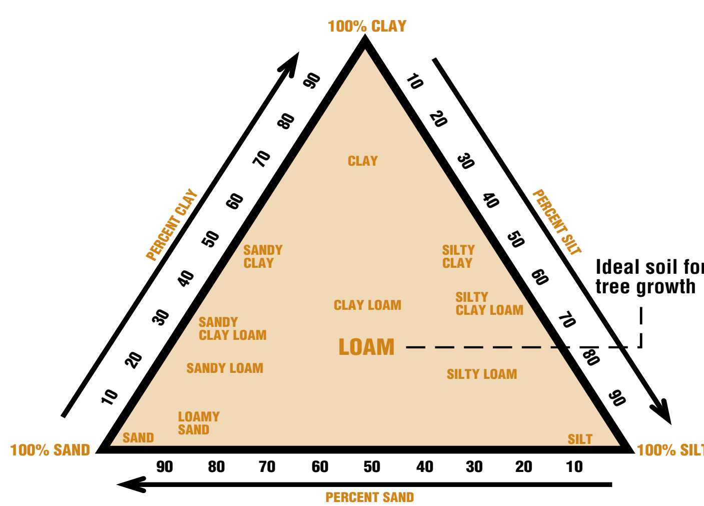


Figure 6. An ideal soil for tree growth is a mixture of sand, silt, clay, and organic matter, called loam.

Preconstruction Activities

The goal of preserving trees in development projects is to protect adequate space for trees with the best health, structure, and appearance, while removing hazardous trees, lower quality trees, and others that are in the way of construction. Above all else, preserved trees need adequate space for root and canopy function and growth. The first preconstruction action is to decide how a tree inventory will be completed.

Tree Inventory

A tree inventory provides information used to make decisions on which trees can be preserved and what measures are needed to protect them. It takes both common sense and professional advice to plan for and complete a tree inventory. Development parcels can have different types of trees arranged in different ways. They can range from large solitary trees to a complex array of species and sizes. The amount of time, effort, and money devoted to an inventory should match the characteristics of the tree resource, physical constraints imposed by the property, and the wishes of the developer. In some municipalities, tree preservation ordinances dictate the type and sizes of trees that must be inventoried. In others, the developer can decide freely how the inventory will be conducted.

There are two approaches to a tree inventory. The preferable way is to inventory trees *before* building pads, lot lines, and streets are engineered. The other is to collect information on trees *after* deciding upon lots and street locations.

For parcels with little variability in the size and species of trees, or no unique or special trees, a developer may choose to do a limited amount of inventory work after lot lines and streets have been surveyed. The developer may first want to stake the footprints, or outlines, of structures, streets, driveways, utilities, and grading. After staking these, trees that must be removed and trees that will be encroached upon by development can be identified. Hazardous trees on the property should also be identified and marked for removal. Developers can use the recommendations found in this guide, such as those for root and canopy pruning, to ensure the survival and long-term health of trees that remain, some of which may be affected by grading or other construction activities.

For development parcels with diverse, large, unique, or special trees, a developer should arrange a more thorough inventory. This type of inventory is completed before lot lines are placed, so that inventory information will be used by engineers and landscape architects in subdivision design. The inventory can be coordinated with initial survey work so information on tree condition, canopy size, and trunk location can be gathered at the same time as information on topographic and other physical features. A basic rule of this type of inventory is that information is collected on all trees in which there is an interest in preserving. If a parcel has many valuable trees and considerable development activity, all trees may be inventoried. In other situations, the developer can decide which categories of trees will be inventoried.

The first step in either approach is for the developer to conduct an initial walk-through of the property with a qualified arborist, forester, or landscape architect.

TREE PRESERVATION TAKES PLACE OVER TIME

Preconstruction

- Tree inventory
- Planning, design, negotiations
- Removals
- Staking of construction footprints under trees—required limb pruning
- Insect control or other care
- Fencing preserved trees

Construction

- Communication and education
- Protection zones
- Required root pruning
- Maintenance of fencing
- Monitoring tree health
- Tree care

After Construction

- Communication and education
- Protecting
- Tree care

During the walk-through, decisions are made about which trees should be tagged and inventoried. A number of factors influence decisions about what kinds of trees should be tagged and inventoried:

Species—It is important to concentrate on the highest quality tree species. If a developer wants to remove all trees of an inferior species, they need only to be marked, but not inventoried.

Size—Although most people prefer larger trees, smaller trees such as dogwood, eastern redbud, and serviceberry should not be overlooked because they can be very valuable and add to the beauty of the property. The developer and consultant should decide the minimum diameter size of trees that will be inventoried for each species. Trees that are not inventoried are candidates for transplanting or removal.

Forest Structure and Tree Location—Groups or groves of trees on the edges of a property, trees in riparian areas, and trees clearly away from development activities need not be inventoried individually. Depending on the location of development, inventorying trees at the edge of groups and groves may be warranted.

Hazardous Trees—Hazardous trees should be identified and marked for removal, wherever they occur.

Site Characteristics—Site characteristics such as fixed entrance points, steep slopes, and wetlands should be considered in deciding which trees to inventory.

Advice for Conducting a Tree Inventory

It is important to retain qualified people who are knowledgeable about the relationship between trees and construction and about species characteristics, tree health, and tree structure when conducting an inventory. In an inventory, a form is used to gather information on tree species, trunk diameter, height, crown size, condition, suitability for preservation, and maintenance needs. To allow identification of trees in the field, a pre-numbered aluminum tag available through forestry and horticultural suppliers is attached to each inventoried tree with an aluminum nail.

Location and size

To prevent untimely conflicts with buildings, streets, and equipment, the location and dimensions of trees must be established. Accurate information is important for preserving trees. Variations as small as several feet between actual and mapped tree locations can drastically affect the amount of root and canopy pruning needed to fit construction. For trees growing in large clusters or woodlots, developers only need information about the trees growing on the edge. For trees growing individually or in small clusters, more detailed information is required. For these trees, tree canopy dimensions should be measured at four compass points, and the location and elevation of each tree trunk should be surveyed. This information is then placed on a grading or site plan. Accurate information on tree size and location allows developers, engineers, and landscape architects to compare the location of trees with the location of buildings, cuts, fills, retaining walls, streets, utilities, routes of heavy equipment, and other proposed construction activities.

Condition

Tree condition is a combination of tree health and tree structure and is a major factor in determining suitability for preservation and tree removal priorities. Tree health should not be confused with tree structure. A tree can be very healthy but have very poor structure because of decay. Similarly, a tree can be very unhealthy, but have a good structure because of a lack of decay.

It is important to preserve only those trees that are healthy and structurally safe. Dead and dying trees and trees that are hazardous should be removed. Tree health is evaluated by observing crown density, foliage color and size, insect and disease problems, injuries, and amount of deadwood. Tree structure is a system of many interactive factors. To assess the structural safety of trees, evaluate the following:

- signs that the tree has dropped large branches in the past
- the condition of the root system, including past injury from root pruning
- trunk wounds, decay, cankers, or conks
- amount and size of deadwood or storm damage in the canopy
- abnormal branching habits, tree form, or weak crotches
- severity of leans and other structural irregularities

Evaluating tree structure and hazard is complicated, so a qualified arborist should be consulted, especially about older and larger trees that will be close to people, buildings, play areas, sidewalks, and cars. Costly measures have been taken to preserve trees in poor condition, but which have great historical or aesthetic value.

Suitability for preservation

Species, condition, size, age, and other factors are used by a qualified inspector to evaluate the suitability of a tree for preservation. In general, certain tree species are more desirable for preservation than others. For example, because white oaks and sycamores are structurally stronger and live longer than silver maples or cottonwoods, they should be given a higher suitability for preservation. Silver maples have a lower preservation value because of their potential to develop structural weakness and to therefore be hazards in developed areas, especially if their roots are damaged during construction. Species with undesirable characteristics such as narrow branch angles, weak wood, susceptibility to severe pest problems, or short life expectancy should be given a lower suitability for preservation than trees of more desirable species.

Tree Inventory Form

Inspector:________________

Date: ________________

Tree No.	Species	DBH	Tree Height	Distance to Dripline N W E S	Direction low or unusual branching N W E S	Tree Condition Good, Fair, Poor	Suitability for Preservation Good, Fair, Poor	Maintenance Recommendations and Comments

Figure 7. A tree inventory form is used by a qualified individual to gather information for a tree report.

GUIDE FOR ASSIGNING CONDITION CLASS OF TREES
Condition = health and structure

CONDITION	DEADWOOD	FOLIAGE	TRUNK
Good	Dieback limited to less than 10 percent of smaller branches.	Normal for species in size and color. Crown density is normal.	Less than 20 percent of trunk has any decay. No decay fungus mushrooms present.
Fair	Dieback includes 10–20 percent of smaller branches and 1 to 2 large, dead branches.	Reduced in size. Lighter in color than normal. Crown density is sparse.	20–33 percent of trunk has decay. Decay fungus mushrooms may be present.
Poor	Dieback includes more than 30 percent of small branches, 3 or more major branches.	Greatly reduced in size and yellow. Crown density is very sparse.	More than 33 percent of trunk has decay or is hollow. Decay fungus mushrooms may be present. More than 33 percent of roots removed or decayed.

Condition, size, and age also are important factors in determining a tree's suitability for preservation. For example, a large white oak with decay, many lost branches, and no historical value would have a poor suitability for preservation, while a large white oak in good condition would have a good or excellent suitability for preservation.

Identify trees in need of care

In the inventory, recommended actions are made to improve the health and structure of worthy trees, especially landmark and other prominent trees. These maintenance recommendations include needed irrigation, fertilizing, pest and disease management, cabling or bracing, and especially pruning.

The information gathered in a tree inventory is summarized in a tree report, and tree canopy dimensions and trunk locations are placed on site or grading plans to develop a tree preservation plan. The tree report and tree preservation plan allow information on tree health and structure, as well as on tree size and location, to be considered when designing a development.

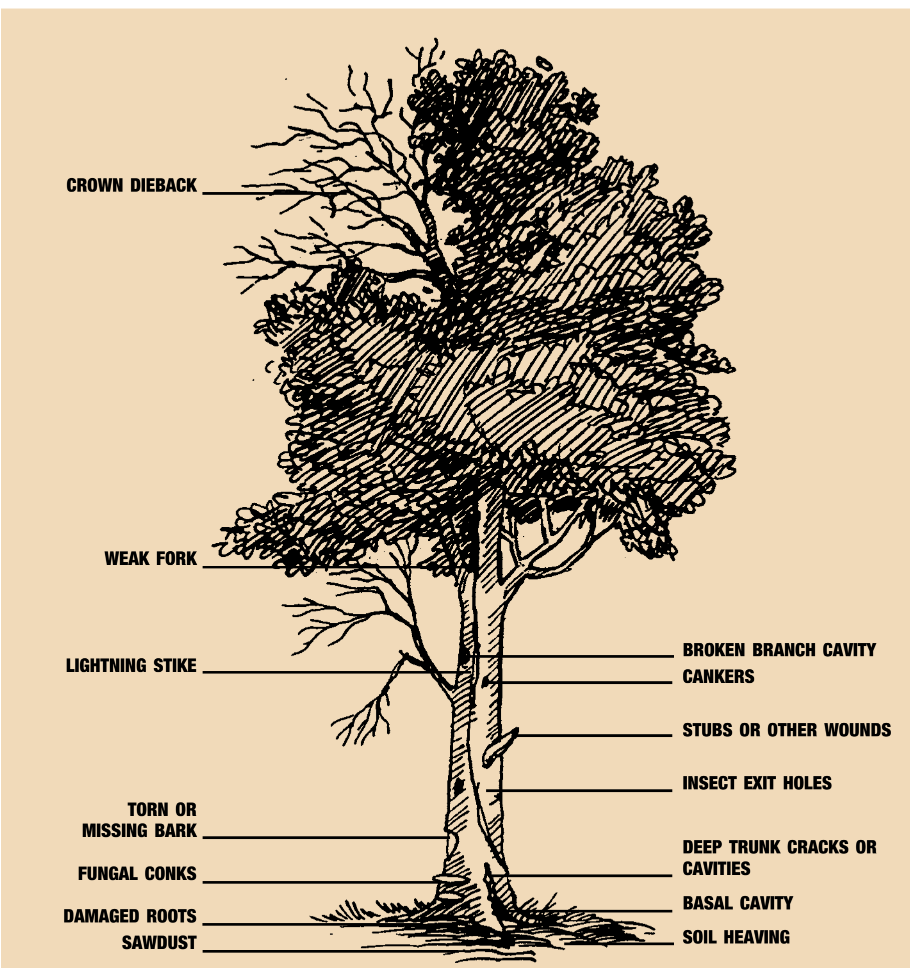


Figure 8. Undesirable tree characteristics to look for when evaluating tree condition and suitability for preservation.

Using Tree Inventory Information

Tree Report

The tree report summarizes inventory data on hazardous trees that should be removed, tree maintenance needs, tree condition, tree suitability for preservation, and which trees should be offered the most protection. The report should identify trees of exceptionally high or low value or interest. In addition, elevation and plan drawings of proposed tree encroachments can be provided. A qualified horticulturist, forester, arborist, or landscape architect should be employed to complete the tree report. The report is provided along with the tree protection plan to everyone who will make decisions about development design and tree preservation.

Figure 9. A tree report provides information on tree species, location, condition, and suitability for preservation. This information can be used to determine if trees should be removed, encroached upon, or retained in a development.

Tree Protection Zone

Injuries to a tree or group of trees can be minimized by providing a tree protection zone (TPZ), a fenced area around a tree that will not be disturbed by construction work. Information from the tree report is used to determine TPZ locations. In a TPZ, the soil is protected from compaction, critical roots are not damaged by pruning, trenching, or excessive grade changes, and trunk and branches are not damaged by equipment or workers. A TPZ will ensure that a tree is protected

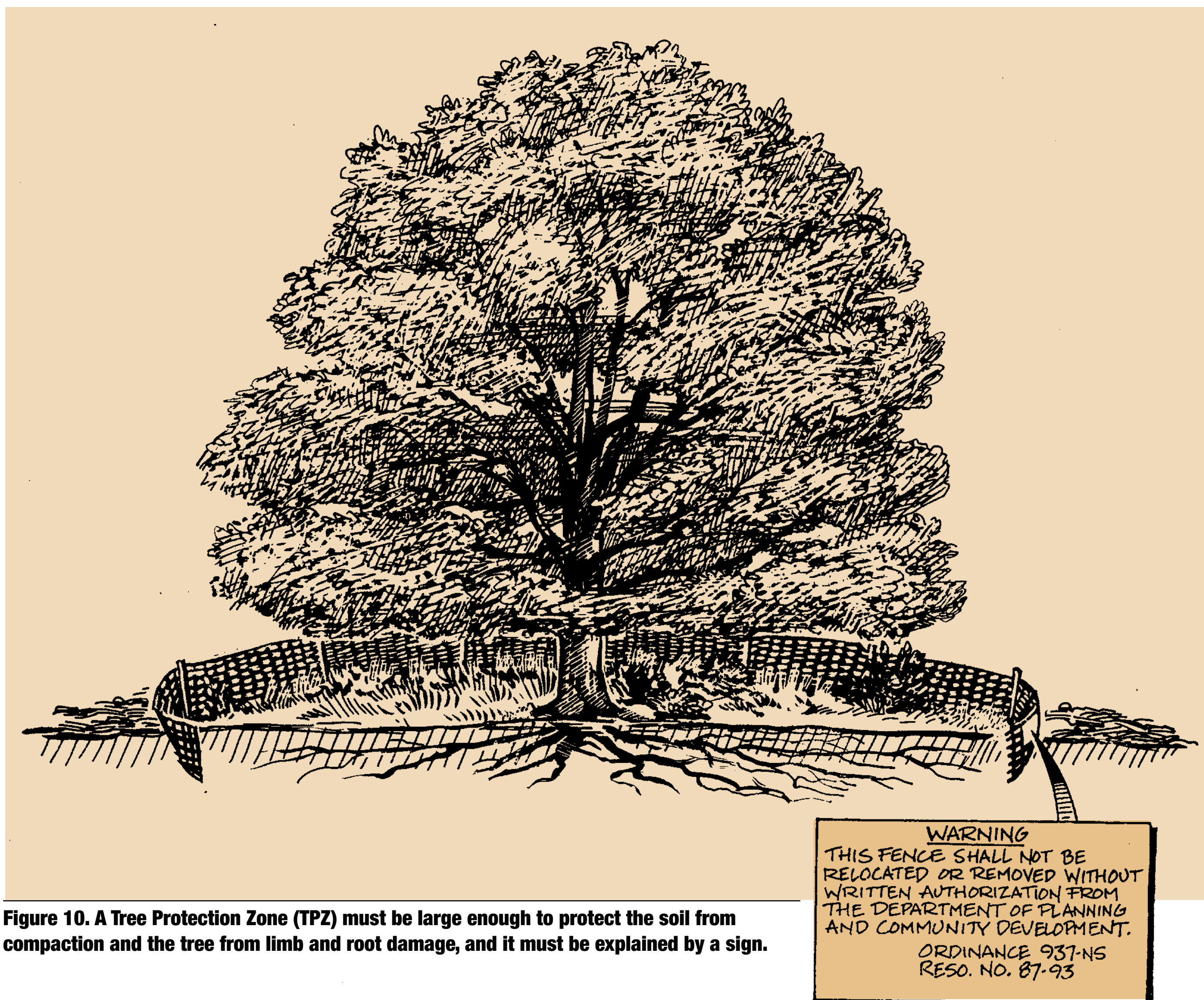


Figure 10. A Tree Protection Zone (TPZ) must be large enough to protect the soil from compaction and the tree from limb and root damage, and it must be explained by a sign.

during construction, has enough space for root and branch growth, and will receive adequate supplies of soil nutrients, air, and water.

When determining the size of a TPZ, the needs of the tree must be considered along with the needs of the contractor on the site. Ideas vary about the correct size for a TPZ, and generally it should be established at or outside the dripline of a tree when feasible. However, space can be limited on construction sites where buildings, infrastructure, and trees must all be accommodated. Also, trees have a variety of canopy shapes—some broad, and others upright or narrow. Using the dripline as a guide for the size of a TPZ could lead to the establishment of protection areas that are either too large or too small, depending on the growth habit of the particular tree. Using the dripline as a rule for a TPZ has been recommended for broad-canopied trees, such as open-grown oaks.

It is commonly thought that trees can withstand the removal of 30 to 50 percent of their root system, but structural stability may be compromised after the removal of more than one-third. Because it is difficult to estimate the full extent of a tree's root system, it is difficult to know when a certain percentage of roots has been affected. Providing an adequate TPZ helps preserve needed tree roots. A *minimum* TPZ for a tree can be determined by using the following rule: Measure the diameter (in inches) of a tree trunk at a point 4.5 feet above ground, known as the diameter at breast height (DBH). Define a circle around the tree with a diameter in feet equal to the number of inches of the trunk's DBH. For example, a red oak with a diameter of 10 inches would have a TPZ 10 feet in diameter. This rule defines the minimum distance to keep construction activity and storage of equipment and materials away from a tree. The more undisturbed space that can be provided around a tree, the better the tree's chances of survival and subsequent growth.

Another TPZ method is described by Jim Clark and Nelda Matheny in their book *Trees in Development* (International Society of Arboriculture, Savoy, IL). In this method, the TPZ depends on the tolerance of a tree species to construction impact, as well as the tree's age and vigor (see Tables 1 and 2). Young, vigorous trees of a species with good tolerance to construction impact can have smaller TPZs.

For especially valuable, large, old, historic, or landmark trees, the TPZ should extend at least to the dripline, preferably beyond, and should be established by an experienced arborist or horticulturist.

TABLE 1. Guidelines for Tree Protection Zones. Distances should be increased for trees of poor vigor and to protect young and other trees with low branching from severe pruning of limbs. This table is adapted from a table provided courtesy of the International Society of Arboriculture, Savoy, IL.

SPECIES TOLERANCE TO IMPACTS	TREE AGE	DISTANCE FROM TRUNK* (feet per inch of trunk diameter)
tolerant	young <1/4 life expectancy	0.5'
	middle aged 1/4-3/4 life expectancy	0.75'
	mature >3/4 life expectancy	1.0'
intermediate	young	0.75'
	middle aged	1.0'
	mature	1.25'
sensitive	young	1.0'
	middle aged	1.25'
	mature	1.5'

*These distances are based on a tree's tolerance to root pruning and soil disturbance and may not be adequate to protect branches of young trees or other trees with low branching. Because severe pruning would destroy the form of such trees, fencing at the dripline or beyond should be considered.

TABLE 2. Size and Tolerance of Tree Species to Construction Impacts. This table represents opinions of the authors and information from three publications: Tree Characteristics, Protecting Trees from Construction Damage, Minnesota Extension Service, University of Minnesota; The Response of Ohio's Native and Naturalized Trees to Construction Activity, T. Davis Sydnor, School of Natural Resources, The Ohio State University; and Relative Tolerance of Tree Species to Construction Damage, Kim D. Coder, The University of Georgia Cooperative Extension Service, Forest Resources Unit.

Tolerance to construction impact can vary greatly according to site characteristics such as soil depth, individual tree characteristics such as rooting habit, prevailing weather conditions such as drought, and the degree of construction impact.

SPECIES	ROOT SEVERANCE	SOIL COMPACTION AND FLOODING	MATURE CROWN SPREAD (FEET)	HAZARD POTENTIAL RATING*	COMMENTS
ailanthus	tolerant	tolerant	20-40	low	
arborvite	tolerant	tolerant	5-10	low	
black ash	tolerant	tolerant	30-60	medium	
green ash	tolerant	tolerant	30-50	medium	
white ash	tolerant	intermediate	40-70	medium	
bigtooth aspen	tolerant	sensitive	20-35	medium	sensitive to increased light and heat
quaking aspen	tolerant	sensitive	20-35	medium	
American Basswood	sensitive	sensitive	50-75	medium	sensitive to fill
American beech	sensitive	sensitive	30-50	medium	
blue beech	sensitive	sensitive	15-20	low	
gray birch	tolerant	tolerant	30-50	low	
paper birch	intermediate	sensitive	30-50	medium	
river birch	tolerant	tolerant	30-50	low	
yellow birch	intermediate	sensitive	25-50	medium	
blackgum	tolerant	tolerant	40-60	low	
boxelder	tolerant	tolerant	35-50	high	
Ohio buckeye	sensitive	sensitive	30-40	medium	
butternut	sensitive	sensitive	50-60	medium	
catalpa	intermediate	tolerant	30-50	medium	
Eastern red cedar	tolerant	sensitive	10-20	low	
Northern white cedar	tolerant	tolerant	10-20	low	
black cherry	intermediate	sensitive	40-50	low	
Kentucky coffeetree	intermediate	intermediate	40-50	low	
Eastern cottonwood	tolerant	tolerant	80-100	high	
crabapple	tolerant	tolerant	20-30	low	
dogwood	intermediate	intermediate	15-20	low	sensitive to increased light and heat
American elm	tolerant	intermediate	70-150	medium	
slippery elm	tolerant	intermediate	40-60	medium	
balsam fir	tolerant	tolerant	20-35	medium	
white fir	tolerant	sensitive	10-20	medium	
ginkgo	tolerant	tolerant	40-80	low	
hackberry	tolerant	intermediate	50	low	
hawthorn	tolerant	tolerant	20-30	low	
Eastern hemlock	sensitive	sensitive	25-35	medium	sensitive to fill
butternut hickory	intermediate	sensitive	30-40	medium	
American holly	tolerant	tolerant	18-40	low	
honeylocust	tolerant	tolerant	50-75	medium	
ironwood	sensitive	sensitive	20-30	low	
larch	tolerant	tolerant	15-25	medium	
black locust	tolerant	tolerant	20-50	high	
red maple	tolerant	tolerant	40-60	medium	sensitive to wounding
silver maple	tolerant	tolerant	50-75	high	
sugar maple	tolerant	sensitive	60-80	medium	sensitive to fill
bicolor oak	tolerant	tolerant	40-50	low	
black oak	intermediate	intermediate	50-70	low	
bur oak	tolerant	tolerant	40-80	low	
pin oak	sensitive	tolerant	30-50	low	
red oak	tolerant	sensitive	40-50	low	
shumard oak	tolerant	tolerant	40-60	low	
white oak	sensitive	sensitive	50-90	low	
willow oak	intermediate	intermediate	30-40	low	
osage orange	tolerant	tolerant	20-40	low	
jack pine	tolerant	sensitive	20-30	medium	
red pine	tolerant	sensitive	20-40	medium	sensitive to increased light and heat
Scotch pine	tolerant	sensitive	30-50	medium	sensitive to poor drainage
white pine	tolerant	sensitive	40-60	medium	sensitive to drainage changes
redbud	intermediate	intermediate	25-35	low	sensitive to increased light and heat
serviceberry	intermediate	intermediate	15-20	low	
sweetgum	tolerant	tolerant	40-65	low	
black spruce	tolerant	tolerant	15-30	medium	
Colorado spruce	intermediate	tolerant	20-30	medium	vulnerable to windthrow
Norway spruce	tolerant	tolerant	20-30	medium	vulnerable to windthrow
white spruce	tolerant	tolerant	20-30	medium	
sycamore	tolerant	tolerant	75-100	low	
tulip tree	sensitive	intermediate	35-50	high	
black walnut	sensitive	intermediate	50-70	medium	
black willow	tolerant	tolerant	20-40	high	
weeping willow	intermediate	intermediate	30-40	high	

***Hazard Potential Rating** refers to the relative potential for a tree to become hazardous due to its large size and likelihood of breakage or decay. For a tree to be considered hazardous, a likely "target" (e.g., a person, a house, or car) must be present. A high rating does not imply that an individual tree is likely to fail.

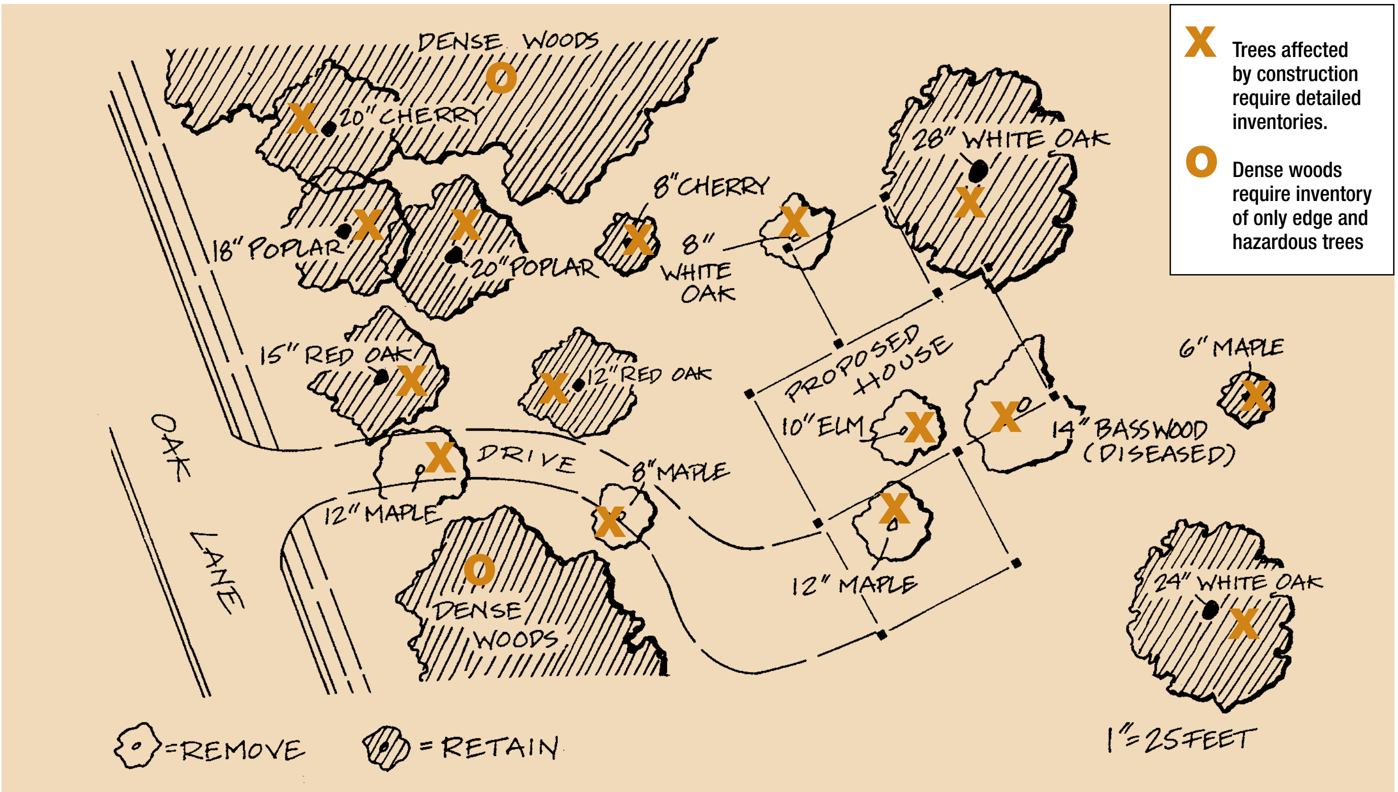


Figure 11. A simple tree preservation plan shows the location of house, driveway, and trees to be removed, encroached upon, and retained.

Tree Preservation Plan

Information on tree preservation zones and the location, size, and condition of trees from the tree report is combined with information on a grading or site plan to prepare a tree preservation plan. The tree preservation plan shows the location of development footprints, including buildings, utilities, and streets, and how trees and tree preservation zones relate to them. The tree preservation plan helps developers make decisions about which worthy trees can be preserved, which should be removed, which can be transplanted, and how trees may be encroached upon. This plan also helps developers determine how footprints, streets, and other factors can be altered to facilitate tree preservation.

A tree preservation plan identifies places where limited space needs to be carefully managed when developers are trying to accommodate both trees and construction. This type of plan leads to changes during the early stages of development that will preserve important trees and help developers avoid costly mistakes and delays. The best plans provide adequate tree protection zones that separate buildings, infrastructure, and construction activities from worthy trees. The following guidelines can help you develop a tree preservation plan.

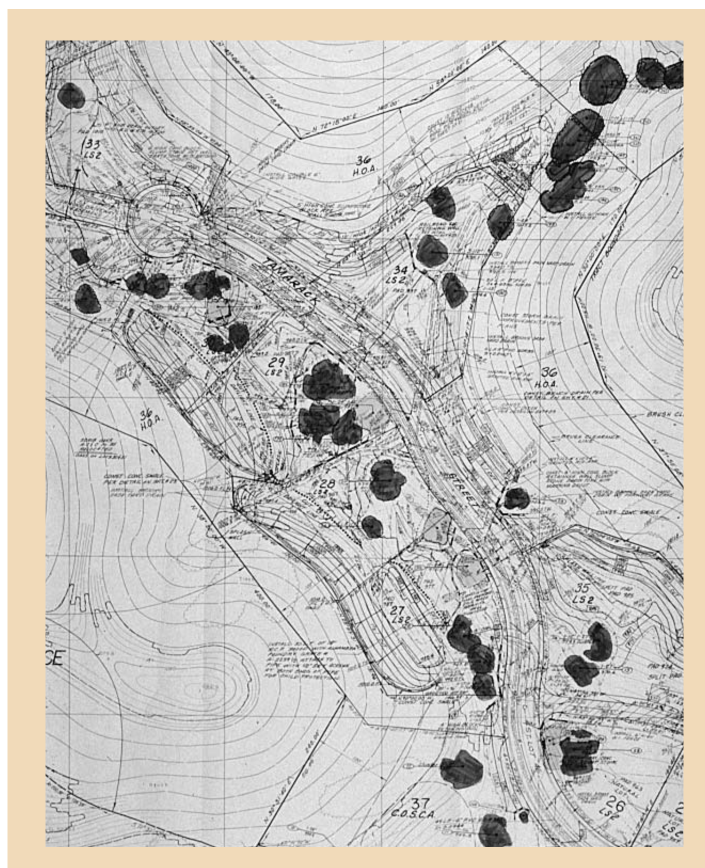


Figure 12. More complex tree preservation plans use a grading plan to show the relationship of grading and construction to trees.

Use accurate information.

The plan should accurately show the spatial relationships between trees and development. A few feet can determine whether or not a tree can be preserved. Errors in either tree or construction location make a tremendous difference in the size of tree preservation zones and the amount of root and canopy pruning required. Problems caused during the construction phase because of inaccurate information about tree location and condition can be expensive in terms of tree health, time, and work interference.

Place utility paths on plans.

Trenches and overhead wires for utilities should be identified on tree preservation plans.

Identify affected trees.

Clearly mark on the grading or site plan any trees that are to be preserved, removed, or pruned, or that might be encroached upon by buildings, roads, parking lots, or utilities.

Consider alternative plans to minimize construction impacts on suitable trees.

Attempts should be made on grading and site plans to eliminate or minimize construction impacts on worthy trees by removing less worthy trees and moving or altering grading, buildings, utilities, and other infrastructure elements. For example, a medium-quality tree might be marked for removal to prevent encroachment on and pruning of a higher-quality tree. Less suitable trees (in terms of species, condition, and age) should be marked for removal to provide space for more suitable trees. All dead or dying trees and hazardous trees should be removed. Only trees that are in good, safe condition should be saved in parks or near buildings, sidewalks, and streets. Nuisance trees such as mulberry (messy fruit) and osage orange (dangerous fruit) can be preserved if they are a safe distance away from buildings, walkways, and parking areas.

Consider alternative construction techniques.

A variety of construction elements and techniques can be used to help preserve trees while providing space for development. For example, crib and retaining walls can be used to limit the length of manufactured slopes and keep soil cuts and fills out of a tree protection zone. Engineered pier or grade beam footings, which reduce pruning damage to tree roots, can be used when working close to tree trunks. Self-supporting concrete or asphalt sections can be engineered to reduce soil compaction and root damage when sidewalks, parking lots, streets, and driveways are placed under or close to trees.

Consider energy needs of buildings.

Strategic tree and building placement can reduce annual energy use for heating and cooling by as much as 10 percent. To help cool buildings in the warm months, trees can be planted or preserved on the west and east sides. To help retain heat in the cold months, construct windbreaks to the northwest of buildings and remove trees to the south of buildings up to a distance equal to the height of a tree, unless they are particularly valuable.

Consider replacing or moving trees.

Smaller trees sometimes can be replaced for less than it would cost to preserve them. Nursery plants can be placed in just the right locations and are often of equal or greater value than existing smaller trees. Usually it is more beneficial and effective to save larger trees, because larger trees can provide greater functional and

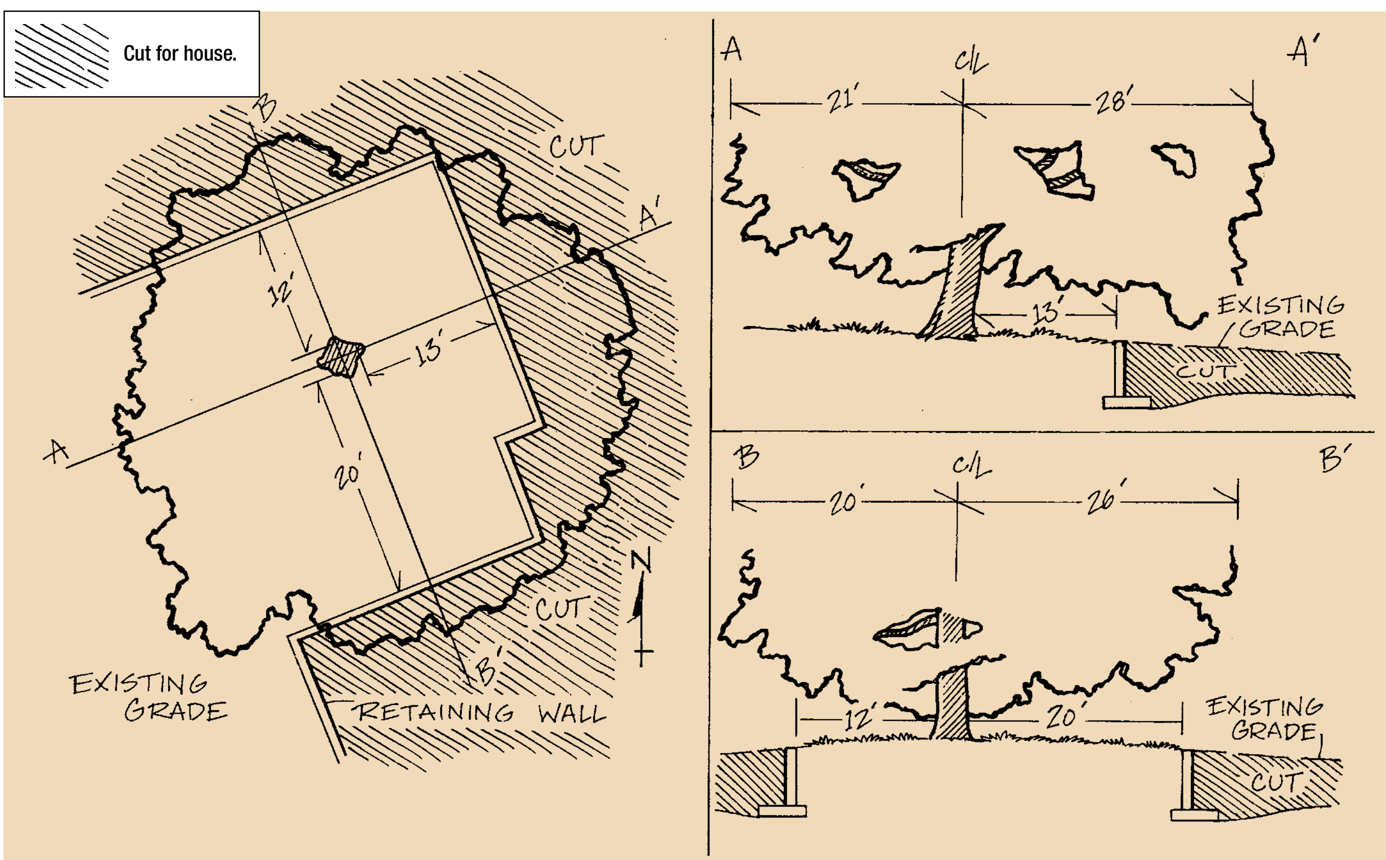


Figure 13. Information from a tree report and tree preservation plan can be used to prepare plan and elevation drawings of proposed construction impacts to trees. These drawings help developers visualize the impacts soil compaction and required limb and root pruning will have on trees.

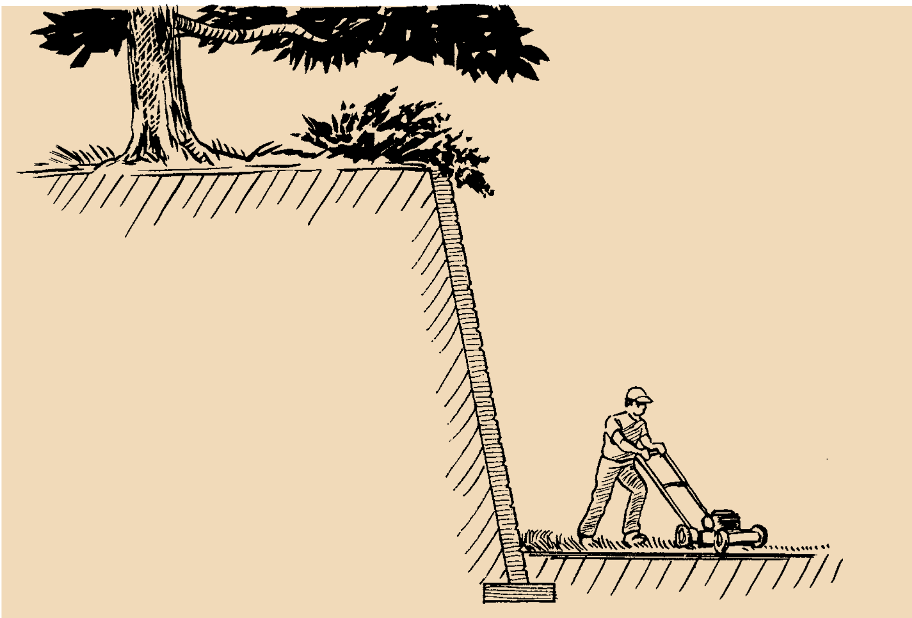
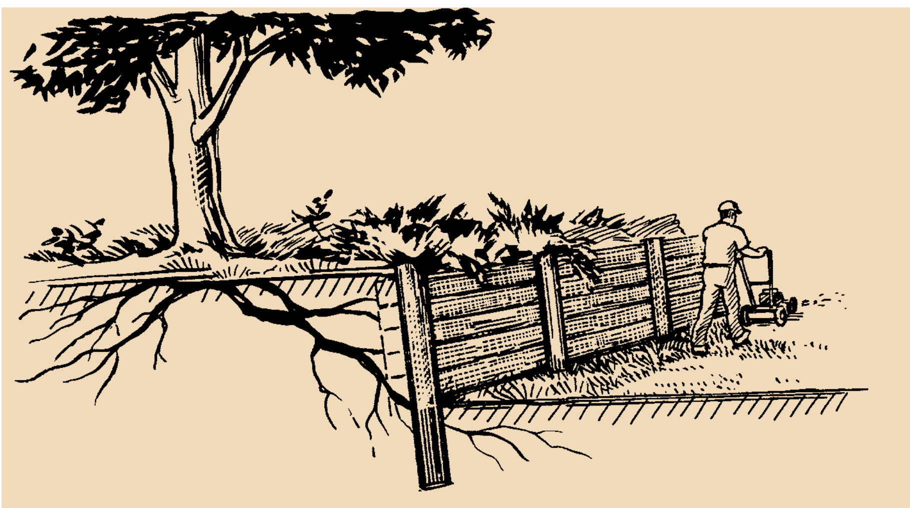


Figure 14. Crib walls can be used to limit the length of manufactured slopes, providing more room for trees and development.



aesthetic benefits and have surprisingly high monetary values in landscapes. The International Society of Arboriculture's *The Guide for Plant Appraisal* (International Society of Arboriculture, Savoy, IL) can be used to appraise the value of trees in developments. In Pennsylvania, a tree with a 25-inch trunk diameter could be worth as much as $10,000.

Existing trees could be transplanted to other locations on the site. Trees that are 4 inches DBH or less could possibly be moved with backhoes or other equipment already owned by most contractors. However, such an operation requires a knowledgeable and experienced person to be successful. Tree spades or other equipment for moving trees up to 10 inches DBH are available in many communities. Larger trees can be moved with cranes and other special equipment, but the relocation costs may exceed the costs associated with saving them at their existing locations.

The transplanting process requires cutting many of a tree's roots, which puts the tree under severe stress. Even with special care, such as staking, irrigation, and fertilization, it often takes several years for a larger tree that has been transplanted to regenerate enough roots to continue growing at a normal rate. All of these factors and costs must be considered when deciding whether it is better to preserve a tree at its existing location, replace it with nursery stock, or relocate it on a construction site.

Figure 15. Attractive retaining walls can be used to limit the size of fill and cut slopes, increasing the size of a tree's protection zone.

Consider cluster development and other alternative subdivision designs.
Developers of larger projects may wish to consider setting aside groves of trees to provide recreation, wildlife habitat, and other environmental benefits. Because of these benefits, it is often desirable to incorporate groves of trees into a development's landscape.

Trees growing in groups have adapted to each other and to their light, wind, and soil conditions. These conditions change when exterior or interior trees in a group are removed. The remaining trees may be subject to windthrow, sunscald, altered soil conditions, and altered water availability.

Cluster development can be used to preserve trees and other natural resources in developments. However, it may conflict with local zoning and subdivision ordinances or with the traditional philosophies of builders. The following practices can help create space for trees and other natural resources:

- Complete a natural resource inventory that identifies important views, riparian areas, paths, and other resources.
- Design grading and site plans to meet specific site characteristics.
- Keep front yard setbacks to a minimum.
- Keep areas of turf and grass to a minimum.
- Use step-down or other types of foundations that reduce grading.
- Keep the width of roads to a minimum.
- Delete or rearrange lots to provide more space for trees.
- Design developments in a clustered format.
- Work with municipal officials to explain the advantages of creative subdivision design.

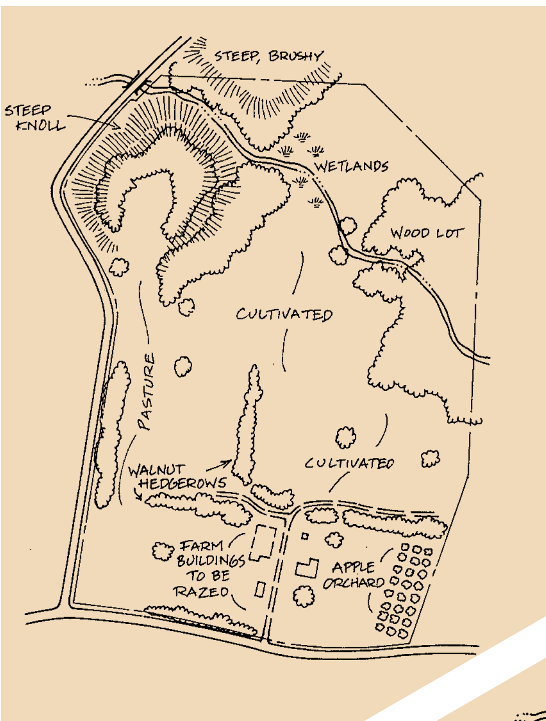


Figure 16. A natural resource inventory identifies all important natural characteristics of a site.

Figure 17. Traditional subdivision design provides for the maximum number of minimum-sized lots and does not consider preserving woodlots or other natural features.

Figure 18. Cluster development can be used to protect development densities while preserving woodlots, meadows, and riparian areas.

Construction Activities

All of the work put into the tree report and the tree preservation plan can be lost through carelessness. It only takes a moment for a piece of heavy equipment or a person with a chain saw to injure or kill a tree that was selected for preservation. Other construction activities, such as the cleaning of cement trucks and paint equipment, can seriously injure or kill a tree. Developers, contractors, and home builders must take every precaution to ensure that trees designated for preservation are not injured during construction. This requires that trees be protected by fenced tree protection zones and that workers be properly instructed and monitored.

Protecting Trees During Construction

Contractors, equipment operators, and workers should be informed of the importance of protecting trees that have been selected for preservation. This message can be reinforced by establishing penalties that must be paid if trees are injured or killed during construction. Penalties should be large enough to emphasize that large trees can be worth thousands of dollars and even small trees can cost hundreds of dollars to replace. The value of injured or killed trees can be appraised by qualified arborists using the International Society of Arboriculture's *Guide for Plant Appraisal*. In addition, lot owners or home builders can have tree preservation terms written into their contracts with developers and contractors. The following recommendations should be implemented to help protect trees during the construction phase.

Using the tree report and tree preservation plan to evaluate trees in the field.
Proposed tree encroachments can be staked in the field so that needed root and canopy pruning and tree removals can be completed before construction begins. Staking curblines, foundations, and other elements also allows for additional evaluation of tree protection techniques, such as retaining walls, before construction begins. Lay out temporary roadways and storage areas.

Hurricane or other protective fencing should be placed around a TPZ to physically protect trees.
Fencing provides a protective barrier and also reminds workers that protecting trees is important. Contractors and workers often want to change or move fencing to make adjustments for construction activities that were not adequately planned and designed. Fencing should be checked periodically and people involved in a project informed that moving a fence is not acceptable.

TYPES OF CONSTRUCTION INJURY

- Soil compaction or pollution
- Root removal and wounds
- Disruption of mycorrhizae and other beneficial soil organisms
- Trunk and butt wounds
- Branch wounds
- Leaf injury
- Unwarranted tree removal

SYMPTOMS OF CONSTRUCTION INJURY (SOIL DESTRUCTION)

- Reduced canopy density
- Reduced leaf size
- Lighter green color of the foliage
- Branch/canopy dieback
- Development of early fall color or leaf drop
- Suckers or epicormic shoots from damaged roots
- Long-term decline in health

Figure 19. Without a tree protection zone, trees and soils can be severely damaged by construction activities. Damage can lead to either fast decline in health or a very slow decline and eventual death.

Do not raise or lower the natural soil level within a TPZ.
Raising the grade within a TPZ by adding or "filling" soil reduces water infiltration and air exchange in the soil around the roots. Lowering the grade or "cutting" soil removes both soil and tree roots, and also damages the roots that remain. Filling or cutting soil within a TPZ can severely injure or kill a tree.

Consider impacts away from important trees.
Construction activities well outside the tree protection zone also can have detrimental effects on a tree's health. For example, cuts and fills can affect natural aquifers and drainage patterns. Large manufactured slopes created by cuts uphill from trees can remove their water source, or increase erosion. Compacted fills and retaining walls on the downhill side of trees can act like dams, causing water to accumulate. Positive drainage should be provided for preserved trees where needed. Effects of grading on important trees should be evaluated.

Do not store materials or operate equipment near or under trees.
Transporting, handling, and storing building materials and supplies near and under trees can compact the soil, which kills and injures tree roots. In addition to injuring tree roots, construction equipment can break limbs or wound bark. Equipment should not be operated in the TPZ and nothing should be stored in it, including fuel, chemicals, soil, and construction materials.

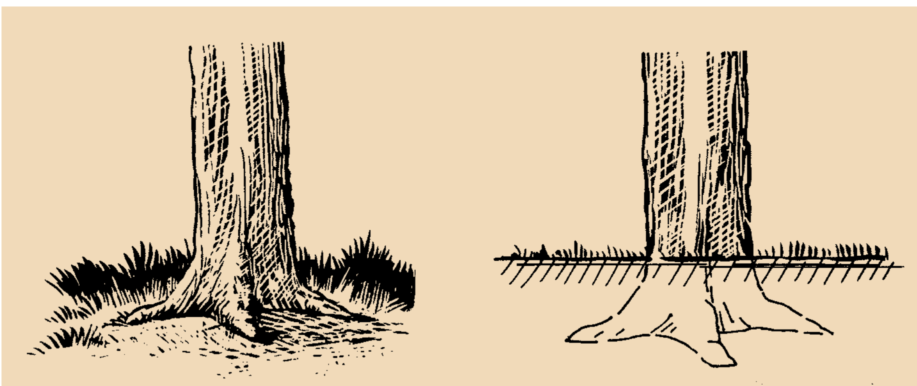


Figure 20. Do not raise the natural soil level within a TPZ. Trees that have been buried in fill can be identified by a lack of root flare.

Figure 21. Cutting or lowering the soil level near a tree severely damages tree roots, leading to a decline in health and even to death.

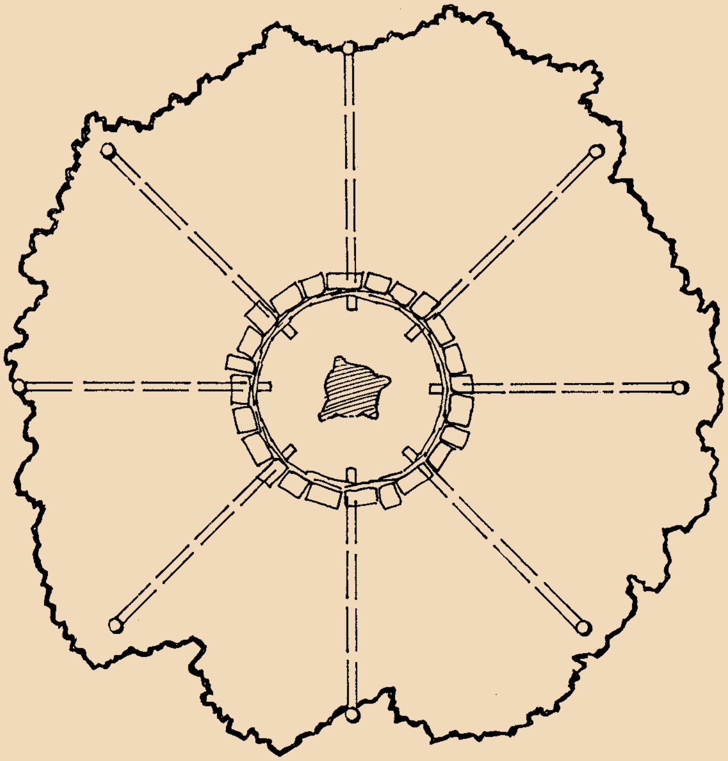
Do not pollute the soil within a TPZ.
Arrange for proper disposal of construction waste. Soils may be polluted by the on-site disposal of construction residues, petroleum products, or other chemicals. Lime-based products such as cement and plaster can dramatically raise the alkaline level of the soil. Many trees, such as pin oak, red maple, and sweetgum, cannot tolerate high pH or alkaline soils. Burying rocks and other debris near trees can damage and inhibit their root growth. The pollution of soils must be prevented if they are to support root growth.

Designate specific sites for equipment cleaning or disposal of construction debris.
Do not bury construction debris to avoid the cost of hauling and disposal. Only sites that are well away from tree preservation or planting areas should be designated for equipment cleaning and disposal of debris.

Use construction designs that minimize soil compaction for streets, parking lots, driveways, and patios.
Streets and parking lots can not support their own weight, so soil compaction is a requirement for standard asphalt or concrete construction. Self-supporting or permeable asphalt or concrete sections for streets and parking lots can be engineered and constructed around trees of high value.

Use aeration and other special preservation systems only when absolutely necessary.
If nonstructural fill is to be placed and lightly compacted within a tree protection zone for a parking lot or other hard surface, an aeration system can be used to assist in the infiltration of water and air. These systems should be designed and installed by professionals. Self-supporting and permeable surfaces are one example of an aeration system. A properly installed aeration system can also consist of a flexible drainage system.

In the past, aeration design has specified using 4-inch perforated PVC pipe. However, roots can grow into, and clog, the perforations. Wrapping the pipe with geotextiles would help alleviate this problem, but the process can be time-consuming and cumbersome. Also, the arrangement of the holes along the pipe keeps a relatively low percentage of soil area open to aeration and drainage. Some of the disadvantages of the 4-inch perforated PVC pipe may be avoided by using a flexible drainage system.



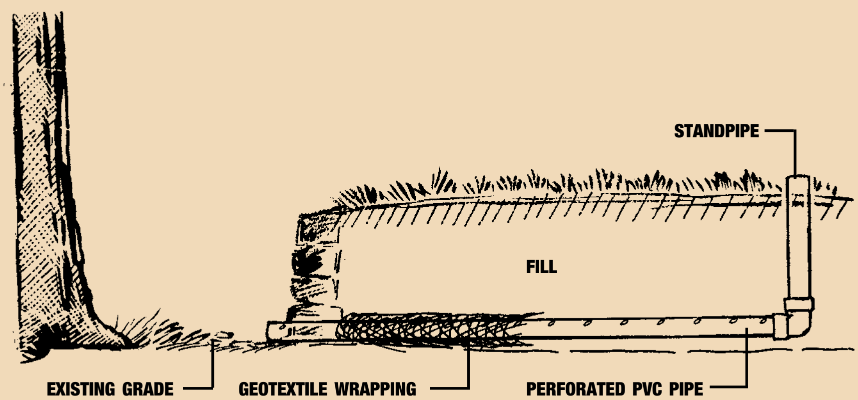


Figure 22. Aeration systems should be designed by professionals and used only when absolutely necessary. The effectiveness of aeration systems is debatable. Some of the disadvantages of 4-inch PVC pipe may be avoided by using a flexible drainage system.

A variety of flexible drainage materials currently are available. They all have a flexible plastic core that is wrapped with geotextile. The plastic core is made in a wide variety of forms that are designed to allow for large open spaces for drainage and aeration. The major variations between them are structural strength/load-bearing capacity and water flow potential.

The choice for the most appropriate style of flexible drainage material should be based on an assessment of site conditions and use. For example, if the site requires significant drainage measures and a connection to a storm sewer, it may be advisable to use the higher-density corrugated plastic drain. If the primary function of the system is aeration, a waffle-like plastic core will be sufficient.

Since the flexible materials are prewrapped with geotextile, installation is quicker and simpler than installing PVC pipe. Most of these materials can be fitted to pipes of other sizes and dimensions, so transition is possible to the pipes that extend to the surface, or to a storm sewer. Unlike the 4-inch perforated PVC pipe, the entire surface area of these flexible drain-age materials allows for maximum dif-fusion of air and water to expanding roots.

Use geotextiles for temporary roads and storage areas.
Soil compaction destroys soil structure, which takes many years to develop. Soil structure directly affects the aeration, drainage, and water-holding capacity of a soil. An inexpensive and recyclable way of protecting soil structure is to use a layer of heavyweight geotextile covered with about 4 inches of wood chips. This system will support the weight of a loaded cement truck and can be used on all construction sites for temporary roadways and materials storage areas.

Retain a qualified arborist to perform tree maintenance services.
An experienced arborist can monitor tree health before and during construction. If necessary, this specialist can then water or fertilize the trees, or provide treatment for a pest or disease problem. Although care should be taken when working around all trees, some trees are more sensitive to construction than others. For example, older and larger trees may need specialized attention, such as fertilization and irrigation, if they are disturbed by root pruning, soil compaction, or other construction activity.

Retain a qualified arborist to perform all required pruning.
Construction workers untrained in pruning or other arboricultural practices often unintentionally damage trees while trimming them. Construction workers who trim trees often leave branch stubs, tear the bark, or remove more branches than necessary. The tree preservation plan should identify which limbs must be pruned to accommodate construction. Required pruning and removal of limbs can be better understood by staking construction footprints. Pruning should be based on the tree preservation plan and be performed by a qualified arborist before construction begins.

Retain a qualified arborist to perform all required root pruning.
A tree's tolerance of root loss may vary greatly depending on its age, species, and health, as well as rainfall and soil quality. Some healthy young trees can survive after losing 50 percent of their roots, although their structure may be compromised. Other species are extremely sensitive to root pruning and soil compaction. Avoid disturbing more than 25 percent of the roots within the dripline for any tree and do not disturb any roots within the dripline of old, valuable, or sensitive trees. Hire an arborist to provide supervision when exposing roots close to large, historic, or notable trees. Any root pruning should

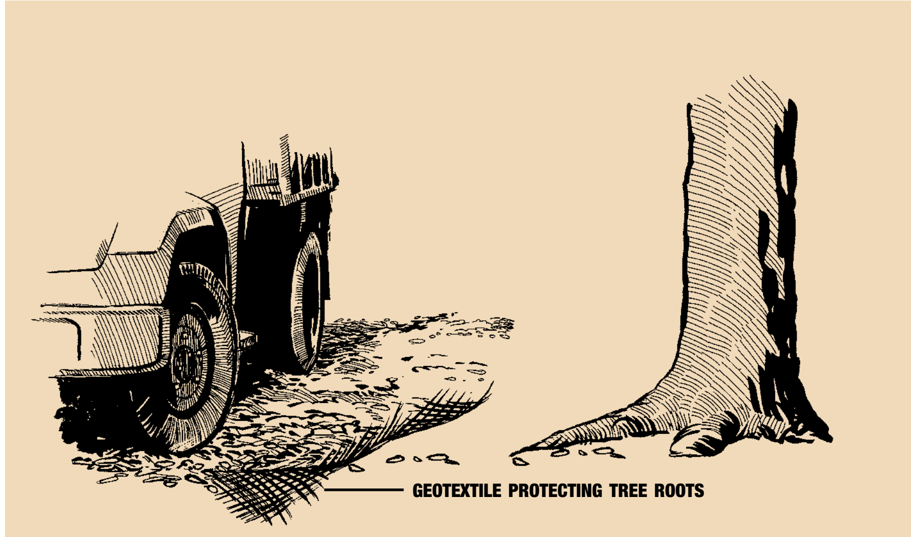


Figure 23. Two to 4 inches of mulch placed on a geotextile sheet protects soils from compaction caused by construction equipment and material storage.

Figure 24. Pruning should protect a tree's natural form. Well-pruned trees are similar in form and appearance to trees that have not been pruned.

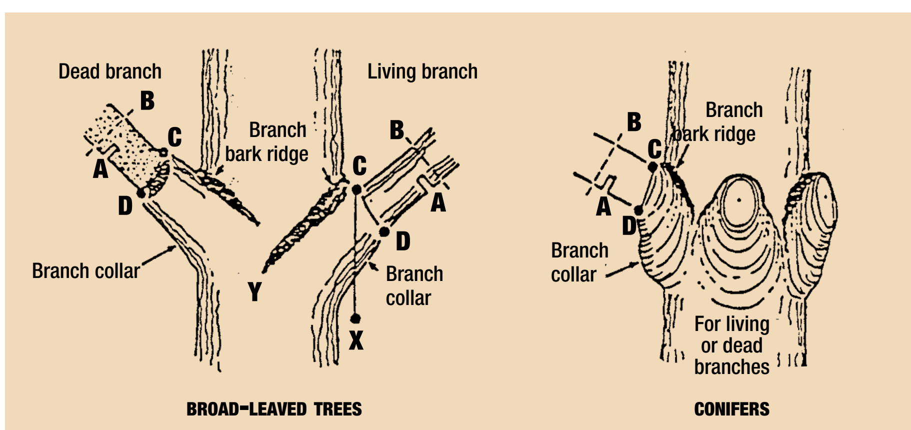


Figure 25. Natural Target Pruning properly removes a branch while protecting the branch collar, which is essential for wounds to heal. First cut A, second cut B, and third cut C-D.

be done by, or under the direction of, a qualified arborist.

Consider using hand labor to expose roots in cut areas needed within or adjacent to a TPZ. Exposing roots with a backhoe or other piece of equipment can tear roots, resulting in damage and decay. Instead, dig with hand tools to expose roots that may interfere with construction. During hot weather, wrap all roots exposed by trenching with dampened burlap if there is a delay in deciding whether the roots should be preserved. If a footing or curb is being constructed, conflicting roots should be severed cleanly with a saw. Newly pruned roots over 3 inches in diameter should be protected from drying by covering the cut end of the roots with a plastic bag secured by a rubber band. During hot weather, cut areas where tree roots are removed or exposed should be covered with black plastic and kept damp until it is time to complete the work.

Do not excavate utility trenches through a TPZ. Injuring roots kills trees. The root systems of trees can be severely injured by trenches that are dug directly through them. Relocate utility trenches or use tunneling or boring equipment when installing underground utilities through a TPZ. Trenching with backhoes and other equipment can destroy entire root systems, while tunneling or boring under the roots has little effect.

Figure 26. When digging near trees suitable for preservation, the first cut should be made by hand labor with shovels under supervision of an arborist. Exposed roots should be neatly cut with a sharp saw. To protect them from drying out, the ends of severed roots can be covered with a plastic sandwich bag held in place by a rubber band.

Figure 27. After roots are exposed and cleanly cut, the soil around them should be watered and covered with black plastic during hot periods. Large equipment can be used for mass grading after tree roots have been protected.

Figure 28. Properly preserved trees will provide benefits for a lifetime.

Do not use a bulldozer to selectively remove trees.

Trees designated to be saved can be easily damaged by bulldozers during the removal of adjacent trees. When a bulldozer is used to remove a tree, the entire tree falls at once and its canopy can damage the branches and bark of adjacent trees meant to be preserved. Bulldozers also compact soils and destroy soil structure. Trained arborists can selectively remove trees without harming adjacent trees.

Use geotextiles and other alternatives for driveways and patios.

When constructing brick, stone, or concrete driveways and patios, it often is necessary to excavate the top 12 inches of soil and then compact the subsoil using heavy equipment. Geotextiles can be used to minimize the degree of soil compaction needed under driveways and patios. When installing interlocking pavers, use geotextiles underneath to minimize the need for compacting the soil. A sand base placed over lightly compacted soil should be covered with a geotextile material to support pavers, patios, or driveways. Wood decks are excellent alternatives to hard-surface patios in areas where trees have been preserved. No removal or compaction of the soil is needed and decks have the added advantages of allowing water and air to reach covered tree roots.

Do not remove the natural leaf mulch or organic litter from beneath trees.

Existing litter or supplemented mulch helps improve soil structure, allows better water infiltration, protects soil and roots from erosion, moderates soil temperatures, and adds carbon and nutrients to the soil. Keep turf away from trees and install landscapes using native shrubs and other plants that will not damage trees preserved and incorporated into development.

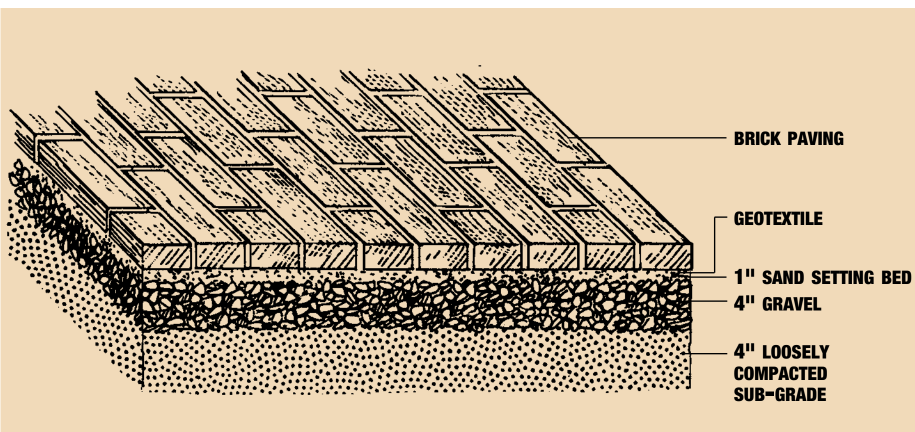


Figure 29. Brick patios and sidewalks can be designed to reduce soil compaction and root pruning.

Repairing Construction Injury

The most common causes of tree injuries are worker carelessness, grade changes, soil compaction, soil pollution, and the incorrect removal or trimming of trees. Depending on the extent of the injuries, trees may die shortly after construction is completed or their health may slowly decline over a number of years. Several techniques can help correct injuries caused by construction activities. Trees should be inspected for two years following construction for declining health, branch dieback, or poor foliage color.

HELPING INJURED TREES

- Keep tree well watered during dry periods
- Fertilize lightly
- Provide a covering of mulch
- Remove deadwood
- Keep all pedestrian and vehicle traffic away
- Consider vertical mulching

Soil Techniques

Understanding structural fills

Structural fills are used to key-in slopes and provide heavily compacted pads for construction. In a structural fill, all the soil is removed until a soil horizon with a certain compaction rate is found. Removed soils are then replaced upon the compacted soil while being compacted with water. It does no good to provide aeration systems or other preservation techniques or to remove fills of this nature from near trees because roots have already been severed in the fill process. Structural fills should be avoided within the TPZ of trees suitable for preservation.

Removing fill

Fill can kill trees quickly, or it can kill them gradually over a number of years. The effect fill has on trees depends on a number of factors. If construction activity has changed the grade under or near a tree, all efforts should be made to restore the area to its natural grade. Trees not surrounded by fill have a noticeable trunk flare at the soil line, while trees buried in fill have no trunk flare (see Figure 20, p. 16). Test holes can be dug at several points near the tree to determine how much fill has been added.

Fill can be removed safely within one year after construction. A backhoe can be used to remove fill to within 4 inches of the original grade, but the rest should be removed by hand with shovels and rakes. Fill that has been in place for several years requires care during removal, and a qualified arborist should be consulted. Some trees survive the initial application of fill because their roots grow into the fill. For trees covered by fill for long periods of time, fill within 4 feet of the trunk should be removed to expose the trunk and buttress roots. If it appears that many new roots have grown and become established in the fill, the excavation should stop and the fill should be replaced. Fill should not be removed during periods of hot, dry weather. Exposure under these conditions could shock a tree by drying out the roots as well as the soil around them.

The removal of fill can create a low spot around a tree that accumulates water. If inadequate drainage is a problem, a French drain or other drainage system must be installed to move standing water away from the tree.

Figure 30. Vertical mulching can help repair compacted soils and help trees recover from root systems damaged by compacted soils and root removal.

Repairing soil structure using vertical mulching

The poor structure of compacted soils can be improved by carefully drilling lines of holes in a concentric pattern beneath a tree. Each 2-inch diameter hole should be drilled to a depth of 12 to 18 inches (without injuring any large roots). The holes should be 2 feet apart, with the inner circle of holes located 3 feet away from the trunk and the last circle located 5 feet outside of the tree's dripline.

These holes can be left open or filled with a mixture of coarse sand and composted organic matter. The organic matter can be anything from composted leaves and grass clippings to composted sewage sludge. The sand gives the mixture some weight and strength, while the organic matter provides a food source for the soil microorganisms that are needed to help redevelop the soil structure. This process of filling the holes is called vertical mulching, and it is still experimental.

The structure of soil that has been damaged by compaction will return very slowly. It usually takes many years for the soil's drainage and aeration characteristics to return to their preconstruction levels. Compacted soils also can be helped by placing 3 to 4 inches of organic mulch over as much of the root system as possible. Keep this mulch several inches away from the tree trunks.

Replacing damaged soil

Soil that has been polluted or damaged beyond repair by pollution or heavy equipment should be removed and replaced. Damaged soil near trees should be removed with hand tools to avoid any further damage to roots. Although it may be better to use an ordinary top soil from the site or the locality, a loam-based soil that contains a balanced mixture of sand, silt, and clay also can be used. It should contain at least 1.5 percent stable organic matter. Soils with lower amounts of stable organic matter should have their levels of organic matter raised to 5 percent by adding composted yard wastes or sewage sludge. Replacement soils should not be ground or tilled too finely, as these processes destroy soil structure.

Tree Techniques

Tree injury

Tree limbs that have been broken or torn off during construction should be pruned according to recognized standards by a qualified arborist. If a tree trunk or butt has been damaged, the wound can be treated by removing dead and injured bark from around the wound with a sharp knife. Cut the loose bark away from the wound to form a clean, smooth surface of healthy wood and bark. Take care not to damage healthy tissue and do not widen the wound any more than necessary to remove damaged bark. Tree wound dressing does not stop decay and should not be used on limb or trunk wounds.

Fertilizing

There are no general fertilizing recommendations that apply to all soils and trees. Healthy, vigorous trees usually do not need to be fertilized at all. To determine fertilizer needs, a soil test must be taken and analyzed by a reputable laboratory. This test is needed to determine the soil's pH and basic nutrient levels. Major nutrients include phosphorus, potassium, magnesium, and calcium. The laboratory should provide recommendations about how much of each of the basic nutrients should be applied.

There has been a considerable amount of debate among highly respected arborists over the best method of applying nitrogen to trees that have been injured and placed under stress by construction activities. Some believe that high amounts of nitrogen should be applied to increase the tree's foliage production. Additional foliage would increase the photosynthetic capacity of the tree, which in turn would result in the production of more energy-rich carbohydrates. The tree could then use the additional carbohydrate to replace roots that were injured during construction.

Others feel that only low amounts of nitrogen should be applied to prevent undue stimulation of growth and the development of too much foliage, which might reduce already low energy reserves in a stressed tree and require more water than the damaged root system could provide. Too much foliage could therefore cause increased stress to the entire plant. We recommend that nitrogen-based fertilizers be applied in slow-release forms in light to moderate amounts.

Recipes do not guarantee the correct application of fertilizers. The tree and the site that it occupies must be understood before fertilizing can be used in a beneficial manner. It is best to have a recommendation from an arborist or other specialist for a specific tree. To provide some guidance, a general recommendation for the application of fertilizer for a tree injured by soil compaction or root damage is to supply 2 to 3 pounds of slow-release nitrogen per 1,000 square feet of surface area to be fertilized. An example of surface area that should be fertilized is the area beneath a tree's canopy. If part of the root system is covered by a paved surface, apply a higher rate to the part that is not covered. Do not apply more than 3 pounds of nitrogen per 1,000 square feet. To calculate the pounds of fertilizer needed to supply a certain amount of nitrogen, divide the amount needed by the nitrogen percentage of the fertilizer. For example, if 80 pounds of nitrogen were needed, and a 25-14-14 fertilizer were being used, you would divide 80 by 0.25. The result would be 320 pounds of fertilizer. The fertilizer should be broadcast evenly beneath and slightly outside the dripline of the tree. Fertilizer can be broadcast over turf. Combining fertilizer with vertical or broadcast mulching can increase the overall benefit to injured trees and soils.

The timing of fertilizer application also is under debate. One recommendation is to apply fertilizer to young trees before leaves are formed in the early spring to promote growth. Fertilizer should be applied lightly for mature and old trees in late summer or early fall to promote nutrient storage.

Irrigation

During periods of hot weather and little rain, irrigation can be used alone or in combination with fertilizing to improve the health of a tree that has been heavily damaged by soil compaction or root removal. In the northeastern United States, a thorough soaking by rain every two weeks during the growing season is more than adequate to meet the needs of injured trees. *Irrigation is not necessary when rainfall is adequate*.

When trees have been injured by construction and are experiencing periods of drought or hot weather, the amount of water needed for irrigation can be estimated by measuring a tree's DBH and using 20 gallons of water per inch of measured diameter. For example, a tree measuring 10 inches DBH would require 200 gallons of water applied once a week during a drought period. Apply the water slowly and deeply by soaking or injecting the soil. In clay soils, apply water first and allow it to soak in, then apply it again. A water furrow or basin may be required to contain water when irrigating through soaking. *Do not cultivate near a tree to construct a water furrow*. Water should be applied within the outer two-thirds of the tree's root zone, or dripline. Large trees require more application points. Allow the soil near a tree to dry between irrigations. In most cases only one irrigation is necessary to assist a tree through a drought period.

To determine water flow, place a hose in a five-gallon bucket. Keep track of the time that it takes to fill the bucket. If it takes five minutes to fill the bucket, then you will know that the flow rate is 1 gallon per minute and it will take 100 minutes to apply 100 gallons. Use common sense when applying large amounts of water. Take your time and avoid causing erosion or flooding of surrounding areas. Move the hose around the tree to irrigate the entire area.

After Construction

Despite the fact that a tree or woodland is preserved and incorporated within a development, some trees are likely to die each year because of the additional landscaping and construction activities of homeowners and inadequate tree care and maintenance. Various activities can injure a tree. These include grading; trenching and paving; building sidewalks, driveways, pools, patios, and home additions; landscaping lawns and lots; and pruning trees incorrectly by topping. Homeowners should provide proper care for preserved trees and should design compatible landscapes and amenities that protect the health of the trees. The following practices can help ensure that trees will remain healthy long after construction has been completed.

Supply homeowners with information.
Developers and realtors can supply home buyers with simple information about the value of their trees, how they can be protected, and experienced arborists in their area.

Keep competing vegetation, especially grasses, as far away from trees as possible.
Not only will grass compete with trees for water and nutrients, it also may produce chemicals that inhibit the growth of trees.

Consider alternative landscaping.
The areas beneath trees should be covered with mulch or planted with native ground covers. There are many species of native plants that provide a variety of sizes, colors, and forms for landscaping beneath preserved trees. A landscape can be created that not only protects trees, but also highlights native plants, conserves water, and reduces the need for fertilizers and pesticides.

Use mulch.
Mulch provides many benefits for trees. It moderates soil temperatures, reduces soil moisture loss, reduces soil compaction, improves soil structure, provides nutrients, and reduces winter drying. Mulch also keeps mowing equipment away, thus avoiding serious bark injuries. These benefits result in more root growth and healthier trees. Observe the following guidelines when applying mulch:

1. The best mulch materials to use are composted leaves, wood chips, bark nuggets, or pine needles. Avoid plastic, stone, sawdust, finely shredded bark, and grass clippings.
2. Mulch should be applied from the dripline to the trunk, but mulch should not be placed against the trunk. The mulch will retain too much moisture if left against the trunk, which may result in disease and decay.
3. If it is not practical to mulch from the dripline to the trunk, minimum mulch circles should be 3 feet for small trees, 8 feet for medium trees, and 12 feet for large trees.
4. Before applying mulch it is best to kill grass with an approved herbicide. Mulch should be applied directly to

Figure 31. Many species of native plants can provide a variety of sizes, colors, and forms to interesting landscapes. Keeping grasses away from preserved trees can increase a tree's health and appearance.

the soil surface or on top of the dead grass; plastic barriers should not be used.

5. The mulch layer should be 2 to 4 inches deep—do not create mulch mountains.
6. To avoid root disturbance, mulch should not be removed. Additional mulch can be added yearly to maintain a 2- to 4-inch depth.

Improve the aeration and drainage of compacted soils.

Aerate compacted soil if the final landscape has already been installed, or if there are large trees on the site that have roots growing throughout the compacted area. Aeration can be done to shallow depths with standard core aerators, or to deeper depths by vertical mulching with power drills or augers.

Prevent additional soil compaction.

Build wooden decks instead of cement or stone patios. Cement or stone patios require the removal of soil and the compaction of the base. Use mulches, preferably with a geotextile base, to prevent compaction in heavily used areas or storage areas.

Irrigate and fertilize when needed.

Follow the recommendations in the construction injury section for irrigating and fertilizing trees damaged by construction.

Provide proper maintenance.

Trees are often severely damaged by topping and other improper pruning methods. Employ only qualified arborists to prune and perform other maintenance. Newly planted trees should be well cared for. Irrigate newly planted trees during dry periods for the first five years to increase establishment and growth.

For More Information

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Notes

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