Soil compaction problems can be prevented by keeping foot and vehicular traffic away from shade trees. To avoid soil compaction, cars and heavy equipment should stay clear of a boundary three times the distance between the drip line and the trunk. If detected early, soil compaction problems can be corrected through aeration of the soil. The soil should be loosened to a depth of six to eight inches using a tool with a small diameter, such as a crowbar. Never plow or rototill under a tree.

Symptoms caused by soil compaction are similar to those caused by changes in grade. Early fall coloration and/or minor twig dieback beginning in the top of the tree are early symptoms of decline brought on by soil compaction. If the compaction problem is not corrected, the trees will eventually die.

Soil compaction and other site disturbances weaken trees and predispose them to disease infections and insect infestations. These are referred to as secondary disease and insects. Often, diseases and insects are attracted to trees in early stages of decline, before the tree begins to express visible symptoms of decline. This complicates the diagnosis and often leads to misdiagnosis of the primary problem. Canker and root rot diseases are more likely to attack trees that are stressed due to site disturbances. In addition, wood borers and other disease-carrying insects are attracted to stressed trees.

Eleven Steps in Diagnosing Decline

1. Walk completely around the tree, stopping on four sides to note any obvious damage or symptoms on the crown or trunk.
2. Use a soil core sampler on four sides of the tree, taking core samples on each side in a zigzag pattern from the trunk to beyond the drip line. This provides information on the soil type and degree of compaction.
3. Carefully inspect the trunk on all sides beginning at or below the soil line. If there is no natural root flare, it is worth digging around the base of the tree to find the depth of the fill. Absence of root flare is an indication of a raise in grade. In addition, young trees planted too deeply can rot below the soil line.
4. If the trunk has thin bark, use the point of a knife to probe in a spiral pattern from the ground to as high as you can reach. Tiny nicks should reveal bright green, moist tissue just beneath the bark.
5. Observe the twig growth extension on four sides of the tree. Comparison of several years growth will indicate how long the tree has been declining. Note the color change in a twig to determine last year's growth. Also look for a "scar" that encircles the twig between growing seasons. Inspect several twigs for an accurate "picture."
6. Look for bright green, moist tissue just under the bark at several points along the major limbs. Moist wood and good green color at the twig end, but dry wood and tannish-green color nearer the trunk may indicate that the tree is declining from the roots up. The reverse situation would indicate decline from the twigs inward.
7. Observe any changes in leaf size and color for clues about possible decline.
8. Observe the tree as you walk completely around it in the opposite direction.
9. Observe the condition of nearby plants. When unrelated species growing in the same general area are showing similar symptoms, it suggests that a man-made stress is occurring. Unrelated plants do not generally succumb to the same disease or insect.
10. Note how the information you have discovered might be affecting the tree. Always look at the whole tree. Don't focus in on only the damaged parts.
11. Remember, diagnosing tree problems is never easy. Keep in mind two major interfering factors when making a diagnosis:
    a) There is a lag time between cause and effect with most woody plant problems.
    b) The obvious problem could either be the primary problem or a symptom of a more major problem. For example, are the scale insects causing the decline, or is the decline attracting the scale insects?

Summary

Site disturbance is an important and often primary factor in the decline of established trees. Misdiagnosis is common due to secondary insect and disease invasion of the stressed trees. These problems are secondary, in that they are opportunistic organisms that tend to attack trees that have already been stressed by factors such as site disturbance. In these cases, decline or death is directly attributable to the site disturbance, with diseases or insects being contributing factors. Insects and diseases are not as likely to occur on healthy trees that have not been subjected to site disturbances.

Thousands of dollars are lost annually by new homeowners who unknowingly destroy trees in costly wooded lots through new construction or landscaping activities. Extreme measures must be taken to ensure that established trees that are to be retained in a landscape are not disturbed during construction, while landscaping a site, or by everyday activities.

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Site Disturbance and Tree Decline

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Retaining older, established trees in the landscape of newly constructed buildings, roads, sidewalks, or utilities is often a major objective of a landscape plan. Trees which are thought to be "saved" often go into a decline and die. In a few instances, the decline can be detected within a few months of the construction activity, but usually it is one to five years before a site disturbance produces obvious symptoms.

Site disturbance is a common and serious cause of tree decline and death in many landscape situations. However, it is not limited to construction site activities. Native and introduced trees are easily disturbed by a number of changes in their surroundings. Anything that alters a tree's natural site can be considered site disturbance. Compaction and grade changes beneath or within close proximity to trees are major types of site disturbance. Minor disturbances, such as suddenly exposing trees to direct sunlight by removing neighboring trees, mowing, fertilizing, mulching, and shallow cultivation, also have been observed to cause trees to decline and die.

Oaks are often the most commonly affected deciduous native species for Oklahoma. Pine trees and other conifers, native or introduced, also are highly susceptible to the activities described above. This fact sheet will focus on site disturbances that involve soil.

General Symptoms of Tree Decline

Trees affected by site disturbance often lapse into a progressive deterioration (decline) in health. Early symptoms of decline include leaves becoming smaller in size, early fall coloration, premature defoliation, and dieback of twigs and progressively larger branches beginning in the upper crown and moving downward. Sucker growth may become more prolific on the trunk and larger branches. Decline usually progresses from the top to the bottom of the tree. Leaf or needle drop may begin within the canopy near the trunk and progress outward, indicating a stressed tree which may be suffering from a root disease or disorder. Despite therapeutic intervention, most trees affected by decline eventually die.

Changes of Grade

Lowering of Grade

In general, the roots of established trees cannot tolerate significant changes in the soil depth. Removing soil from around trees is one of the most severe types of site disturbance. In many construction projects and in some landscaping projects, soil is removed to obtain a desired grade. This results in the roots being totally severed, injured, or exposed which leads to desiccation (a dehydration injury) of the roots. Also, the impaired roots fail to deliver adequate amounts of water and nutrients to the crown of the tree.

The results of cutting roots are obvious and should be avoided if possible. Lowering of the grade, which results in severing and exposing most of the root system, not only is detrimental to the tree's health, but also renders the tree structurally unstable. This is a common factor involved in tree failures which results in injury to people and property. Tree failures are often difficult to predict. Trees may fall unexpectedly, even without the assistance of wind.

Cutting large roots close to the trunk inflicts much more structural injury than cutting smaller roots near or beyond the drip line. Cutting roots on one side of a tree may lead to acute decline or death of only that half of the tree. Digging large pits for cellars or swimming pools can damage large, nearby trees. Not only are roots destroyed, but the water table can be adversely changed which can lead to a tree's demise.

Symptoms resulting from the cutting of roots are similar to symptoms produced by other types of site disturbance. There is a progressive decline of the tree, with the rapidity of the decline determined by the number and size of the severed roots.

Removing even small amounts of soil results in the roots becoming closer to or at the soil surface. When shallow roots, which absorb water, oxygen, and nutrients, are directly exposed to air and sunlight, they quickly dehydrate and die. It can be difficult for trees under stress to replace lost shallow roots; therefore, trees suffering from this condition usually enter a state of decline. Removing soil also destroys litter, duff, and organic matter which naturally accumulate beneath trees. Destroying these materials could cause changes in the soil moisture and temperature, resulting in damage to the root system.

Tree Preservation at Construction Sites

In many cases, it is impossible to avoid site disturbance during construction. In these situations, there are measures that diminish the injury to trees due to site disturbance. For

instance, if trenches must be dug near trees, the degree of damage can be reduced by careful placement of trenches to avoid large roots. Trees can be saved by tunneling under roots that are greater than one and a half inches in diameter (Figure 1).

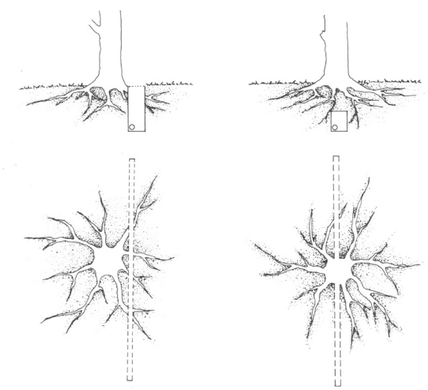

Figure 1. Tunnel beneath root systems. Drawings at left show trenching that would probably kill the tree. Drawings at right show how tunneling under the tree preserves many of the important shallow roots.

Precautions should be taken to avoid or prevent the removal of soil from within the area that contains the majority of the tree's roots. Inform construction workers of your desire to leave the soil beneath trees undisturbed and mark off the area with stakes and tape. Remember to stake off an area at least three times larger than the tree's drip line.

Injury resulting from significant lowering of the grade can be decreased or prevented by terracing the new slope around the tree, rather than cutting the soil away in a uniform gradient. The terrace should extend at least to the edge of the tree crown and be supported by a retaining wall (Figure 2). In this manner, the original soil depth and many of the conducting roots will be preserved.

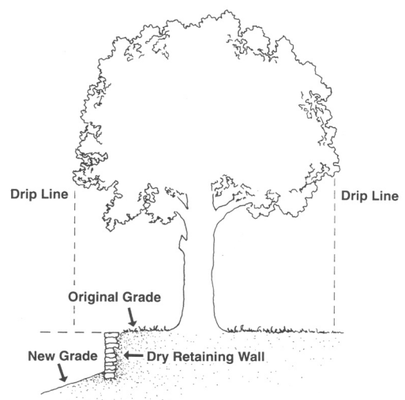

Figure 2. Construct a retaining wall when grade is lowered.

Raising of Grade

Raising the grade or adding soil over the roots of an established tree is not recommended. In fact, soil should never be piled, even temporarily, over the roots of trees that are to be preserved. Many of the roots that absorb oxygen are within the top three to six inches of soil and extend two or three feet beyond the drip line (Figure 3). Adding soil will produce near anaerobic conditions that often result in suffocation of the roots. The degree of suffocation is directly related to the depth of soil added. Toxins are often produced by bacteria which thrive under the anaerobic conditions created by the added soil, thus further jeopardizing the tree's health. Established trees and newly transplanted trees will suffer if not planted at the proper depth. Never add fill soil over the top of the root ball of transplants. This, in essence, is raising the grade.

Early symptoms of decline caused by raising the grade are the same as the symptoms described for other types of site disturbance.

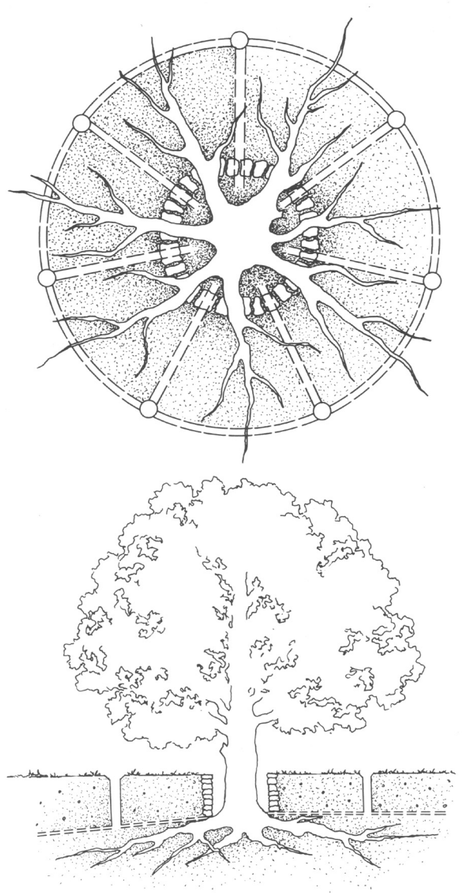

Figure 3. Typical root system for most Oklahoma-grown trees. Note that many roots are shallow and extend well beyond the drip line. Ideally, compaction, fill, and excavation should be avoided well outside the drip line.

In situations where raising the grade cannot be avoided, trees may be protected by the installation of a system of gravel and drainage tiles around the root system (Figure 3). Tree owners wanting information on the gravel and tile drainage system can obtain detailed information from their local Extension office.

Planters

Caution should be exercised when constructing a raised bed to serve as a planter around the trunk of a tree. This is not a recommended practice, especially in the case of established trees. Soil in constant contact with the trunk is often detrimental to the health of the tree. Tree trunks do not tolerate prolonged exposure to soil moisture and soil microorganisms. Soil in contact with the trunk restricts the movement of oxygen and carbon dioxide into and out of the portion of the trunk covered by soil. Over a period of years, tissues in the lower trunk die which leads to root dieback and root collar disorders.

Symptoms of root collar disorders include the general symptoms of decline. In addition, the lower trunk near the area where the trunk joins the roots may develop collar rot. Collar rot appears as a sunken, discolored area at the base of the tree from which dark-colored sap may ooze.

Some species may tolerate fill over roots better than others, but all can be injured by raising the grade. Some species which are most sensitive to changes in grade are oak, dogwood, maple, and pine. However, other tree species are sensitive, depending on the degree of grade change, the environment, and other stress factors. The only time raised planters are safe is when the tree and planter are established at the same time. Constructing even a small raised bed around an established tree is strongly discouraged. It's true that everyone has seen trees that have tolerated this practice. However, more often than not, they are eventually injured or even killed. The fact that trees may appear "normal" for two to five years following the disturbance makes it difficult to link the decline to the construction of planters.

Covering Surface Roots

Another reason that grade is raised is to cover surface roots. This is not recommended for the same reasons given earlier, nor should the roots be removed. Either establish a shade tolerant turfgrass or carefully plant a ground cover in the affected area. Minimize the ground preparation for the turf or ground cover. Make plantings at the existing soil grade, rather than raising the grade in an attempt to improve the planting bed.

Soil Type and Mulch

The type of soil used to raise the grade also contributes to the effect on trees. Sand, gravel, or "light soils" cause fewer problems than clay-type soils. However, even sand, gravel, or "light" soils pose some hazard to trees when used to raise the grade. Obviously, asphalt or concrete placed over the roots of existing trees will cause suffocation stress similar to fill injury.

Another contributing factor to tree decline is improper mulching. Although not common, mulching material that is too deep or too heavy can impede gaseous exchange of the root system, thus causing injury to the tree. Never add more than three to four inches of mulches.

Detecting a Raise in Grade

An easy method to determine whether or not a tree has experienced a change in grade is to notice if the trunk flares out at the base. If the trunk lacks a flare and enters the ground in a straight line, fill has probably been added. It is very unusual for a tree's trunk to be the same width at the soil line as it is one to two feet above the soil line. If flare is not detected, carefully dig down and determine the depth at which the roots are located. If the fill is less than 12 inches deep, therapeutic treatment (soil removal) may be an option.

Therapeutic Treatment

Treatment of fill injury is futile if the fill is not removed within a relatively short period of time. If the added soil is left in place throughout the growing season, considerable root injury is likely to occur. Once injury is detected, it cannot be completely reversed by simply removing the fill.

If the fill is less than 12 inches deep and decline symptoms are mild or absent, therapeutic treatment can sometimes prolong the life of the tree. However, therapeutic treatments are controversial and have not been proven to be totally effective. It is suggested that before excess pruning is performed, one should try good irrigation and fertilization practices. However, some "tree experts" suggest treatments may be of benefit in restoring a balanced root:shoot ratio and stimulating new root growth. Therapeutic treatment consists of thinning the crown at least 10 to 20 percent on declining trees, and concentrating on the removal of all dead and dying branches. Trees showing mild or no symptoms may be thinned 10 percent a year for two years and watched carefully for at least 10 years. Additional thinning may be required if decline symptoms reappear. Phosphate fertilizer should be applied to the entire area under the drip line to stimulate root growth. Avoid heavy use of nitrogen, which stimulates foliage production, which may not be supported by a damaged root system.

Soil Compaction

Root growth and function are severely compromised in compacted soils. Foot traffic or vehicles driven across an area where trees are growing can result in the soil becoming more dense and less accommodating to movement of water and gases in and out of the soil. The organic content of the soil decreases and the clay content increases. This reduces the capability of the roots to absorb moisture, oxygen, and nutrients.

Certain species of native trees, primarily oaks, appear to be very sensitive to even low levels of soil compaction. Trees growing in areas where compaction has occurred may appear normal for several years, but eventually these trees will begin to show signs of decline often beginning with yellowing of the foliage (chlorosis). Off-colored foliage is particularly common in declining oaks. Unfortunately, once symptoms are detected, it is usually impossible to reverse the decline.

Areas of severe compaction usually do not support any type of vigorous growing vegetation except some weed species. Compacted areas can also be detected by utilizing a soil probe or spade. It will be more difficult to insert a probe into the soil of a compacted area as compared to a "low traffic" area.