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Protecting Trees from Construction Damage: *A Homeowner's Guide*

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This is a revision of the original publication authored by Nancy L. Miller, David M. Rathke,and Gary R. Johnson, and is dedicated to the memory of David M. Rathke.

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Are you planning to build or remodel a home? Are your city's streets, curbs, sidewalks, and buried utilities about to be widened, modernized, or replaced? Before you start, consider the impact of construction on plants.

Trees and shrubs contribute to property values by enhancing appearance, reducing noise, cutting energy costs, screening unsightly views, and attracting songbirds and other wildlife. Unfortunately, plants meant to be part of a home's permanent landscape often are needlessly damaged or killed during construction. Careful planning and coordination with a tree-care specialist and your builder can reduce damage and save you the trouble and expense of treating or removing injured plants.

This publication explains some things that landowners can do to minimize the impact of construction on trees. It describes landscape protection plans, special

construction techniques, symptoms of damage, and treatment strategies. Although the information presented focuses on trees, it also can be applied to protecting shrubs.

Hiring a Tree Care Specialist

Each construction site has its own unique set of soil, tree species, and building process conditions. For this reason we recommend that you get advice from a professional urban forester or arborist *with experience in protecting trees from construction damage*. This person will be familiar with the growth characteristics and common problems faced by tree species in your area. He or she can help you evaluate plant health and the likely impacts of construction activities.

For your own protection:

- hire only professionals who are part of an established business listed in the phone book
- ask for references
- make sure the person you hire carries insurance for property damage, personal liability, and workers compensation.

Membership in the National Arborist Association, Minnesota Society of Arboriculture, or International Society of Arboriculture or certification from the International Society of Arboriculture are good indicators of reputable businesses.

Check with your local Extension office, or contact the local chapter of the International Society of Arboriculture (217-355-9411) for a directory of tree-

care companies with certified arborists.

The Root of the Matter . . .

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Trees can be damaged or killed by a wide variety of construction activities. Some practices lead to obvious injuries such as broken branches or torn bark. Open wounds of this type deplete a plant's energy resources and provide entry points for insects, or for diseases such as oak wilt.

The worst damage, however, often remains hidden underground. Roots are one of the most vital parts of a tree. They are responsible for nutrient and water uptake, store energy, and anchor the plant. Because they are so important, it is critical that you protect roots that lie in the path of construction.

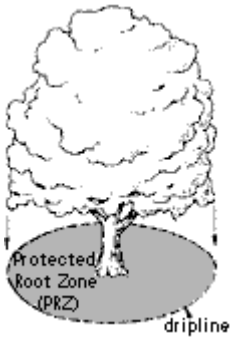

Figure 1. *One common method used to define a tree's protected root zone (PRZ) is to consider it to be the part of the roots that lie directly below its branches within an area known as the* ***dripline****.*

Trees are never the same shape below ground as they are above, so it is difficult to predict the length or location of their roots. Typically, however, approximately 90-95 percent of a tree's root system is in the top three feet of soil, and more than half is in the top one foot. The part of this root system in which construction damage should be avoided is called the Protected Root Zone (PRZ).

One common method used to identify the PRZ is to define it as the "dripline"--the area directly below the branches of the tree (Figure 1). However, many roots extend beyond the longest branches a distance equal to two or more times the height of the tree. For this reason you should protect as much of the area beyond the dripline as possible.

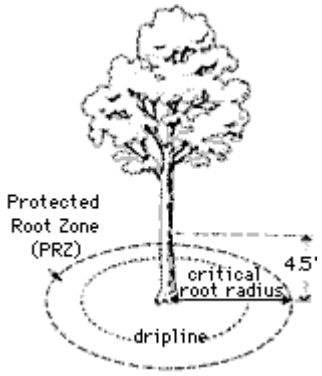

Figure 2. *Approximate a tree's* ***Protected Root Zone*** *by calculating the critical root radius (crr). First, measure the tree*

Unfortunately, on most sites space is limited and this rule must be bent. Just how close an activity can come without seriously threatening the survival of a tree depends on the species, the extent of damage, and the plant. s health. Some healthy trees can survive after losing 50 percent of their roots. However, other species are extremely sensitive to root cutting, even outside the dripline.

diameter in inches at breast height (DBH). Then multiply that number by 1.5 or 1.0. Express the result in feet.
Example:
dbh=8 inches
8 X 1.5 =12
crr=12 feet

Table 1 shows the relative sensitivity of various tree species to root disturbance. If possible, disturb no more than 25 percent of the roots within the dripline for any tree, protect intermediate species to the dripline, and allow extra space beyond the dripline for sensitive species. For all trees, avoid needless or excessive damage. A qualified tree-care specialist can help you determine how much root interference a particular tree can tolerate.

Measure diameter (width)=dbh

dbhX 1.5=critical root radius for older, unhealthy, or sensitive species

***or** dbh X 1.0=critical root radius for younger, healthy, or tolerant species*

When dealing with trees that have been growing in the forest or that naturally have a narrow growth habit, an approach called the "critical root radius" is more accurate than the dripline method for determining the PRZ. This is particularly true for columnar trees and for those where competition has reduced the canopy spread.

To calculate critical root radius, begin by measuring the diameter at breast height (dbh). This is done by measuring the tree's trunk diameter (thickness) at a point 4.5 feet above the ground. The measurement should be done in inches. For each inch of dbh, allow for 1.5 feet of critical root radius for sensitive trees, or 1.0 feet for tolerant trees. For example, if a tree's dbh is 10 inches, then its critical root radius is 15 feet (10 x 1.5 = 15). The PRZ is an area around the tree with a diameter of 30 feet (2 x radius), and is the area in which a critical amount of the tree's roots may be found. Whenever possible, isolate this area from construction disturbance (see Figure 2).

Table 1. Tree Characteristics

Species	Root Severance[6]	Soil Compaction & Flooding[6]	Soil pH Preference[8]	Mature Tree Height (feet)[8]	Mature Crown Spread (feet)[8]
Northern white cedar	Tolerant	Tolerant	6.0-8.0	40-50	10-20
Balsam fir	Tolerant	Tolerant	4.0-6.0	40-60	20-35
White fir	Tolerant	Sensitive	4.0-6.5	50-75	10-20
Tamarack	Tolerant	Tolerant	4.0-7.5	50-75	15-25
White pine	Tolerant	Sensitive	4.5-6.5	80-100	50-80
Jack pine	Tolerant	Sensitive	4.5-6.5	30-80	20-30
Red pine	Tolerant	Sensitive	4.5-6.0	50-80	20-40
Scotch pine	(Tolerant)	(Sensitive)	4.0-6.5	60-100	30-50
Eastern redcedar	Tolerant	Sensitive	4.7-7.8	40-50	10-20
Black spruce	Tolerant	Tolerant	3.5-7.0	30-70	15-30
Colorado spruce	Intermediate	Tolerant	4.6-6.5	50-100	20-30
White spruce	Tolerant	Intermediate	4.5-7.5	40-80	20-30
Black ash	Tolerant	Tolerant	4.1-6.5	40-70	30-60
Green ash	Tolerant	Tolerant	6.0-7.5	30-60	30-50
White ash	Tolerant	Intermediate	5.0-7.5	70-80	50+
Bigtooth aspen	Tolerant	Sensitive	4.8-6.3	50-75	20-35
Quaking					

aspen	Tolerant	Sensitive	4.8-6.5	40-60	20-35
Blue beech	Sensitive	Sensitive	6.5-7.5	20-30	15-20
Paper birch	Intermediate	Sensitive	5.0-8.0	50-70	30-50
River birch	Tolerant	Tolerant	4.0-6.5	40-70	30-50
Yellow birch	Intermediate	Sensitive	4.5-8.0	50-70	25-50
Boxelder	Tolerant	Tolerant	6.5-7.5	40-60	35-50
Ohio buckeye	Intermediate	Intermediate	6.1-6.5	30-50	30-40
Butternut	Sensitive	Intermediate	6.6-8.0	40-60	50-60
Catalpa	Intermediate	Tolerant	6.1-8.0	50-80	30-50
Black cherry	Intermediate	Sensitive	6.0-7.5	50-70	40-50
Kentucky coffeetree	Intermediate	Intermediate	6.5-7.5	50-80	40-50
Eastern cottonwood	Tolerant	Tolerant	5.5-8.0	80-100	80-100
Red-osier dogwood	Tolerant	Intermediate	6.1-8.5	8-10	10-12
American elm	Tolerant	Intermediate	5.5-8.0	70-100	70-150
Slippery elm	(Tolerant)	(Intermediate)	6.6-8.0	60-70	40-60
Hackberry	Tolerant	Intermediate	6.6-8.0	30-130	50+
Hawthorn	Intermediate	Intermediate	6.0-7.5	20-40	20-30
Bitternut hickory	Intermediate	Intermediate	6.0-6.5	40-75	30+

Honeylocust	Tolerant	Intermediate	6.0-8.0	50-75	50-75
Ironwood	Sensitive	Sensitive	6.1-8.0	25-50	20-30
Basswood	(Intermediate)	Sensitive	5.5-7.3	70-100	50-75
Black locust	Tolerant	Sensitive	4.6-8.2	30-60	20-50
Red maple	Tolerant	Tolerant	4.5-7.5	50-70	40-60
Silver maple	Tolerant	Tolerant	5.5-6.5	60-90	75-100
Sugar maple	(Intermediate)	Sensitive	5.5-7.3	60-80	60-80
Mountain ash	Tolerant	Intermediate	4.0-7.0	15-25	15-25
Black oak	Sensitive	Sensitive	6.0-6.5	50-80	50-70
Bur oak	(Tolerant)	Intermediate	4.0-8.0	70-80	40-80
Northern pin oak	Sensitive	Sensitive	5.5-7.5	50-75	30-50
Red oak	Tolerant	Sensitive	4.5-7.0	60-80	40-50
Bicolor oak	(Intermediate)	Tolerant	6.0-6.5	60-70	40-50
White oak	Sensitive	Sensitive	6.5-7.5	60-100	50-90
Wild plum	Tolerant	Sensitive	6.5-6.6	20-25	15-25
Serviceberry	Intermediate	>Sensitive	6.1-8.5	6-35	6-15
Black walnut	>Sensitive	Intermediate	6.6-8.0	70-100	60-100+
Black willow	Tolerant	Tolerant	6.5-8.0	30-60	20-40

1: Hightshoe, 1988; 2: Minnesota Association of Soil and Water Conservation Districts Fo and Clark, 1991; 4: Minnesota Society of Arboriculture, 1996.

Values in parentheses reflect the authors' or technical advisors' opinions.

***Hazard Tree Rating** refers to the relative potential for a tree to become hazardous. For a potential "target" (e.g., a house, a sidewalk, or other trees) must be present. A high hazard will always fail.

****Landscape Value** refers to the relative value of each species in Minnesota based on har flowering and fruiting characteristics, structural strength, longevity, insect and disease resi general desirability.

Plan Ahead!

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You'll save time and money if you develop a landscape protection plan before construction begins. Careful planning will help you avoid the expense and heartache of later repairing or removing trees located too close to construction activities.

Figure 3. *Careful planning may avoid the creation of hazardous tree situations such as damaged trees located too close to the house or dangerous overhanging limbs.*

These steps will help you create a successful landscape protection plan:

1. **Mark construction zone boundaries.** Obtain a complete set of site development plans, including the proposed location of buildings, drive-ways, sidewalks, and utility lines. Ask the builder or architect to mark areas where heavy equipment will be used, where soil will be permanently added or removed and to what depth, and where fill and building materials will be temporarily stockpiled. Use a measuring tape, stakes, and string to temporarily mark the boundaries of construction activities on the site.

2. **Inventory trees on the site.** Record the location, size, and health of each tree. Wilted leaves, broken or dead limbs, trunk rot, and thin tops are all symptoms of stress. Trees that are overmature, display poor form, lean heavily over future

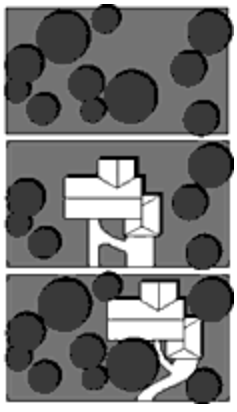

Figure 4. *You may be able to save some trees by siting the new*

buildings, or have severe insect or disease problems (Figure 3) should be marked for removal prior to construction. Also mark trees that need prun-ing to make room for future structures and construction equipment.

construction away from the center of the lot.

3. **Select the trees to be saved.** Examine the site carefully and note how each tree fits into the future landscape. Keep in mind that the builder may be able to shift the location of a building, utility line, or driveway. Although local ordinances differ, driveways and utility lines don't always have to be straight, and homes don. t always have to be in the center of the lot (Figure 4). If considerable damage to the tree's root system within the PRZ is inevitable, you should seriously consider changing the original design, adding protection measures, or removing the tree before construction begins.

4. **Protect the trees you plan to save.** Develop a map with the builder or architect showing the location of trees to be protected and the safest route for access to the building zone. Then install bright orange polypropylene fencing and post "Off Limits" signs at the PRZ of the trees you plan to save (Figure 5). Your primary objective is to protect delicate root systems, so provide your trees with as much space as possible. Make sure all construction workers know that nothing inside this area is to be raked, cut, stored, or otherwise disturbed. A landscape protection contract signed by the builder and all contractors will help ensure compliance. Take several photographs of the site before construction begins to document the protection methods used and the condition of individual trees.

5. **Prepare the trees for construction disturbance.** You'll boost your trees' chance for survival if you make sure they're as healthy as possible before construction begins. Regularly water the trees if rainfall is not adequate. Fertilize them if soil tests or deficiency symptoms indicate they are nutrient stressed. (For soil test information, contact your county extension agent or call the University of Minnesota's Soil Testing Lab at 612-625-3101.) Prune branches that are dead, diseased, hazardous, or detrimental to the plant's natural form.

6. **Protect and preserve the soil for future tree planting.** Apply a layer of wood chips at least six inches thick over areas that will be used for traffic or materials storage during construction. If these areas become part of the

new landscape, the wood chips will prevent the soil from becoming too compacted.

7. **Monitor the construction process.** Visit the site periodically and inspect the trees. Irrigate the PRZ of the trees regularly-- never let trees become water-stressed. Your presence alerts workers of your concern for the careful treatment of the trees. Should damage occur, begin repairs as soon as possible. Immediately inform the builder of any violations in the landscape protection contract and photograph the damage. Insist that protective fences remain in place until all construction workers have left the site.

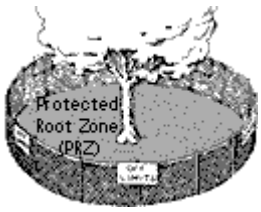

Figure 5. *Put up fences and signs around trees you want to save to alert construction workers to damage potential.*

8. **Make a final inspection of the site.** After construction has been completed, evaluate the condition of the remaining trees. Look for indications of damage or stress. It may take several years for severe problems to appear. Careful monitoring and preventive treatment (e.g., watering) may help minimize damage.

9. **Commit to long-term maintenance.** Trees will not recover from construction damage in one or two years. Mulch as much of the PRZ as you can tolerate and plant understory shrubs and perennials within the mulched areas. Irrigate the PRZ regularly for several years--never let the trees become water-stressed. Have an arborist inspect the trees every year or two for several years to determine if pruning, fertilization, and/or pest/disease control tactics are necessary.

Tree selection tips . . .

- Save the best and chip the rest. Use those wood chips to provide a blanket of protection over the root systems of trees that can be saved. It is expensive for the builder to work around trees,

and it also is expensive to remove damaged trees after construction has been completed.

- Understand the characteristics of your trees or get the advice of someone who does. If you know about your trees you can help insure their survival and improve the future site appearance of the site.
- Select tree species that fit the spatial constraints of the site (Table 1), remembering that trees grow throughout their lives. Be sure to consider overhead powerlines.
- Young, small trees tend to survive disturbance better than old, large trees. Large trees almost never survive within five feet of a new building and should not be kept.
- Healthy young trees that fall in the construction zone may be saved by transplanting.
- Don't put all your eggs in one basket! Save a mixture of tree species to safeguard your landscape against contagious diseases or insects.
- Improve tree survival by saving groups of trees rather than individuals.

Minimize the Impact of Construction Activities

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In addition to protecting the PRZ, there are other ways in which you can reduce the impact of construction activities on your trees. Some of these are relatively simple; others can be extremely expensive. Carefully consider the importance

of each tree to the future appearance of the site and consult a tree-care specialist before deciding whether protective measures are worth the cost.

Site Clearing

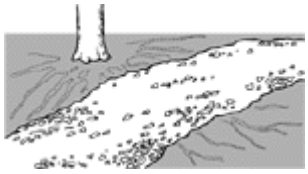

Figure 6. *A root system bridge will help protect trees in the path of construction vehicles.*

When you remove a large number of trees, you expose the remaining plants to new conditions. Sudden increases in amounts of sunlight and wind will shock many of your trees. It is not uncommon to find scorched leaves, broken branches, and uprooted trees after a site is cleared. Although some of these problems are temporary, they may compromise tree health when coupled with additional construction damage.

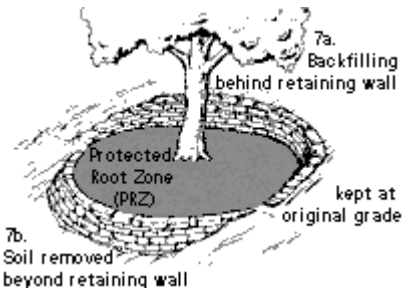

Figure 7. *If you change the grade within the root zone, use retaining walls to keep as much of the original grade as possible.* ***a)****backfilling;* ***b)*** *cutting.*

You can avoid sun and wind stress by saving groups of trees rather than individuals. When possible, remove the unwanted plants in winter after the leaves have fallen. Dormant plants are less susceptible to damage, and frozen ground helps protect roots. Bulldozers should not be used to remove trees near plants to be preserved. Heavily wooded sites should be gradually thinned over two to three years to reduce removal shock on remaining plants. This is especially important in dense pine, spruce, or fir forests.

Soil Damage

Soil compaction is the single largest killer of urban trees. Tree roots need loose soil to grow, obtain oxygen, and absorb water and nutrients. Stockpiled building materials, heavy machinery, and excessive foot traffic all damage soil structure. Lacking good soil aeration, roots suffocate and tree health declines.

Prevent soil compaction by carefully selecting storage areas and traffic routes (the future driveway is a good choice for both) and installing protective fences and signs. If you can. t reroute traffic, install root system bridges with steel plates suspended over railroad ties or spread several inches (six inches or more) of wood chips on the soil within the PRZ (Figure 6). Trees that are pruned or removed during the construction process should be chipped on site and the

chips used for soil preservation tactics such as this. Heavy mixing trucks can be kept off tree roots by transporting concrete from the truck through conveyor pipes.

Improper handling or disposal of materials used during construction also can harm roots. For example, wood products treated with pentachlorophenol and creosote can be deadly to tree roots; CCA-treated timber (greenish color) is a better alternative. Ask the builder about the materials to be used on the site and read product labels. Chemical spill damage can be prevented by filling gas tanks, cleaning paintbrushes and tools, and repairing mechanical equipment well outside tree PRZs. Insist that all building debris and chemical wastes be hauled away for proper disposal, and not burned or buried on the site.

Finally, avoid changes in soil pH (acidity). Increases in pH are particularly dangerous to many species (Table 1). Alkaline clays or limestones should not be used for fill or paving, and concrete should be mixed on a thick plastic tarp or outside the site. Mixing trucks should never be rinsed out on the site.

Grade Changes

Moving large amounts of soil within the PRZ usually kills a tree. Except where absolutely necessary, avoid disruptions to the natural contour of the site or shift them well outside the PRZ.

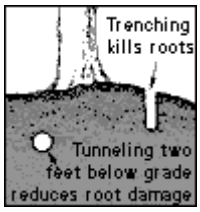

Figure 8. *Protect roots from damage when laying utility lines by tunneling rather than trenching.*

Soil additions compact the soil around a tree and often raise the water table. You may be able to protect compaction-tolerant trees (Table 1) from additions of six inches or less of soil by using a porous fill within the PRZ. Porous fill can be made by mixing one part loam, one part coarse sand, and one part shredded bark.

Deeper fills require more expensive measures. A retaining wall beyond the PRZ may protect some trees (Figure 7a). These walls preserve much of the original root system and redirect excess water away from sensitive plants. Your tree-care specialist may suggest other, more elaborate measures for protecting trees that

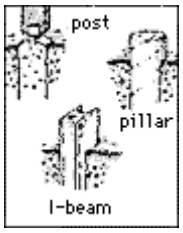

Figure 9. *You can minimize damage to trees near foundations by using posts, pillars, or I-beams*

must be covered with soil close to the trunk. However, as a general rule, it is best to remove trees that would be buried by 24 inches or more of fill around the base.

rather than foundation walls.

Cutting the soil away from a tree removes vital feeder roots, eliminates nutrient-rich topsoil, and often lowers the water table. Damage caused by shallow cuts (less than two inches) at least three feet away from the base of the tree may be minimal, but still can be a shock to a tree's vitality (health). If possible, avoid making the cut during hot, dry weather; water the tree (undisturbed portions) before, during, and after soil removal; and allow only hand digging inside the PRZ. A shallow layer of mulch (pine needles, wood chips, or coarsely chopped twigs and bark) and clean root cuts will help wound closure and regrowth. Deeper cuts within the root zone will require construction of a retaining wall no closer than the limit of the PRZ (Figure 7b).

Excavation

As much as 40 percent of a tree's root system could be cut during the installation of a nearby utility line. This reduces water and nutrient uptake, and may compromise the stability of the tree. If it is not possible to relocate the utility line outside the tree's PRZ, you can reduce root damage by as much as percent by tunneling under the tree's root system (Figure 8). When digging a trench near a tree, begin tunneling when you encounter roots larger than one inch in diameter.

Trenching for building foundations also poses a danger to nearby trees. Although not often used in Minnesota, posts, pillars, or I-beams sometimes can be substituted for foundation walls and footers on homes (Figure 9). Drilling single holes as opposed to cutting deep trenches saves many critical roots.

For all digging operations, insist that exposed roots be cut cleanly to promote quick wound closure and regeneration. Vibratory plows, chain trenchers, and hand tools do a better job at this than bulldozers and backhoes. Minimize damage by avoiding excavation during hot, dry weather; keeping the plants well watered before and after digging; and covering exposed roots with soil, mulch, or damp burlap as soon as possible.

Pavement

Sidewalks and driveways located too close to a tree endanger its health and may threaten pavement stability. Factors such as frost heaving, poor drainage, and pavement flaws give roots an opportunity to expand, gain a foothold, and cause damage. Homeowners are faced with costly repair bills and potential liability for the hazardous situation that develops.

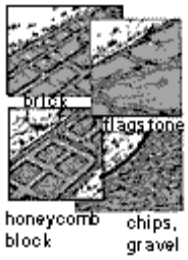

Figure 10. *Paving materials such as brick or flagstone over sand will produce less disruption than poured concrete to the roots of a nearby tree.*

These problems can be avoided if you consider the spatial needs of a tree and its root system when designing the layout of new sidewalks and driveways. Just how much space is required depends on a tree's sensitivity to root cutting and its future size (Table 1). It's best to locate sidewalks and driveways outside the anticipated PRZ. At a minimum, walkways should be at least three feet from the trunk of a tree; driveways may cover up to half the distance from the tree's PRZ to its trunk, as long as no excavation occurs. No tree should be boxed into an area less than eight feet by eight feet by three feet deep, with larger trees receiving at least 300 cubic feet of root/soil volume.

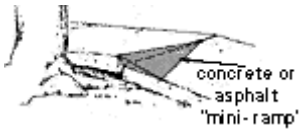

Figure 11. *A "mini-ramp" can be used to smooth the uneven surface caused by root damage to pavement.*

You can minimize disruption by using alternatives to conventional paving materials. In some communities, brick or flagstone walkways on sand foundations can be substituted for concrete (Figure 10). These materials protect soil pH and allow water and oxygen penetration. Preserve natural contouring by spanning uneven areas with wooden walkways elevated on posts. Elevated decks are excellent alternatives to concrete porches. Where additional pavement strength is needed (e.g., driveways), concrete requires less excavation than asphalt. "Structural soils" may be used under pavement to allow for both adequate pavement base strength and tree root penetration. . Structural soils. are composed of 80% stone chips, 20% clay-loam soil, and a polymer binding agent. Ask your builder about raised pavement techniques near valuable trees.

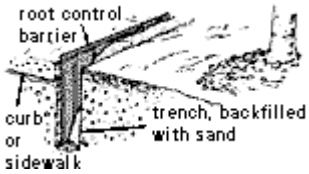

Figure 12. *A vertical underground barrier will help keep tree roots from damaging concrete as they grow.*

There are several techniques for repairing pavement that has been damaged by protruding roots. For trees that are highly sensitive to root disturbance, consider

creating a concrete or asphalt . mini-ramp. to smooth the uneven surface between two sidewalk sections (Figure 11). Local ordinances governing liability should be consulted prior to using this technique. Relocate walkways with broken concrete slabs a few feet farther from the tree. For trees that can tolerate root disturbance, a vertical underground barrier may redirect root expansion away from pavement (Figure 12).

All tree species are capable of causing root damage to sidewalks, foundations, or pipes. Species notorious for damage-causing roots are noted in Table 1.

Symptoms of Construction Damage

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Conspicuous symptoms of construction damage may take years to appear. Tree decline from soil compaction, for instance, may take three to seven years to appear as obvious symptoms of distress. Because of this delay, landowners often attribute tree losses to other causes. Carefully monitor affected plants and keep written records to help you recognize the less visible signs of tree stress. Remember, the most serious damage remains hidden in the root system.

Figure 13. *Suckering is one symptom of construction damage.*

Wilted or scorched leaves and drooping branches usually are the first signs of construction damage. In deciduous plants these symptoms may be followed by early fall coloring and premature leaf drop. Damaged conifers will drop excessive amounts of inner needles. In subsequent years you may notice yellowed or dwarfed leaves, sparse leaf cover, or dead branches.

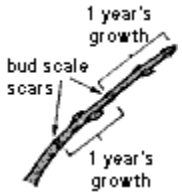

Figure 14. *Annual growth is the distance between bud scale scars on twigs. The twigs of healthy trees usually grow two to six inches longer each year.*

Other indicators might include flowering out of season, excessive water sprout formation on the trunk (Figure 13), abnormal winter dieback, or abnormally large amounts of seed. Flower and seed production and water

sprout formation are defense mechanisms for ensuring species survival and commonly indicate that the plant is experiencing extreme stress.

In addition to observing a tree's appearance, monitor its annual growth. A slightly damaged plant will grow more slowly and be less resistant to insects, diseases, and weather-related stress. Examine the annual shoot and branch growth (Figure 14). Healthy trees generally will grow at least two to six inches at the ends of the branches each year. Photographs and records of the tree prior to construction also can help identify growth problems.

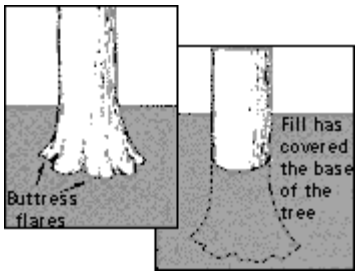

Figure 15. *To determine whether the grade has been changed around trees on a newly built site, check for the presence of* ***buttress flares*** *at the base of the trunk.*

If you purchased your home following construction, you can identify deep fills around large trees by looking for buttress flares at the base of the trunk (Figure 15). Most common shade trees in Minnesota have buttress flares, and their absence usually indicates that the tree's base has been covered. It may be helpful to examine the condition of trees on other sites where your builder has worked.

In many cases you would be wise to have a tree-care specialist look for early symptoms of tree stress. Dollars invested in consultations with professionals before damage becomes obvious may be repaid in considerable savings later on.

Treatment of Damaged Plants

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When a tree is injured by construction activities, energy and resources normally used for growth must be redirected toward the process of wound closure and regrowth. During this critical period plants are particularly vulnerable to additional stress, especially insects, diseases, and severe weather. You can minimize these problems by quickly treating the damage.

Water

Construction activities often alter the amounts of water received by trees. Thoroughly water plants before and immediately after they receive any kind of direct damage (e.g., severed roots). Continue periodic watering (at least four to five times per summer) throughout the next several growing seasons. Be careful not to overwater your trees. Soaking the soil to a depth of 8-10 inches throughout the PRZ is a good rule-of-thumb.

Two to four inches of mulch (wood chips or bark) spread over as much of the root system as practical will help the tree retain water and stimulate root regeneration. Living ground covers over the root system will have a similar effect, and may be more aesthetic. Apply these techniques to any deciduous tree exhibiting wilted leaves or any coniferous tree dropping excessive amounts of needles from the inner branches.

Drainage systems and grade changes may cause some trees to receive too much water. Species differ in the amount of water they can tolerate (Table 1). Intolerant plants will exhibit twig and branch death. don't wait for these symptoms to appear. If you suspect your plant is receiving too much water, contact a tree-care specialist for an evaluation of the problem. Treatment differs by tree species and by the amount of time the water remains on or close to the surface. For some species, a retaining wall or culvert may be needed to redirect the flow of water.

Excavation of Back-Filled Trees

If you or your tree-care specialist has determined that excessive soil additions have been made around valuable trees, efforts should be made to restore the original grade, at least within the PRZ.

Approach this grade restoration carefully. Determine how much fill has been added by sampling depths at several different points within the PRZ (Figure 16). If the depth is great (more than 12 inches), you may remove most of the backfill with mechanical equipment. Once you are within 10 to 12 inches of the

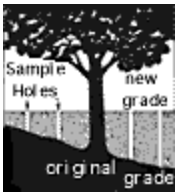

Figure 16. *Before you remove fill that has been added around trees, take vertical samples to determine how deep you need to go.*

original grade, complete the fill excavation carefully with shovels and rakes. Make certain no soil is piled up against the tree trunk, and aerify the soil within the PRZ to complete the operation. If the tree is already exhibiting advanced symptoms of decline, however, restoration to original grade will probably be fruitless. In this case, remove the tree and plant a new one.

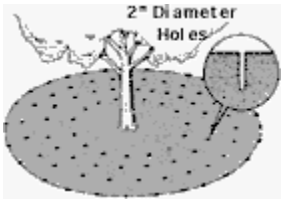

Figure 17. *A series of two-inch holes 12 to 18 inches deep will help alleviate root damage caused by compaction.*

Aeration and vertical mulching

Soil compaction around a tree's roots may cause leaf wilt, early fall coloring, top dieback, and slow growth. Reduce the effects of compaction by carefully drilling a series of two-inch-diameter holes in the soil to a depth of 12 to 18 inches. Begin three feet from the tree trunk and continue drilling at one- to three-foot intervals in concentric rings around the tree out to the PRZ (Figure 17). Each hole may be refilled with sand, peat moss, or mulch. For severely compacted soils, this procedure--called vertical mulching--should be repeated every two to three years until the tree has fully recovered. A tree-care specialist may recommend other alternatives, including soil injections of air or pressurized water, to improve soil aeration.

Fertilizer

Injured trees may need additional nutrients to replace damaged root systems. Fertilizers containing phosphorus and nitrogen can help stressed plants recover since these nutrients promote root and plant growth. Avoid excessive nitrogen; increased stem and foliage growth can cause stress, especially during hot, dry weather or if the tree has been stressed due to construction activities. Because of this problem, many experts recommend waiting two years after damage has occurred before fertilizing the trees. Specific guidelines for selecting and applying fertilizer are described in *Tree Fertilization* (Minnesota Extension Service publication FO-2421).

Pruning and Wound Repair

Careful pruning and wound repair are important treatments for damaged trees. Prune broken or dead branches cleanly at the branch collar (Figure 18). To test whether a branch is dead, bend several twigs. Twigs on live branches tend to be

pliable, while twigs on dead branches tend to break. Buds also can be used to evaluate branch condition. Live buds appear full and normal in color while dead ones appear shriveled or dry.

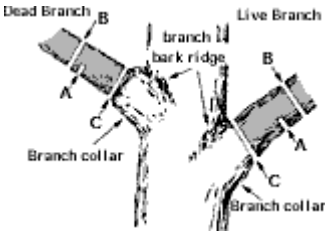

Figure 18. *Prune branches at the branch collar.*

Pruning is commonly recommended for large trees that have suffered root damage. However, opinions differ over the merits of this practice. Assuming that the tree has adequate water and is not in severe decline, some experts believe that retaining maximum leaf cover is important for root regeneration and only dead limbs should be removed. Others argue that pruning selected live limbs is necessary to compensate for lost roots. Generally, it is best to follow the recommendation of your tree-care specialist experienced in construction damage to trees.

When properly done in moderation by a skilled professional, pruning may reduce wind resistance and limb failure and improve tree health and appearance. DO NOT let anyone cut off all of the top branches to the same height (" topping").

The treatment of trunk wounds depends on the extent of damage. If 50 percent or more of the bark has been removed around the entire trunk, the tree will not likely survive and should be removed. If only a patch of bark has been removed leaving a few splinters, use a sharp knife to cleanly cut off the loose bark to a place on the stem where it is firmly attached. DO NOT make the wound any larger than necessary.

You do not need to use pruning paint or dressing to cover exposed wounds or pruned limbs. Except for special cases involving disease control, these products do little more than improve appearance.

Oak Wilt

Oak wilt is a lethal fungal disease normally spread through root grafts between adjoining oak trees. The disease also may be spread overland by sap beetles of the Family Nitidulidae. In Minnesota, construction activities that injure roots, break branches, or otherwise open a wound on an oak between April 1 and July 1 provide the beetles easy access to transmit the fungus. (Some studies have found the occurrence of oak wilt to be four times more likely within 160 feet of

a construction site.) Immediately (within minutes) cover all open wounds with any water-based paint or shellac during this period. If you suspect oak wilt, contact your city forester or private tree-care specialist. If you have oaks on your site, obtain a copy of *Oak Wilt in Minnesota* (Minnesota Extension Service publication MI-3174) for additional information on identifying the disease and protecting your trees.

Other Insect and Disease Problems

Insects are attracted by distinctive chemicals that are released by plants recovering from injuries. Examples of insect pests that can sense a tree under stress include the pine bark beetle, bronze birch borer, two-lined chestnut borer, sap beetle (transports oak wilt fungus), and some scale insects. These insects can kill a plant by their feeding or boring or by transmitting disease.

Likewise, some diseases multiply in plants experiencing stress. Verticillium wilt, ash yellows, and *Armillaria mellea* are examples of diseases that attack weakened trees.

Continually monitor the health of your trees, especially those near construction activities, for insect and disease problems. Proper treatment, including corrective pruning, watering, and pesticide or fungicide applications, can restore tree health. Contact your county extension educator or local forester for additional information on specific tree pests.

Tree Removal

Even the best protection plans cannot guarantee plant survival. Death may occur shortly after construction or years later. Look for trees with very few leaves and many dead branches. If the tree does not leaf out the following year it is dead. Large trees that lean or exhibit rot, deep trunk cracks, or extensive top dieback are potentially hazardous (Figure 19). They should be evaluated by a tree-care specialist or be removed. Dead trees are excellent for wildlife, but dangerous to people and buildings. Large trees should be carefully removed by professionals so as not to damage the remaining plants.

Tree loss can have a dramatic impact on site appearance. Prompt replacement will minimize your grief. Remember, the tree you plant is your own.

Street Trees and Construction Damage

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Established street trees are subjected to damage from construction activities perhaps even more frequently than forest trees. The infrastructure of any community--streets, sidewalks, curbs, and buried utilities--is continually updated, repaired, or expanded and trees growing in boulevards (tree lawns) or close to these public services are vulnerable to construction activities.

The most common type of damage street trees suffer is root loss. This is particularly harmful because these trees already are growing in root-limited spaces, and are often less healthy than other landscape trees due to the environmental stresses of boulevards (small volumes of soil, often a poor quality of soil, accumulations of deicing salts, and characteristically drier conditions than other landscape sites).

Trees growing in boulevards or near streets typically have an unbalanced and very restricted root distribution. Therefore, any root removal or damage during construction is often a more significant loss compared to trees growing in more open areas. Root loss not only affects the health of these trees but a more serious effect may be on their condition or stability. A boulevard tree that experiences significant root loss will have a different center of gravity as a result. This shift in balance often results in less stable trees--especially the large, mature ones - and leaves them more vulnerable to toppling (wind throwing) during severe weather.

Minimizing construction damage to street trees

Minimize root loss.

Most healthy trees can tolerate one-sided root cutting and recover from the loss with long-term after-care. Trees that have roots cut on two sides usually suffer much more damage and are less stable (see Figure 20). It is questionable whether to save trees that suffer root loss on three or more sides.

The number of cuts near street trees may be

reduced by a variety of methods and compromises. If possible, avoid widening streets or sidewalks when they are replaced. If curbs are slated to be replaced, hand-form the curbs adjacent to tree roots, rather than excavating with machinery for mechanical forms. Excavation with machinery destroys major branch roots, even if the new curb remains in the same position as the old curb.

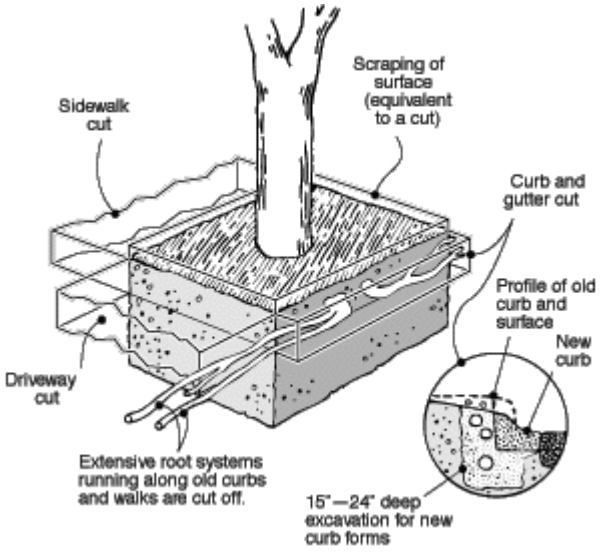

Figure 20. *Root cuts on more than one side seriously affect the health and stability of even healthy trees.*

Consolidate utilities into common trenches whenever possible, and tunnel under tree root systems (see Figure 8). Often it is possible to run several utilities in a common trench, minimizing the number of trenches and root cuts.

Do not regrade the surface of the boulevard. Although it is not trenching, it still cuts and removes roots, usually the fine roots that absorb most of the water and nutrients for the tree. If the new grade creates a mowing/maintenance problem, consider the installation of retaining walls at the curb line, or remove the turfgrass from the boulevard and replace it with mulch and landscape plantings.

Figure 21. *Consider planting a "blooming boulevard" as an alternative to turf cover.*

Avoid Damage to the Soil.

Do not allow equipment, vehicles, or materials to be stored on the boulevard. Establish a separate staging and parking area on a paved area away from the tree lawn. If this is not possible, cushion the boulevard with at least six inches of wood chips applied as a mulch.

Do not allow any foreign materials to be buried or deposited into the boulevard soil. Don't bury debris (such as concrete) or wash out equipment or tools in the

boulevard soil area.

Maintain the Health of the Trees During Construction.

As long as the soil drains water adequately, water, water, water the trees. root systems. Adequate water before, during, and after construction is the most critical requirement for boulevard trees if they are to tolerate construction damage. Place soaker hoses over their root systems and soak them a minimum of one time per week during construction and immediately after, allowing two to three hours per soaking.

Continue Therapy and Care for Several Years After Construction.

Never let the trees become water stressed. Plan on having an arborist remove dead wood in the canopy within two to three years after the construction. Seriously consider removing the turf from the trees' root systems and replacing it with mulch and low-growing shrubs and herbaceous perennials. "Blooming boulevards" are becoming more common in communities across the nation and are often allowed in city ordinances (Figure 21). If your community's ordinances don't allow "blooming boulevards," try to have them changed.

Reconsider Replanting Narrow Boulevards.

Not all boulevards should have trees growing in them. Trees are most at risk for future construction/reconstruction damage when they are planted in boulevards less than 8-10 feet wide. In places where boulevards are very narrow, consider creating "green easements" that allow public trees to be planted in private lawns adjacent to the public property. They will enjoy a larger rooting area and a longer life.

Conclusion

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It's not always easy to save trees during construction, but your efforts are worth the trouble. Healthy, well-placed trees can increase property values by 9 to 27 percent. Protecting tree health on a construction site is a matter of recognizing the potential impacts. Advance planning and simple steps to minimize damage

often can prevent future problems. Many trees have a tremendous capacity to survive disturbance, but in an urban setting we continually test them. Take the time to protect and monitor the health of your investment. Your home and our communities will be healthier, more attractive places to live.

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