## Tree Risk Inspections and Use of Specialized Diagnostic Tools

Tree risk inspections provide a systematic method of examining trees, assessing defects present, and estimating the degree of risk trees pose to public safety. Visual inspections of individual trees, using the 360-degree walk-by method, are sufficient for detecting most defects and assessing the probability of tree failure. Some defects, however, do not have external signs or symptoms and their detection requires in-depth inspections and the use of specialized diagnostic tools. Every tree risk management program must include regularly scheduled tree risk inspections, whether visual or in-depth.

In-depth tree assessments are warranted when a tree poses a high degree of risk to public safety and exhibits suspected defects that cannot be fully evaluated during the visual inspection process. For example, in high-use/risk areas where stem girdling roots (SGR) are a suspected defect, soil excavation near the base of the tree may be necessary to determine the presence of SGRs and the extent to which they constrict the stem. In the case of some root problems, it may be necessary to excavate soil to locate primary support roots and investigate if they have been severed or are decayed. For trees in high-use/risk areas that exhibit external signs of decay but the extent of internal decay is uncertain, it is advisable to measure the thickness of the outer ring or shell of sound wood within the tree, and to determine if safe shell limits (see Defects: decayed wood) are met. For each type of in-depth assessment, diagnostic tools are available to assist in the examination. Examples of in-depth assessment methods and diagnostic tools are discussed below.

### Root Collar and Stem Girdling Roots Assessments

Root collar examinations are performed to detect damage or decay in buttress and primary support roots and the presence of stem girdling roots. A root collar examination typically takes from fewer than 20 minutes for smaller trees and less extensive examinations, to more than 2 hours for larger trees requiring more excavation (Johnson and Hauer 2000). The examination begins by probing into the soil near the root collar with a 3/8-inch-diameter probe, rod, or steel wire (coat hanger gauge) to determine the depth of primary branch roots and the presence of any encircling roots or other root damage such as decay or severing. See Figure 3.155. The root collar is defined as the base of the tree were the primary roots first begin to branch away from the stem and normally appears swollen or slightly flared.  Next, the soil is excavated outward from the root collar and primary support roots are examined. For the average-sized landscape tree (9 to 15 inches d.b.h.), with roots 6 to 10 inches from the surface, soil should be excavated 12 to 18 inches outward from the trunk. If the primary branch roots are deeper, widen the examination area proportionately. Gradually loosen and remove soil until the stem/root conflict or root collar is exposed. Hand trowels, knives, stiff bushes,

**Figure 3.155.** *A metal probe inserted into the soil near the root collar.*

wet/dry vacuums, air compressors, and water can be used to loosen and remove soil around roots. Shallow examinations of smaller trees do not require the use of elaborate equipment. However, vacuums and portable air compressors are most effective with larger trees and examination areas. Do not use spades or shovels unless certain that no roots exist in the soil to be excavated. After the soil is excavated, look for the presence of stem girdling roots and evidence of stem compression or other root damage. In the case of root decay, a metal rod may also be used to probe the roots farther out from the trunk and to test for presence of advanced decay. If the roots are severely decayed, they will be punky in texture and easily probed by the metal rod. The risk of tree failure is considered to be high if girdling roots constrict greater than 40 percent of the stem's circumference or greater than 40 percent of roots within the CRR are damaged or decayed.

## Decay Detection Assessments

Decay assessments determine the location and extent of decay present in a tree and whether the decay represents a significant risk to the structural integrity of the tree. The outer shell of sound wood is measured to ensure safe shell limits are met and the tree does not pose an unacceptable level of risk. Many devices are available to detect internal decay and other defects in standing trees. Traditional, low-tech devices include the steel rod, mallet, increment borer, and portable drill. High-tech devices include penetrometers (Resistograph, densitomat, and Sibert Decay Detecting Drill (DDD 200)), sonic and ultrasonic detectors (Mertigard Stress-wave Timer, Sound Impluse Hammer, and Arborsonic Decay Detector), electrical conductivity meter (Shigometer, Vitalometer), and the Fractometer. Harris et al. (1999) described the use, limitations, and invasiveness of many of these instruments. Nicoletti and Miglietta (1998) reviewed technical aspects of several decay detection instruments and offered opinions on the reliability of each. The following instruments are commercially available for use by tree care professionals in the United States. The information presented is current as of the date of writing; however, readers should be alert for new developments in technology.

## Examples of Decay Detection Devices Commonly Used in the United States

### *Metal Rod*

A 3/8-inch-diameter metal rod may be used to probe stem and root tissue to detect the size of cavities, depth of cracks, or the presence of advanced decay. If the stem or root tissue is severely decayed, they will be punky in texture and easily probed by the metal rod.

### *Rubber Mallet*

A rubber mallet (Figure 3.156) can be manually struck against the bark or exposed wood surface, and, with experience, an operator can interpret whether the resulting sound indicates hollowness or severe decay. This method is highly subjective, and is dependent on the operator's experience and interpretation skills. Care should be taken not to mistake the sound emitted by striking loose bark as the presence of decay within the wood of the tree. This method is non-invasive, and the tool is cheap, easy to carry, and requires no maintenance.

**Figure 3.156.** *A rubber mallet.*

### *Increment Borer*

**Figure 3.157.** *An increment borer.*

The increment borer (Figure 3.157) consists of a hollow tube with an external screw thread at one end. It is screwed into a tree and removes a core of wood approximately 5mm in diameter. The core can be examined for the presence of discoloration or decay along the wood cross-section, and the presence of decay can be manually mapped along the length of the core. Multiple borings around the stem circumference will provide a measurement of the thickness of the outer shell of sound wood, limited to the length of the core. Increment borers are inexpensive, easy to carry, and require limited maintenance. However, this method of assessment is invasive to the tree, and causes the largest diameter wound of the decay detecting devices commonly in use. In trees with internal decay, an increment borer can break an existing barrier zone within the tree and may allow decay to progress into healthy wood. Finally, if the coring tip becomes dull, the tool may get stuck and removal from the tree can be difficult.

### *Penetrometers*

Penetrometers record the resistance encountered by a probe as it is impelled into the wood rotating at a high speed. The portable drill, Resistograph, and Siebert DDD 200 are the most commonly used decay detection instruments of this type in the United States. All of these devices assess changes in the mechanical resistance of wood to quantify the amount of decay present. They work on the premise that during the wood decay process, wood density decreases and, correspondingly, wood hardness and drilling resistance declines. In simplified terms, sound wood is dense, hard in texture, and has a high resistance to the drill penetrating it. In contrast, severely decayed wood is less dense, softer in texture, and has reduced drilling resistance.

**Portable drills.** Portable drills (Figure 3.158) have been used for many years by trees care professionals in the United States and are considered by many to be reliable decay detection tools. A cordless 3/8-inch drill, with a 1/8- by 12-inch brad point tip bit is used. As the tree is drilled, decay is indicated by reduced resistance to the drill penetrating the wood. The bit is pulled out typically at 0.5-inch intervals, and the wood shavings are evaluated for presence of discoloration, punkiness, and odor as indicators of decay. An advantage of the portable drill over other decay detecting drills is that drill shavings provide direct evidence of the presence and location of decay. By examining the wood shaving at frequent intervals, the operator can manually map discoloration, decay, and cavities with reasonable accuracy along the length of the drill path. This tool is relatively inexpensive, quite easy to carry, and requires very little maintenance. A disadvantage of the portable drill is the potential for subjective error in quantifying decay.

**Figure 3.158.** *A portable drill.*

Studies have shown the portable drill to be effective in detecting late-intermediate and advanced decay (greater than a 20-percent weight loss in the wood) when used by experienced operators, but far less reliable when used by inexperienced operators (Costello and Quarles 1999). In addition, even experienced operators can not reliably detect the presence of early to early-intermediate stages of decay (less than a 20-percent weight loss in the wood) with a portable drill.

**Figure 3.159.** *The resistograph.*

**Resistograph.** The Resistograph (Figure 3.159) is a relatively new instrument developed in Germany. It is easy to operate and use, and weighs between 5 and 6 pounds, depending on the model. A battery-operated motor drives a specially engineered drill bit (needle) into the wood at a constant speed of 8, 16, or 24 inches per minute. Drilling depth is 12, 16, or 20 inches, depending on the model, and the drill bit diameter is 1/8 inch at the cutting tip and 1/16 inch along the shaft. The drilling resistance at the needle tip is transferred through a gearbox to a pointer that is visible at the top of the instrument and graphs the results on a waterproof wax paper printout. As the drill penetrates the wood, resistance to the pressure of the drill is measured and recorded, and the pattern of changes in resistance is used to determine decay presence or absence. For example, relatively high resistance readings indicate sound wood, while low readings suggest decay or other defects. Several models exist, with the higher end models (E Series) containing an electronic component with an optional personal computer interface for on-screen viewing, and specialized Windows® software for data analysis. A printer attachment is available for viewing and interpreting results onsite.

An advantage of the Resistograph over the portable drill is the fact that results are quantitative, and a written record is graphed on waterproof paper for documentation. Advanced decay and cavities can be detected, and their location can be mapped along the cross-section of the drill depth. A disadvantage of the Resistograph over the portable drill is its increased weight and size that makes it more difficult to transport and use in the field. A disadvantage of the Resistograph over the Sibert Decay Detecting Drill is that the drill bit is sharp, not blunt, and becomes dull and needs regular replacement.

**Sibert Decay Detecting Drill (DDD 200).** The Sibert DDD 200 measures changes in the speed of penetration, at a constant forward pressure of penetration, and functions on the same principles of the portable drill and the Resistograph. The results are quantitative and can be displayed and printed for documentation purposes. The drill bit is 1.5 mm wide, blunt, and is normally 200 mm in length. The drill width is less than the Resistograph, and is reportedly less likely to snap. The drill bit is blunt (versus a sharp drill bit that becomes dull and requires regular replacement), and rotates at 7,000 rpm which supposedly eliminates the problem of wood chips filling the drill path and causing friction to develop along the length of the drill shaft. Models are available that provide an electronic output, viewable on a computer screen and printable.

**Limitations of penetrometers.** Studies have been conducted to evaluate the reliability of the portable drill and the Resistograph by comparing decay assessments generated from each instrument with decay assessments from laboratory measurements of wood density and visual examinations of density samples for elm and blue gum trees (Costello and Quarles 1999). Wood density values below a critical level were used to determine the presence of decay within wood samples tested, and then compared to Resistograph readings and portable drill findings. Both instruments were able to reliably detect late-intermediate and advanced decay and the presence of cavities. Neither, however, was able to reliably detect the presence of early to early-intermediate stages of decay. In cases where early to early-intermediate decay advances well in front of the advanced decay cylinder within the tree, penetrometers may produce an assessment that underestimates the amount of decay present. This may have significant safety implications because wood can suffer loss of strength in the difficult-to-detect earlier stages of decay.

Another limitation of decay detection devices is the variability of the wood resistance readings and lack of tree species profile data. The resistance patterns of sound wood in different tree species may vary significantly, and there may be substantial differences even within an individual tree. These differences depend on factors such as patterns-of-growth rate and the presence of resins, reaction wood, and heartwood. Friction between the probe shaft and the displaced wood fibers which line the drill hole can cause an increase in resistance with increasing depth. The friction can become strong enough to skew the resistance readings too high and prevent detection of decayed wood. For these reasons, familiarity with wood resistance patterns, between tree species and within tree species, is critical for an accurate interpretation of decay presence and absence. The operator should obtain reference data from anatomically comparable undecayed or sound wood for each tree species evaluated, as a standard of comparison. Profile data has been collected in Germany on many tree species (Mattheck et al. 1997); however, published data is lacking for U.S. tree species. Until this information becomes available, it will be difficult to accurately interpret test results for U.S. tree species.

Cost is another issue to consider. The Resistograph and Siebert DDD 200 are expensive to purchase and maintain. Many small communities, with limited budgets, would be prohibited from purchasing them. A possible solution to this problem would be for two or more communities to share the cost of purchasing the instrument, and then schedule its use on a rotational basis.

### *Electrical Conductivity Meters (Shigometer/Vitalometer)*

The Shigometer was invented by A. L. Shigo in the early 1980's. The French have modified the instrument and market it as the Vitalometer. A 3-mm (3/32-inch) hole is drilled into the tree trunk to a depth of 30 cm, an electrode is inserted, and the electrical resistance (ER) is measured at 1-cm intervals with an ohmmeter. The quantity of free ions varies from one type of wood to another and the greater the number of free ions, the lower the ER. Decayed wood has more free ions than non-infected wood. As the electrodes encounter decayed wood the ER drops substantially and abruptly; a drop of 50 percent indicates the presence of decayed wood.

Several problems limit the effectiveness and use of electrical conductivity meters in the field. For example, the drill bit is fragile and often snaps when drilling. Interpreting results can be difficult when the moisture content of the wood is below the fiber saturation point, when the wood is impregnated with resin (resin acts as an insulator), and when the drill hole fills with water (as often happens with bacterial wet wood). Wood that is discolored, but not decayed, may result in reduced ER readings, and cause the operator to overestimate the amount of decay in the wood.

### *Sonic and Ultrasonic Detectors*

**Sonic devices** (stress-wave timers). The Mertigard Stress-wave Timer and the Sound Impluse Hammer are acoustic devices that measure the time taken for a stress or shock wave to pass through an object, in this case a tree trunk. The stress wave is initiated by a hammer blow that is delivered to a start probe located on one side of the trunk, and the time required for it to travel to a second, sensor probe located on the opposite side of the trunk is measured. Probes are mounted on steel screws that are inserted into the outermost wood of the tree. All sonic devices work on the principle that transmissibility of sound waves through a body is determined by the body's density. Damaged wood is usually less dense because it has been decayed by fungi or tunneled by insects. If a portion of the trunk is damaged and the wood density reduced, transmission of the sound takes longer than if the tree was free of defects. Severe defects reduce the sound velocity to less than 70 percent of the characteristic values of sound wood (Bethge et al. 1996).

A major disadvantage of stress-wave timers is that although they are capable of detecting the presence or absence of internal defects such as decay, cracks, and holes, they cannot map the specific location or quantify the extent of internal defects. Another disadvantage of stress-wave timers is their inability to detect certain kinds of decay that cause embrittlement of the wood; in particular, decay caused by *Ustilina deusta* (Schwarze et al. 1993). For stress-wave timers, a reduction in wood density will result in a decrease in the sound velocity, whereas a reduction in the elasticity of the wood will increase the sound velocity. Decays that result in embrittlement cause a reduction in both wood density and elasticity, and hence produce no net change in the sound velocity.

**Ultrasonic devices.** Ultrasonic devices work on the same principle as the stress-wave timers, but measure the transit time of an ultrasound pulse between a transmitting sensor and a receiving sensor. The sensors (approximately 40 mm in diameter) must be in direct contact with wood to ensure a good acoustic contact with the tree, requiring two discs of bark to be removed for each measurement. The Arborsonic Decay Detector (Figure 3.160) is an example of an ultrasonic device used by tree care professionals in the United States.

**Figure 3.160.** *The arborsonic decay detector.*

Similar to stress-wave timers, ultrasonic devices can detect the presence or absence of defects, but the type of defect (e.g., decay, cracks, cavities) and the severity of strength loss cannot be distinguished. Use of these devices does not allow the operator to measure the thickness of the outer shell of sound wood or to map the specific location and extent of defects. As in the case of stress-wave timers, certain studies have indicated that test readings obtained with ultrasonic timers generally need to be evaluated by reference to readings from sound wood of the tree species concerned (Lonsdale 1999). Ultrasonic devices might be expected to share with stress-wave timers the inability to detect certain types of decay, particularly those that cause embrittlement of the wood, and this possible shortcoming should be investigated. Unlike stress-wave timers, ultrasonic devices cannot be used on very large diameter trees, as the signals that they emit are quite rapidly attenuated in the wood. In the case of the Arborsonic Decay Detector, the maximum path length is about one meter.

### *Fractometer*

The Fractometer is an instrument that determines wood quality in terms of wood strength and elasticity (Mattheck et al. 1994). A 5-mm diameter core of wood is extracted with an increment borer, placed in a clamping device, and stressed to the point of failure by increasing the force pushing against it. The fracture moment and angle of failure are measured at a number of points along its length. Measurements of breaking strength allow zones of weakened wood to be mapped with the stem cross-section, and the bending angle measurements help to determine if the wood is liable to undergo brittle on non-brittle fracture. Mattheck et al. (1994) concluded that large fracture moments and small fracture angles were indicative of sound wood. A decrease in fracture moment, an increase in fracture angle, or a combination of the two is indicative of the presence of decay.

Several limitations exist with the use of the Fractometer. Sample cores from several tree species tested in the United States could not be properly tested using this instrument because core samples broke when the lever arm was initially placed against the sample, and no measurable results could be obtained (Matheny et al. 1999). The tree species tested included Monterey cypress (*Cupressus macrocarpa*), ponderosa pine (*Pinus ponderosa*), black cottonwood (*Populus trichocarpa*), Douglas fir (*Pseudotsuga menziesii*), and coast redwood (*Sequoia sempervirens*). Secondly, the operator must know the breaking strength value that should be expected for sound wood (decay-free) for a given tree species. The manufacturer provides strength data for different tree species, but this data is based on work completed in Germany, and the values should not be regarded as standards for U.S. tree species. A study assessing the fracture moment and fracture angle of 25 tree species in the United States using the Fractometer (Matheny et al. 1999) concluded that due to the variation in test results among geographic locations and within individual species, operators must compare Fractometer results with decay-free samples taken from the same tree and should not rely on tables of standardized results.

This assessment method is more invasive than many decay detection devices, and involves the use of an increment borer and the collection of 5-mm core samples. It is essential for the borer to be kept sharp and aimed at towards the center of the tree (i.e., parallel to the rays and at right angles to the axes of the stem). Any deviation form these conditions could produce misleading results.

### *A Final Word About Decay Detection Devices*

Decay detection devices should be used with discretion because most are invasive in their mode of application and cause some degree of injury to the tree. Wounds, created when probes are drilled into the tree or when the bark is removed to attach sensors, may serve as entry points for decay organisms. Invasive methods may also allow existing decay to spread internally by interfering with the tree's ability to compartmentalize the decay. Although it is uncertain to what extent these small diameter wounds contribute to the development of decay within trees, the injury caused by most decay detection devices should not be overlooked. It is advisable to restrict the use of decay detection devices to situations when additional information about the location and extent of internal decay is critical to assessing the probability of tree failure, particularly for trees in high use areas.

When using decay detecting devices, limit the number of drill holes or sensor sites to the minimum needed to collect critical field data. When determining the number and location of sampling sites, try to visualize the width and length of the decay column based on external signs and symptoms. Make multiple borings around the circumference of the stem and at more than one height along the length stem to help determine the width and length of the of the decay column, respectively. Test areas that you suspect to have the thinnest shell of sound wood. The shell of sound wood will be thinnest between root flares, where the defect symptoms are most pronounced, or just behind the bulge on an inrolled crack (Hayes 2000).
The specific assessment device that you choose to use will depend on the field situation, your level of experience, and the size of your pocketbook. For example, a low-tech, inexpensive tool such as the portable drill has been documented to be quite effective in detecting advanced decay, and sometimes intermediate decay, when operated by a person experienced in its use. The stress-wave timers and the ultrasonic timers are capable of detecting the presence of internal defects such as decay, cracks, and holes, but cannot be used to quantify the extent or position of the defects. In most cases, more detailed mapping of the defects will be desired, and currently the penetrometer devices have more potential to measure the location and severity of defects. When measuring the thickness of sound wood surrounding cavities or decay columns, the device employed should be suited to the size of the tree. For example, drilling devices, although limited to the length of the drill-bit or probe, can be used on most large diameter trees since the acceptable safety factor (safe shell limits) depends on as little as the outermost 30 percent of the cross-section being completely sound. Currently available ultrasonic timers, however, will provide data only if the cross-section of the tree is less than or equal to one meter (39.37 inches).

Misinterpretation of results is an inherent problem associated with all of the above-mentioned decay detection devices. Problems with misinterpretation of results can be minimized by ensuring that devices are evaluated under a wide range of conditions that should include different defect types and severities, and a wide range or tree species over a large geographic area. As mentioned above, tree species profile data, from anatomically comparable undecayed sound wood for each tree species evaluated, should be developed for U.S. tree species as a standard of comparison for each device used.

In the future, what is needed ideally is a compact, non-invasive device that is affordable, quick and easy to use, and that will provide reliable information on the location, extent, and type of defect or decay. The use of radar, x-rays, x-ray tomography, thermal imaging, frequency imaging, and nuclear resonance is being explored and may one day provide the solution.

## Formulating Tree Risk Ratings

The purpose of tree risk inspections is to detect defective trees in target areas, assess the severity of the defects, and recommend corrective actions before tree failure occurs. Tree risk ratings can assist communities in quantifying the level of risk posed to public safety and in prioritizing the implementation of corrective actions. Two systems of field inspection and risk rating follow, one from the Minnesota Department of Natural Resources, and one from the U.S. Forest Service. Although these systems are similar in many ways, their approach to risk rating (step 3) differs. Each is presented in its entirety to be used as a stand-alone process.

## A 7-Step Process Using the Minnesota DNR System

### *Step 1. Locate and Identify Trees to be Inspected*

Inspections can be conducted anytime of the year with the exception of times when snow cover prevents examination of the root collar area. When the inspectors arrive on the site, they must determine which trees to inspect. Only trees that could fall onto a target or into a target area need to be inspected. To determine whether a tree could fall on a target, measure or estimate tree height and the distance to the target. If the target area is within 1.5 X the tree's height, then the tree should be inspected (Figure 3.161). When in doubt, measure heights and distances. Consider tall, distant trees as well as those immediately adjacent to the target area.

### *Step 2. Inspect Individual Trees and Assess Their Defect(s)*

Individual tree evaluations must include a close inspection of the rooting zone, root flares, main stem, branches, and branch unions. Use a pair of binoculars to visually inspect the higher branches. All sides (360 degrees) of the tree must be examined. During the inspection, judge the severity of each tree's defects with respect to defect severity levels established in this manual. A more detailed explanation of the seven defect categories and their failure thresholds can be found in the beginning of this chapter. Assign a single defect level for each tree: low-, moderate-, or high-risk of failure.

A common error made during hazard tree inspections is confusing crown vigor with structural soundness. Just because the crown is full and green, it doesn't necessarily

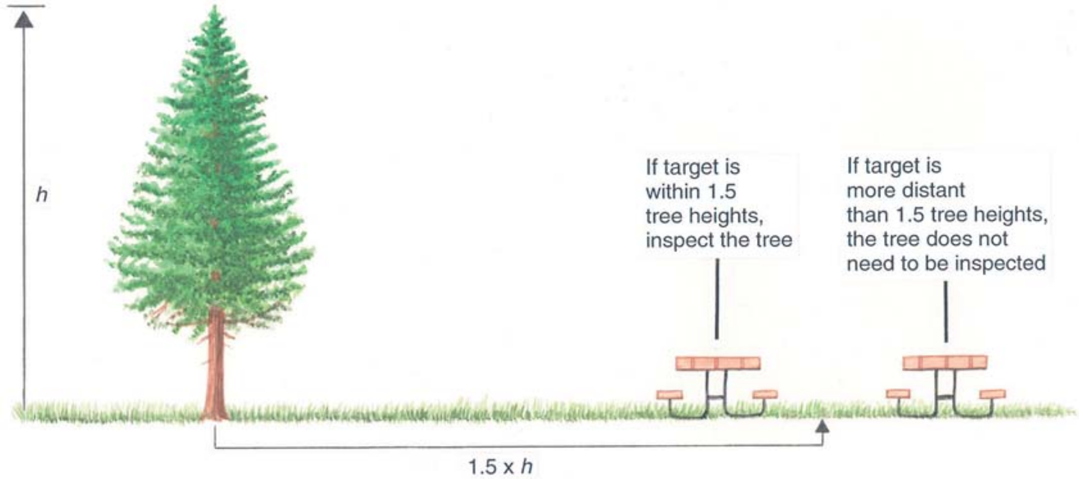


**Figure 3.161.** *If the target is within 1.5 times the tree's height, then the tree should be inspected.*

mean that the tree is sound. Health and vigor are related to energy supply. Energy and food-related activities occur in the thin layers of cambium and sapwood. When cambium and sapwood healthy, the crown looks good. But that doesn't mean the tree is sound. Structural soundness is related to the condition of stem wood, branch attachments, and anchoring roots.

### *Step 3. Estimate the Risk Rating for Each Tree*

Use the severity levels found in this manual as *guidelines* when assessing trees. Remember, these are guidelines; no absolute rules can be made to cover the natural variability of trees and their defects. Although the list of defects and their combinations appears to be lengthy, it is not exhaustive. Inspectors need to use their judgment and local experience when evaluating and assessing tree defects.

All defective trees cannot be detected, corrected, or eliminated. To begin with, our knowledge of the trees is less than complete. Although we can readily recognize most defects and symptoms, there are root problems and some internal defects that are not easily discernable and may require in-depth inspections and the use of specialized diagnostic tools. Secondly, trees can survive for many years with internal defects. Defect severity can and does change with time. Whereas all defective trees cannot be detected, our aim is to find 80 percent or more of the defective trees with each inspection. By doing inspections and acting on them, we can successfully manage the risk of tree failure.

*There are three categories of tree risk ratings:*

**Low-risk rating :** At the current time, the defects do not meet the threshold of failure. No corrective action is necessary.

**Moderate-risk rating:** At the current time, the defects do not meet the threshold for failure. The defects may or may not result in eventual tree failure. Corrective action is discretionary.

**High-risk rating :** Currently, these defects indicate that the tree is failing, is in imminent danger of failing, or has already partially failed. Corrective action should be taken as soon as possible.

### *Step 4. Prioritize Highly Defective Trees for Treatment*

In some communities, the defective tree population may be very low or may be manageable with existing resources. In this case, the community may opt for assigning the risk rating equal to the defect rating. The risk rating for each inspected tree can be estimated by simply rating its defects.

**Low probability of failure** = Low-risk rating
**Moderate probability of failure** = Moderate-risk rating.
**High probability of failure** = High-risk rating.

Larger communities, or those with a high proportion of defective trees, may want to rank their highly defective trees in order to prioritize treatments and removals. In this case, target area usage is used to augment the ranking. Target area usage is simply an estimation of the occupancy and duration of occupancy of an area by people and their vehicles, buildings or equipment. Inspectors must assess each tree's target area for its human occupancy during the data gathering phase of tree inspections.

Community policy usually dictates how the frequency of target area use is estimated. The following is an example of what your community could choose to do.

Frequent use areas would generally be located along downtown streets, along congested streets, near schools, in public playgrounds and picnic areas, near bus stops, near public buildings, in parking lot interiors. Intermediate use areas would include parking lot peripheries, and along secondary streets. Low use areas would be in industrial areas, in public wooded areas, and along trails.

Assign a point value for each inspected tree as follows:

1 = Frequent use.
2 = Intermediate use
3 = Low or occasional use

Only rank trees that have a "high" defect rating. Use the following formula (see Table 3.6):

Trees with high defect rating + Target area use rating = Treatment ranking

**Table 3.6. Ranking highly defective trees for treatment priority.**

| Defect rating | Target area use rating | Treatment priority |
|---|---|---|
| High | Frequent use = 1 | 1 (Highest) |
| | Intermediate use = 2 | 2 |
| | Low or occasional use = 3 | 3 |

Based on your community's policy, remove or treat trees starting with those ranked as 1 and move on down the list as financial resources allow.

***Step 5. Conduct a Public Review Before Implementing Corrective Actions***

Communication with community members and landowners is recommended before corrective actions are taken. If people are informed of the need for the corrective actions before the time they begin to see trees being removed or pruned, there will be clearer understanding and better community acceptance of why the actions are being taken.

***Step 6. Take Corrective Action as Soon as Possible on the Highest Risk Trees***

Once high risk trees are identified, action must be taken as soon as possible. Negligence may be assumed if a community identifies high risk and then takes no action. See Chapter 5 for more information about treating and correcting high-risk trees.

***Step 7. Document the Process: Inspection Results, Actions Recommended, and Actions Taken***

Documentation should include recording the inspection dates, individual tree ratings and corrective actions recommended and then carried out. These are absolutely critical to keep on file. Document all ratings, including the low ratings, on the field sheets. Data may be taken during street tree inventories, hazard tree inventories, as reported by community personnel, etc. Use the form supplied in this manual or create one that suits your needs. See Form 2. Maps are helpful and can be reused in subsequent years.

### Form 3.2: Hazard tree inspection form

(*See Forms Section for a full-size copy of the form*)

**HAZARD TREE INSPECTION FORM**

Unit __________

Subunit __________

Inspectors __________

Date __________

Remarks __________

MAP

| Tree location or map number | Tree species | Defect(s) | Hazard potential H or M | Remarks | Recommended action | Action taken/date |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Local Manager __________ Date __________

Source: MN DNR

## A 7-Step Process Using the USDA Forest Service Community Tree Risk Rating System

### *Step 1. Locate and Identify Trees to be Inspected*

Inspections can be conducted anytime of the year with the exception of times when snow cover prevents examination of the root collar area. When the inspectors arrive on the site, they must determine which trees to inspect. Only trees that could fall into a target area need to be inspected. To determine whether a tree could fall on a target, measure or estimate tree height and the distance to the target area. If the target area is within 1.5 X the tree's height, then the tree should be inspected (Fig 3.179). When in doubt, measure heights and distances. Consider tall, distant trees as well as those immediately adjacent to the target area.

### *Step 2. Inspect Individual Trees and Assess Their Defect(s)*

Individual tree evaluations must include a close inspection of the rooting zone, root flares, main stem, branches, and branch unions. Use a pair of binoculars to visually inspect the higher branches. All sides of the tree must be examined. During the inspection, the severity of each tree's defects is judged with respect to defect severity levels established in this manual. A more detailed explanation of the seven defect categories and their failure thresholds can be found in the beginning of this chapter.

A common error made during hazard tree inspections is confusing crown vigor with structural soundness. Just because the crown is full and green, it doesn't necessarily mean that the tree is sound. Health and vigor are related to energy supply. Energy and food-related activities occur in the thin layers of cambium and sapwood. When they're healthy, the crown looks good. But that doesn't mean the tree is sound. Structural soundness is related to the condition of stem wood, branch attachments and anchoring roots.

### *Step 3. Estimate the Risk Rating for Each Tree*

Use the severity levels found in this manual as *guidelines* when assessing trees. Remember, these are guidelines, no absolute rules can be made to cover the natural variability of trees and their defects. Although the list of defects and their combinations appears to be lengthy, it is not exhaustive. Inspectors need to use their judgment and local experience when evaluating and assessing tree defects.

All defective trees cannot be detected, corrected, or eliminated. To begin with, our knowledge of the trees is less than complete. Although we can readily recognize most defects and symptoms, there are root problems and some internal defects that are not easily discernable and may require in-depth inspections and the use of specialized diagnostic tools. Secondly, trees are masters at covering up problems and surviving. Defect severity can and does change with time. Whereas all defective trees cannot be detected, our aim is to find 80 percent or more of the defective trees with each inspection. By doing inspections and acting on them, we can successfully manage the risk of tree failure.

The U.S. Forest Service uses a 10-point numeric system to rate the risk of damage or injury posed by a defective tree or tree part. This numeric system provides communities with a management tool to help prioritize corrective treatments. Trees with the highest numeric risk ratings receive corrective treatment first. The total risk rating is equal to the numeric sum of three primary components, and under certain situations, an optional fourth component. See the formula below:

Risk Rating (3-10 points) = probability of failure (1-4 points) + size of defective part (1-3 points) + probability of target impact (1-3 points) + optional subjective risk rating (0-2 points)

The optional subjective risk rating is used if professional judgment suggests the need to increase the total risk rating and invoke immediate corrective action. For example, trees with a numeric risk rating of 9 or 10 would be identified as high priority trees to receive corrective treatments first. An inspector may wish to increase a tree's risk rating from 8 to 9 as a means of ensuring the tree will receive immediate corrective treatment. The total risk rating should not exceed 10 points.

*Below is a discussion of the four components contained in the 10-point risk rating system:*

**Probability of failure: 1-4 points**

1. Low: some minor defects present:
   - Minor branch/ crown dieback
   - Minor defects or wounds
2. Moderate: several moderate defects present:
   - Stem decay or cavity within safe shell limits: shell thickness >1 inch of sound wood for each 6 inches of stem diameter
   - Crack(s) without extensive decay
   - Defect(s) affecting 30 to 40 percent of the tree's circumference
   - Crown damage/breakage: hardwoods up to 50 percent; pines up to 30 percent
   - Weak branch union: major branch or codominant stem has included bark
   - Stem girdling roots: <40 percent tree's circumference with compressed wood
   - Root damage: <40 percent of roots damaged within the CRR
3. High: multiple or significant defects present:
   - Stem decay or cavity at or exceeding shell safety limits: shell thickness < 1 inch of sound wood for each 6 inches of stem diameter
   - Cracks, particularly those in contact with the soil or associated with other defects
   - Defect(s) affecting >40 percent of the tree's circumference
   - Crown damage/breakage: hardwoods >50 percent; pines >30 percent

- Weak branch union with crack or decay

- Girdling roots with >40 percent of tree's circumference with compressed wood

- Root damage: >40 percent of roots damaged within the CRR

- Leaning tree with recent root breakage or soil mounding, crack or extensive decay

- Dead tree: standing dead without other significant defects

4. Extremely High: multiple and significant defects present; visual obstruction of traffic signs/lights or intersections:
    - Stem decay or cavity exceeding shell safety limits and severe crack

    - Cracks: when a stem or branch is split in half

    - Defect(s) affecting >40 percent of the tree's circumference or CRR and extensive decay or crack(s)

    - Weak branch union with crack and decay

    - Leaning tree with recent root breakage or soil mounding and a crack or extensive decay

    - Dead branches: broken (hangers) or with a crack

    - Dead trees: standing dead with other defects such as cracks, hangers, extensive decay, or major root damage

    - Visual obstruction of traffic signs/lights or intersections

    - Physical obstruction of pedestrian or vehicular traffic

**Size of defective part(s): 1-3 points**

1. Parts less than 4 inches in diameter

2. Parts from 4 to 20 inches in diameter

3. Parts greater than 20 inches in diameter

**Probability of target impact: 1-3 points**

1. Occasional Use: Low use trails and roadways; parking lots adjacent to low use areas; natural or wilderness areas; transition or buffer areas with limited public use; industrial areas.

2. Intermediate Use: Moderate to low use school playgrounds, parks, and picnic areas; parking lots adjacent to moderate use areas; secondary roads and inter sections,(neighborhoods) and park trails within moderate to high use areas; and dispersed campgrounds.

3. Frequent Use: Emergency access routes, medical and emergency facilities and shelters, and handicap access areas; high use school playgrounds, parks, and picnic areas; bus stops; visitor centers, shelters, and park administrative buildings and residences; main thoroughfares and congested intersections in high use areas; parking lots adjacent to high use areas; interpretive signs, kiosks; scenic vistas; and campsites (particularly drive-in).

**Other risk factors: 0-2 points**

This category is to be used if professional judgment suggests the need to increase the risk rating and invoke immediate corrective actions. Total risk rating typically should not exceed 10 points. It is especially helpful to use when tree species growth characteristics become a factor in risk rating. For example, some tree species have growth patterns that make them more vulnerable to certain defects such as weak branch unions (silver maple) and branching shedding (beech species, *Fagus*).

***Step 4. Prioritize Defective Trees for Treatment***

The removal or immediate corrective treatment of high-risk trees must be a top priority within any tree risk management program. Trees with the highest numeric risk rating (10) should be treated first. Based on your community's policy, remove or treat defective trees starting with those rated as 10 and move down the list as financial and human resources allow.

***Step 5. Conduct a Public Review Before Implementing Corrective Actions***

Communication with community members and landowners is recommended before corrective actions are taken. If people are informed of the need for the corrective actions before the time they begin to see trees being removed or pruned, there will be clearer understanding and better community acceptance of why the actions are being taken.

***Step 6. Take Corrective Action as Soon as Possible on the Highest Risk Trees***

Once high risk trees are identified, action must be taken as soon as possible. Negligence may be assumed if a community identifies high risk and then takes no action. See Chapter 5 for more information about treating and correcting high-risk trees.

***Step 7. Document the Process: Inspection Results, Actions Recommended and Actions Taken***

Documentation should include recording the inspection dates, individual tree ratings and corrective actions recommended and then carried out. These are absolutely critical to keep on file. Document all ratings, including the low ratings, on the field sheets. Data may be taken during street tree inventories, hazard tree inventories, as reported by community personnel, etc. Use the forms supplied in this manual or create one that suits your needs. See Form 3: USDA community tree risk evaluation form and Form 4: Guide to risk rating codes. Maps are helpful and can be reused in subsequent years.

**Form 3.3: USDA community tree risk evaluation form** (*See Forms Section for full size form)*

USDA COMMUNITY TREE RISK EVALUATION FORM
Example Form *

Location:___________________ Date:________________ Inspector(s):_______________________

| Tree # | Species | DBH | Location (Street Address) | Defect Code(s) | 1 Probability of Failure | 2 Size of Defective Part(s) | 3 Probability of Target | 4 Other Risk Factors (Optional) | Description of Other Risk Factors | Risk Rating (Sum of Columns 1-4) | Corrective Action Code(s) | Action Completed | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1-4 pts | 1-3 pts | 1-3 pts | 0-2 pts | | 3-12 pts | | Date | Initials |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

* This is an *example* form adapted from various sources by the US Forest Service, Northeastern Area Hazard Tree Training Team. The US Forest Service assumes no responsibility for conclusions derived from the use of this form. Managers should construct their own forms, based on need and experience. Revised: 4/03

## Form 3.4: Guide to codes for USDA community tree risk evaluation form

*(See Forms Section for full size form)*

Guide to Risk Rating Codes

**(companion guide to the Community Tree Risk Evaluation Form)**

PROBABILITY OF FAILURE: **1-4 points**

1. **Low:** some minor defects present:
   - minor branch/ crown dieback
   - minor defects or wounds
2. **Moderate:** several moderate defects present
   - stem decay or cavity within safe shell limits: shell thickness > 1 inch of sound wood for each 6 inches of stem diameter
   - crack(s) without extensive decay
   - defect(s) affecting 30-40% of the tree's circumference
   - crown damage/breakage: hardwoods up to 50%; pines up to 30%
   - weak branch union: major branch or codominant stem has included bark
   - stem girdling roots: <40% tree's circumference with compressed wood
   - root damage: < 40% of roots damaged within the CRR
3. **High:** multiple or significant defects present:
   - stem decay or cavity at or exceeding shell safety limits: shell thickness < 1 inch of sound wood for each 6 inches of stem diameter
   - cracks, particularly those in contact with the soil or associated with other defects
   - defect(s) affecting > 40% of the tree's circumference
   - crown damage/breakage: hardwoods >50%; pines >30%
   - weak branch union with crack or decay
   - girdling roots with > 40% of tree's circumference with compressed wood
   - root damage: > 40% of roots damaged within the CRR.
   - leaning tree with recent root breakage or soil mounding, crack or extensive decay
   - dead tree: standing dead **without** other significant defects
4. **Extremely High:** multiple **and** significant defects present; visual obstruction of traffic signs/lights or intersections:
   - stem decay or cavity exceeding shell safety limits **and** severe crack
   - cracks: when a stem or branch is split in half
   - defect(s) affecting > 40% of the tree's circumference or CRR **and** extensive decay or crack(s)
   - weak branch union with crack **and** decay
   - leaning tree with recent root breakage or soil mounding **and** a crack or extensive decay
   - dead branches: broken (hangers) or with a crack
   - dead trees: standing dead **with** other defects such as cracks, hangers, extensive decay, or major root damage
   - visual obstruction of traffic signs/lights or intersections
   - physical obstruction of pedestrian or vehicular traffic

SIZE OF DEFECTIVE PART(S): **1-3 points**

1. Parts less than **4** inches in diameter
2. Parts from **4 to 20** inches in diameter
3. Parts **greater than 20** inches in diameter

PROBABILITY OF TARGET IMPACT: **1-3 points**

1. **Occasional Use:**
   - low use roads and park trails; parking lots adjacent to low use areas; natural areas such as woods or riparian zones; transition areas with limited public use; industrial areas.
2. **Intermediate Use:**
   - moderate to low use school playgrounds, parks, and picnic areas; parking lots adjacent to moderate use areas; secondary roads (neighborhoods) and park trails within moderate to high use areas; and dispersed campgrounds.
3. **Frequent Use:**
   - emergency access routes, medical and emergency facilities and shelters, and handicap access areas; high use school playgrounds, parks, and picnic areas; bus stops; visitor centers, shelters, and park administrative buildings and residences; main thoroughfares and congested intersections in high use areas; parking lots adjacent to high use areas; interpretive signs, kiosks; scenic vistas; and campsites (particularly drive-in).

OTHER RISK FACTORS: **0-2 points**

- This category can be used if professional judgment suggests the need to increase the risk rating.

- It is especially helpful to use when tree species growth characteristics become a factor in risk rating. For example, some tree species have growth patterns that make them more vulnerable to certain defects such as weak branch unions (silver maple) and branching shedding (beech).

- It can also be used if the tree is likely to fail before the next scheduled risk inspection.

**Table 1. Defect Codes**

| Code | Defect |
|---|---|
| D | Decay |
| CR | CRack |
| Root | Root Problems |
| RSG | Stem Girdling |
| RS | Severed |
| RPD | Planting Depth (too deep) |
| RGC | Grade Change |
| RSB | Sidewalk Buckling |
| WBU | Weak Branch Union |
| CA | CAnker |
| PTA | Poor Tree Architecture |
| PTA:LT | Leaning Tree |
| PTA:TT | Topped Tree |
| EE | Excessive Epicormics |
| DEAD | DEAD tree, tops or branches |
| VO | Visible Obstruction |
| PO | Physical Obstruction |

**Table 2. Corrective Action(s) Codes**

| Code | Action |
|---|---|
| Prune | |
| PD | Deadwood |
| PW | Weakwood (defective part(s)) |
| PC | for Clearance |
| PT | to Thin crown or reduce crown weight |
| PR | to Reduce crown height |
| Target | |
| TM | Move |
| TEV | Exclude Visitors from Target Area |
| CB | Cable/Bracing |
| CWT | Convert to Wildlife Tree |
| RT | Remove Tree |
| Monitor | Monitor regularly |
| NA | No Action Required |



Return to Table of Contents | Chapter 3, Next Section 8