Forest Health Protection

Pacific Southwest Region

April 2012 (Report # RO-12-01)

Hazard Tree Guidelines For Forest Service Facilities and Roads in the Pacific Southwest Region

Peter A. Angwin, Daniel R. Cluck, Paul J. Zambino,

Brent W. Oblinger and William C. Woodruff

These hazard tree guidelines provide a means to identify and abate hazard from trees that are likely to fail and cause injury to either people or property on Forest Service system roads or at Forest Service facilities (i.e. campgrounds, boat ramps, trailhead parking, summer home tracts, administrative sites, kiosks, information centers, etc.) in California. They are intended to provide consistent direction for hazard tree identification and abatement and their use is highly encouraged and fully supported by Forest Health Protection (FHP) staff.

It must be recognized from the outset that even under the best of circumstances and with the highest standard of care, our ability to predict tree failure is not infallible. Simply put, we are limited in our ability to reasonably foresee all tree failures all the time. However, by exercising good professional judgment and using a systematic approach such as the one suggested in these guidelines, it is possible to significantly reduce (but not totally eliminate) the risk of injury to people and damage to property (Figure 1) .

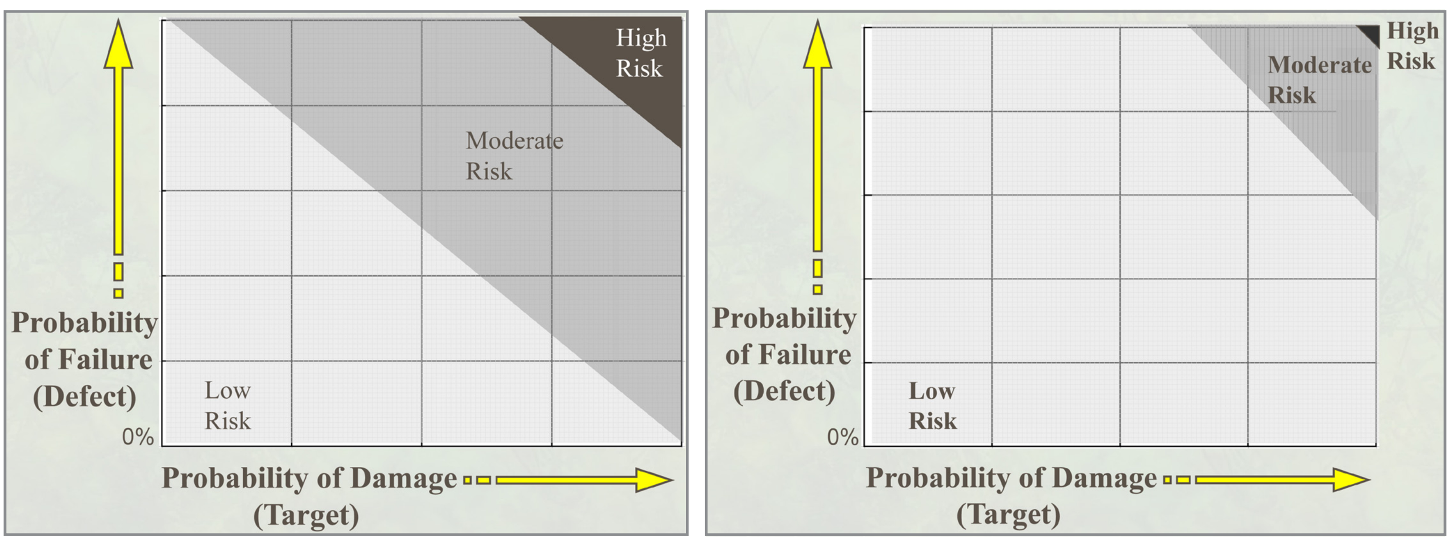

Figure 1. Distribution of risk in a tree population before (left) and after (right) hazard tree inspection and high-priority action (Dunster and Associates Environmental Consultants Ltd.)

The specific objectives of these guidelines are to:

1. Describe the need for hazard tree management and review current policy direction for the National Forest System.
2. Explain hazard tree evaluation procedures and describe a hazard tree rating system appropriate for:

a. recreation, administration, high-use areas, and
b. other areas with at-risk targets, including Forest Service road systems.

3. Describe ways to mitigate hazard from trees.

Assistance with hazard tree management is available from FHP staff in the Regional or Shared Service Area offices. Available assistance includes:

1. Training in identification, mitigation and management of hazardous trees, as well as in the use of the International Tree Failure Database. Training may range from formal instruction to informal site visits.

2. On-site consultation to address specific hazard tree situations.

3. Helping to draft NEPA documents in support of hazard tree management.

4. Assistance with vegetation management planning for recreation areas.

5. Financial assistance to treat specific insect and pathogen-related problems, including the development of associated vegetation management plans and NEPA documents.

Hazard/Danger Tree Definition

Tree hazards include dead or dying trees, dead parts of live trees, or unstable live trees (due to structural defects or other factors) that are within striking distance of people or property (a target). Hazard trees have the potential to cause property damage, personal injury or fatality in the event of a failure.

It has often been common practice to refer to such trees as either "hazard trees" or "danger trees" according to the different settings in which they are found; "hazard trees" near structures or in recreation areas versus "danger trees" along roads. Properly speaking, hazard trees and danger trees are synonymous terms, referring to trees that have the potential to cause death, injury or property damage if they fail. This document uses the two terms interchangeably.

Additional Definitions

When rating trees for hazard or danger, one attempts to determine whether a loss from failure of a tree could be reasonably expected to occur before the next inspection. Loss is defined as property damage or personal injury and may be expressed in dollars. Failure is the mechanical breakage of a tree or tree part. Failures often result from the interaction of defects, weather factors, ice or snow loading or exposure to wind. Defects are flaws in a tree that reduce its structural strength. Trees may have single or multiple defects which may or may not be detectable. Failures result in accidents only if they strike a target. Targets can be stationary, such as buildings, or mobile, such as vehicles or people. In this discussion we will not consider other trees as targets, but will only address people, property, and structures. A hazard tree rating system is principally concerned with recognizing, assessing and recording detectable defects where actions can be taken to reduce or eliminate the hazard.

Responsibility and Forest Service Policy

The Chief of the Forest Service and the Regional Forester have stressed that the safety of the public and our employees is our central concern. In developed recreation areas and within the transportation corridors, hazard tree management is vital to everyone's safety. In the USDA Forest Service Strategic Plan for 2007-2012, Objective 4.1 is to "*Improve the quality and availability of outdoor recreation experiences*."

Two of the means and strategies that are listed to accomplish this goal are to "*Provide tools, guidance, and resource management to provide safe recreation use*." and "*Efficiently and effectively manage and maintain recreational opportunity infrastructure while protecting public health and safety*." Identification and mitigation of hazard trees on Forest Service land is clearly part of the Agency's mission.

Line officers have the responsibility for annual inspection and management of hazard trees on campgrounds and other heavily used recreation areas. Forest Service Manual, FSM 2332 states that health and safety-related items must be given highest priority in the operation and maintenance of recreation sites. FSM 2332.1 states that "*To the extent practicable, eliminate safety hazards from developed recreation sites. Inspect each public recreation site annually before the beginning of the managed-use season. Maintain a record of the inspections and corrective actions taken with a copy of the operation and maintenance plan. Immediately correct high-priority hazards that develop or are identified during the operating season or close the site*." FSM 2332.11 requires that, "*Consistent with preserving the recreation resource, remove trees or tree limbs identified as hazardous at developed recreation sites. Obtain assistance from timber management, forest pest management, and recreation specialists, as necessary*."

Treatment to prevent the future development of hazard trees by Heterobasidion root disease is also specified. Region 5 FSM Supplement 2303.14 states: "*To perpetuate the forest environment in and around developed recreation sites, **treat all freshly cut coniferous stumps** to prevent introduction and spread of Fomes annosus*." (causal agent of Heterobasidion root disease). The newly revised Forest Service Handbook, FSH R5 Supplement 3409.11, Chapter 60 (effective February 9, 2010) states: *Because of the high value of residual trees in developed recreation areas, and especially the importance of minimizing the development of hazard trees in these areas, it is recommended that in developed recreation areas **all conifer stumps greater than 3" across (outside bark diameter) receive borax** at the time the stump is created. …The same directions shall apply to other high value areas, such as progeny test sites, seed orchards, and other areas where there are high value trees*." It is anticipated that R5 FSM Supplement 2303.14 will be revised to match the FSH 3" borax treatment recommendation.

Forest Supervisors have a similar responsibility for the safe operation and management of roads and must "*…to the extent permitted by funding levels, systematically provide for elimination of identified hazards*." (FSM 7733.04c). Forest Service Handbook direction, (7709.59 Chapter 40, effective 02/05/2009) contains more specialized guidance pertaining to hazard trees. FSH 7709.59_40.3 policy states that:

1. *Safety is the predominant consideration in road operation and maintenance and takes priority over biological or other considerations.*
2. *Roadways must be managed for safe passage by road users. This includes management of hazards associated with roadside vegetation, including identification and mitigation of danger trees.*
3. *Identification of danger trees must be performed by qualified persons.*
4. *When high priority hazards to road users are identified on National Forest System roads and those hazards cannot be immediately mitigated, the roads must be closed.*

FSH 7709.59_41.6 also affirms that "*Road maintenance includes removing danger trees that threaten safe use of the transportation system*." In addition, FSH 7709.59_41.7 states that "*Roads that are open should have a condition survey at least annually. Roads that have been closed should be checked for obvious hazards prior to being opened. Roads open to travel should be checked following major storms or similar events that could significantly affect their condition, result in changes in their traffic service level, or have created new safety hazards*." This section also states that "*Danger tree hazards on roads will be prioritized by high, medium and low categories*."; that "*Roads or segments thereof identified as high priority constitute a considerable adverse effect on public safety and thus require prompt action*.";

that work to eliminate danger trees in areas of highest exposure should be scheduled first; that road segments should be closed if the hazards cannot be mitigated; and finally, that roads identified as medium to low priority tree hazard are not time-sensitive, but "*should be monitored for increases in hazard due to ongoing tree deterioration*." This direction also makes it clear that "*Road maintenance, including treatment of danger trees, may be categorically excluded from analysis and documentation in an environmental assessment or environmental impact statement under certain circumstances. See FSH 1909.15, chapter 30 for guidance concerning categorical exclusions and specifically section 31.12(4). Please refer to FSH 7709.59_40 for more information regarding hazard trees and road maintenance*."

Legal Aspects

Anyone who is injured or suffers property damage from a tree failure may sue the landowner, including governments. During such a suit, the agency may be held negligent and liable if the claimant can prove that:

1. The agency had a legal duty to the claimant; and
2. The agency breached its duty; and
3. The agency's breach was the legal cause of the claimant's injury or property damage.

If the Forest Service is negligent in attempting to carry out its duties, it may be held liable for resulting damages. One of the questions that is typically asked following an accident is, "Do you have a regular program of tree inspection and maintenance?" If so, the plaintiffs will want to know how thorough it is, how the inspectors are trained, the methodology and equipment used in the inspection, what kind of record keeping is used, etc. Then the questions turn to the tree that failed. When was it last inspected? What were the results? Was there any defect or indicator that might have suggested to a trained inspector that this particular tree was hazardous? Risks from hazard trees can never be totally removed, if it is desired to maintain recreation sites and roadways in forested conditions. Still, the Forest Service is duty-bound to reduce those risks to an acceptable level. A proactive hazard tree management and inspection program can not only protect lives and property, it can ensure that managers and Forest Health Protection staff have confidence in their ability to answer the above questions in case of a lawsuit.

Hazard Tree Management Programs

A hazard tree management program includes: 1) designating responsible individuals, 2) identifying and prioritizing the sites to be examined, 3) performing and documenting the inspection, 4) performing the necessary actions to reduce the hazards, 5) maintaining the records of inspection and actions taken, and 6) recording tree failures. The program should be compatible with available resources (personnel and funding).

1. DESIGNATING RESPONSIBLE INDIVIDUALS:

Designation of responsible individuals should occur prior to initiating a hazard tree program. As mentioned above, each line officer is responsible for preparing operations and maintenance plans and implementing them for their public use areas (FSM 2330.43). One employee should be responsible for the hazard tree management program at each Ranger District. This will ensure that the program functions are completed, including periodic surveys, required mitigation actions, and records maintenance, and that there is continuity from year-to-year. The individual should have the authority to supervise crews and the background and training to run a hazard tree program. This includes knowledge of the public use areas, the ability to identify and rate defects as to their potential to cause failure, and the ability to prescribe the proper actions to reduce the tree hazard. Knowledge of past failures in an area is an added benefit because of the information it provides on the types of defects and tree species involved in such failures. The inspection crews, if any are formed in addition to the responsible individual, also need to have adequate training in recognizing and rating tree defects. They should have familiarity with the recreation sites to determine occupancy and the likelihood of a target being present. Similarly, knowledge of the local weather conditions would be useful since many failures occur during storms and unusual weather conditions.

While the above discussion specifically addresses the qualifications of the lead person and crew responsible for inspections in developed recreation areas, the same attributes apply for the people involved with performing hazard tree inspections along Forest Service roads.

2. IDENTIFYING AND PRIORITIZING SITES TO BE EXAMINED:

Developed Recreation Areas, Administration Sites and Other High Value Sites

Annual safety inspections are required for every public National Forest recreation site (FSM 2332.1). This includes hazard tree inspections. Inspections should normally be done prior to the primary use season, with sufficient time allowed for corrective actions. Inspections may also be needed following severe storms during the use season. While Region 5 FHP generally recommends inspecting once a year with supplemental inspections after storms, local conditions (including level of use of the recreation area, tree species and unusually good or poor tree health or defect levels) may necessitate additional inspections or allow for fewer inspections. While some areas may need to be inspected twice a year, in other areas it may be reasonable to only fully inspect every two or three years, with a more cursory inspection in the intervening years. However, if more cursory inspections are done, close attention should be given to any trees that were noted as suspect in previous inspections. In any case, the reasons for changing the inspection interval should be well documented and supported by local conditions.

A systematic inspection is preferable. A map of an area will simplify the planning of a survey route and will aid in the recording of tree locations during the survey. In recreation sites, areas can be divided into tree hazard risk zones (High, Medium and Low) prior to inspection (Figure 2). Inspection intensity should vary directly with the risk level. All trees that have a target within striking distance should be visually examined. On level ground, this striking distance is generally one to one and a half times the tree height. On sloped ground, additional striking distance should

Figure 2. Recreation areas can be divided into tree hazard risk zones which determine the intensity of evaluation.

be added on the downhill side to take into account the potential for a falling tree or tree part to slide or roll. At the very least, all trees within areas of intensive public use should be evaluated. Special attention should be given to trees >8” diameter at breast height (dbh), since two-thirds of reported failures occur in trees of this size.

The High Risk Zone includes high use areas with many people, parked vehicles and permanent structures. This zone is the highest priority for regular inspection and treatment. The Medium Risk Zone includes areas with intermittent use by people and moving vehicles. The priority for inspections in this zone is based on amount and type of use. The Low Risk Zone includes areas lacking vehicles or structures with low visitor use. Regular inspections and treatments in this zone have low priority.

Forest Service Roads

As was stated above, the Forest Service Handbook stipulates that roads that are open should have a condition survey at least annually, that roads which have been closed should be checked for obvious hazards prior to being opened and similar checks should be made following major storms. Because it is not feasible to intensively survey all roads every year, a system to prioritize roads for intensive and more cursory inspection is recommended. When establishing priorities for roadside hazard tree inspection and mitigation, land managers should consider the Road Maintenance Level (1-5), the level of public use and the potential for trees to strike the road. The intensity and frequency of hazard tree inspections will also depend on past failure history, the species of tree and impacts from insects, diseases, weather and fire. While some roads may only require an informal inspection every few years, others may require a more intensive inspection program similar to what would be required in a developed recreation area. Again, the rationale for the prioritization decisions should be well documented and supported by local conditions. The table below provides a suggested prioritization scheme for the inspection of roads:

Table 1. Road inspection priority

Road Segment	Exposure Duration	Inspection Priority
Areas where people stop and congregate such as: • Trailheads & parking areas	Long	**Higher**
• Active projects/contracts along the road where work is stationary such as culvert replacement and bridge construction • Intersections along operational maintenance level 3-5 roads, scenic vistas, geologic points of interest, anywhere along roads where people are encouraged to stop	Short	↓
Areas along roads with higher traffic volumes such as: • Operational maintenance level 3-5 roads not within intersections • Haul routes during commercial use – Operational maintenance levels 2-5 Level 2 roads are included because of elevated traffic volume during commercial use	Intermittent but High frequency	**Lower**
Areas with low traffic volumes, such as: • Operational maintenance level 2 roads	All	**Low**

3. PERFORMING THE INSPECTION

All trees with a target need to be identified and rated for hazard potential using an accepted rating system. Following rating, action is prescribed to correct or monitor the situation. Examples of rating systems include those developed by the state of Washington (Mills and Russell 1980), the province of British Columbia (Wallis, Morrison and Ross 1980), and Regions 2 and 6 of the Forest Service (Johnson 1981; Harvey and Hessburg 1992; Filip et al 2012), and the systems for evaluation of roadside danger trees in use in Region 6 (Schmitt 2004; Toupin et al 2008). These systems are described in the publications listed at the end of this guide. While all of these systems are appropriate for assessing and documenting tree hazards, a modified version of the "7-Point System" of Mills and Russell, that has been in use the longest in Region 5, is described in this document and recommended for continued use.

General Procedures

The hazard tree inspection form in Appendix 1 and tatum guide in Appendix 2 will help inspectors to record all of the data needed to determine hazard ratings. While performing an assessment, the area should be covered in a logical sequence, such as by campsite number or road segment. From year-to-year, try to approach sites/roads from different directions to get a better perspective of the trees. Always try to survey with optimal lighting. Record tree number, species, dbh, and mapping information as appropriate.

The hazard tree inspection process involves four steps:

1. **Assess the target for each tree**. If the tree would not hit a road, major trail, structure, parking area, campsite or other target, you can ignore it. Do not overlook any desirable sleeping areas near campsites that are used by campers. A line tape and clinometer are useful in determining target zones, as are forestry laser measuring devices.

2. **Assess the tree for defects**. When first learning to evaluate hazard trees, it helps to consider all possible defects and decide if any apply. Look at the tree from 2-3 perspectives, close and far and all around. Diameter tapes, hand lenses, binoculars, sounding mallet and field identification guides are all helpful tools. Based on indicators and experience, it may be necessary to follow up initial visual observations with more invasive methods using a pulaski, hand axe, increment borer or drill to look inside the tree. Because wounding can lead to further damage by decay organisms, do not drill or cut into a tree unless other indicators or your experience leads you to believe that additional useful information will be gained. In any case, be sure to document all of your tests and observations, both positive and negative. The various kinds of defect one may likely encounter are outlined later in this guide.

3. **Calculate the hazard rating score**. The hazard tree evaluation system that is provided combines target and defect into an overall hazard rating for the tree. In some cases, you may feel the rating does not accurately reflect the hazard potential of the tree. Remember, tree inspection and hazard rating are a combination of science and experience. Rate each tree according to what experience and sound judgment tell you is right, and make notes in the space provided on the hazard tree form to document your assessment. If necessary, use a supplemental notebook. Even if the rating seems reasonable, use the notes column to record details on the defects, such as the identity of the root pathogen, canker, conk, etc.

4. **Determine a corrective action**. Corrective actions may address either the defective tree or the target. Depending on the circumstances, these may include moving the target or removing the tree.

Assessing Targets and Defects

The two most important items to evaluate in a hazard tree inspection are targets and defects. Following are important considerations. **Keep in mind that the target and defect categories presented here are guidelines only. Local conditions, history, observations, and experience are far more important to consider when rating targets and defect than strict adherence to guidelines. However, changes should be well documented and consultation with your local Forest Health Protection specialist is encouraged:**

1. Assessing Targets

Target potential (sometimes referred to as "failure impact" or "damage potential") incorporates the potential for a tree or tree part to strike a target ("potential failure zone"), the potential for damaging a target, and the value of the target. Moving targets are less likely to be struck than stationary targets. When a tree or tree part fails, it may strike other trees or debris on the ground and fling material a considerable distance. For this reason, the potential failure zone of a tree on level ground is generally (depending on local conditions and judgment) one to one and a half times the height of the tree (Figure 3). Similarly, when only a branch, top or other tree part fails, the potential failure zone may be one to one and a half times the length of the tree part that becomes dislodged (Figure 4). On sloping ground where the tree or dislodged part may slide or roll downhill, the failure zone may need to be

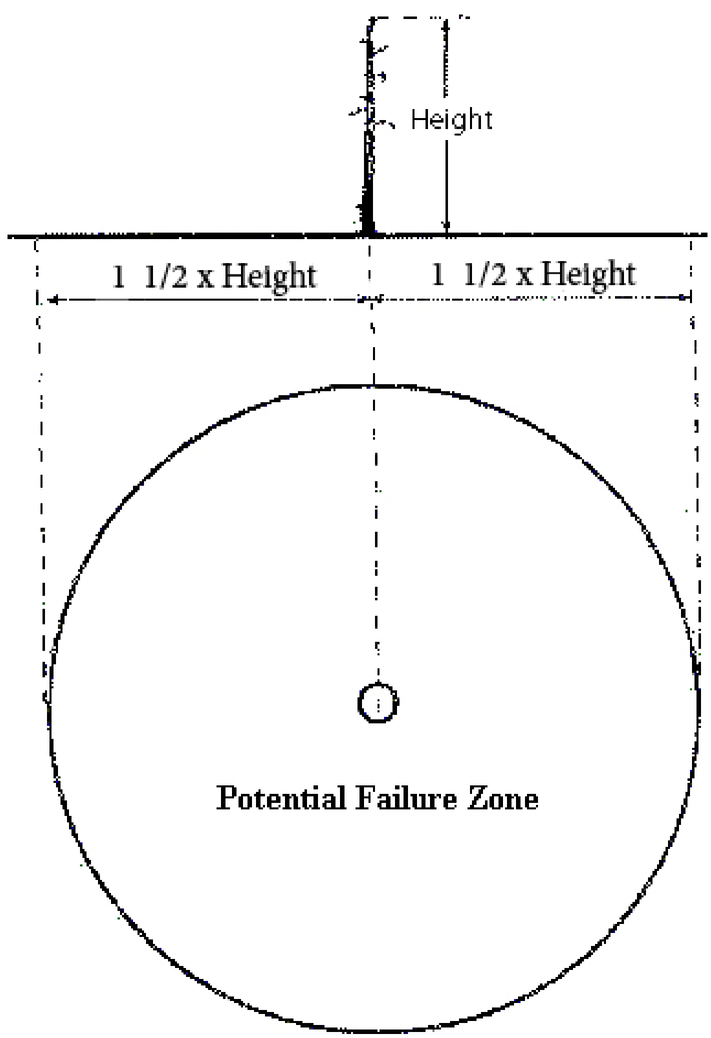

Figure 3. Potential failure zone associated with total tree failure with no slope or lean.

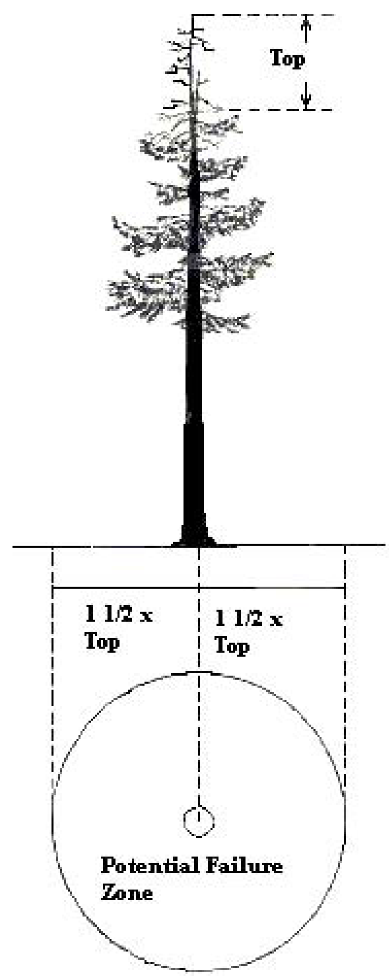

Figure 4. Potential failure zone associated with top failure with no slope or lean.

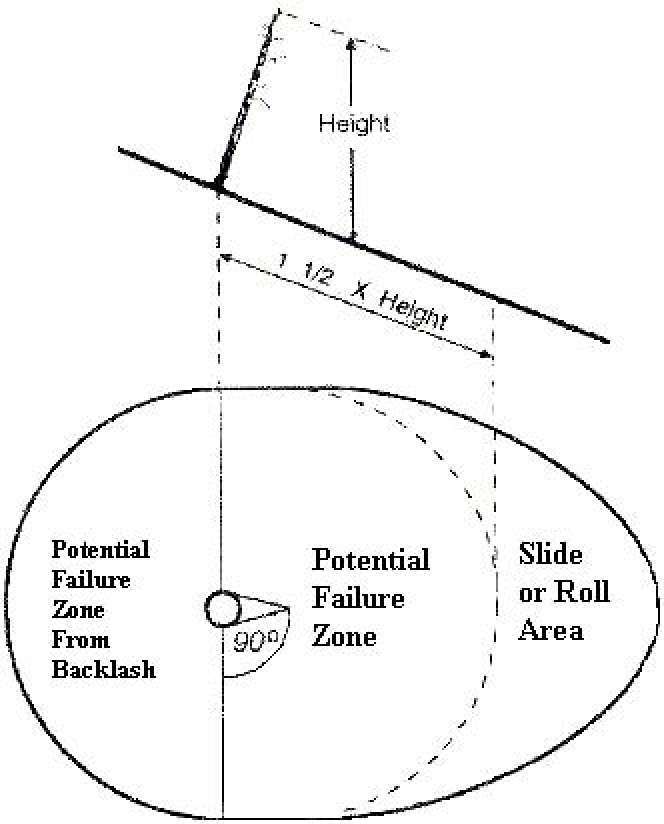

Figure 5. Potential failure zone associated with total tree failure with slope and lean.

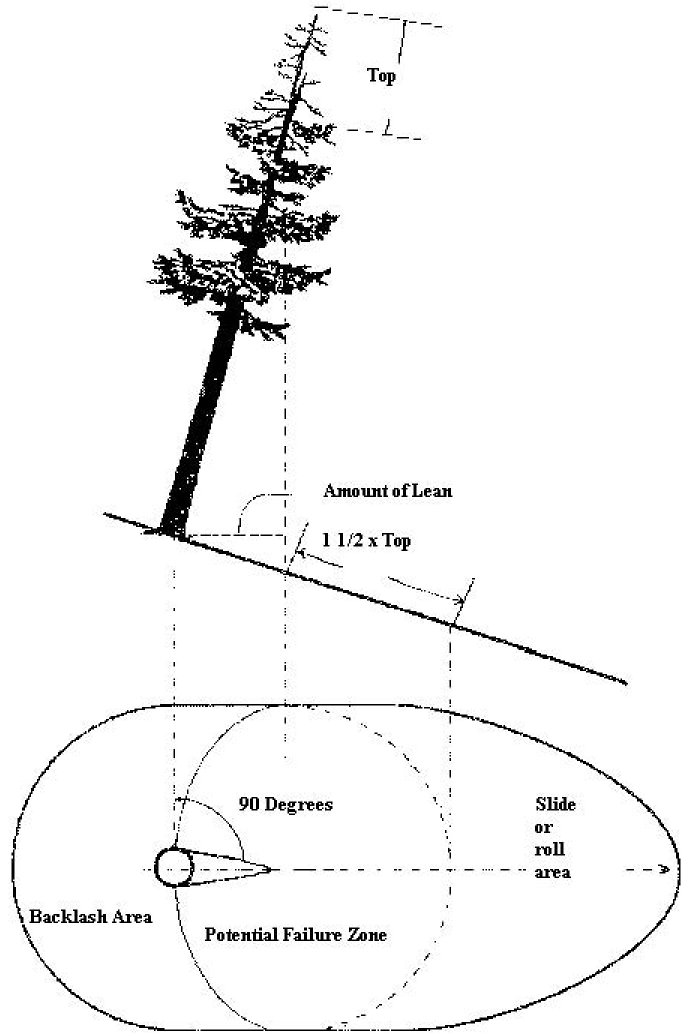

Figure 6. Potential failure zone associated with top failure with slope and lean.

extended on the downhill side for whatever distance is necessary to protect people or property (Figures 5 and 6). Potential failure zones should only be established to the extent that a tree or tree part may reasonably strike a target, and should not be arbitrarily expanded as a pretext to capture timber volume. Inappropriate assignment of target zones in this manner could lead to the loss of the categorical exclusions that allow the routine treatment of hazard trees (FSH 1909.15, Chapter 31.12 (3, 4 and 5).

Once the potential failure zone is determined, the tree is assigned a "Failure Impact Rating" (sometimes referred to as a "Target Rating") that represents both impact potential and target value. Generally, a target that is rated high has a high value (person or property) with a high likelihood of being impacted in the event of a failure (long exposure duration, such as a permanent or overnight stationary target). In roadside evaluations, impact potential and target value is rated according to "Exposure Duration" (Long, Short or Intermittent With High Frequency), which reflect such factors as road maintenance level, traffic volume, and degree to which people stop and congregate. Specific examples for both developed recreation area and roadside assessments are in the description of the 7-Point Rating System later in this guide.

2. Assessing Defects

Common indicators of defect are cracks, weak branch unions, stem or branch decay, cankers, dead tree, top or branches, bark and wood boring beetles, root damage and root disease, lean and poor architecture. Multiple and connected defects increase failure potential. Information on the biology, identification and management of many of the biotic and abiotic agents that can contribute to tree defect is detailed in the 2009 USFS/CALFIRE California Insect and Disease Training Manual on the internet at http://www.fs.fed.us/r5/spf/publications/foresthealth/manual_090507.pdf. The unique symptoms and probabilities of failure for the above defects are presented below:

a. **Cracks**. Vertical cracks in the trunk, often accompanied by callus that may or may not be ruptured, may indicate that tree failure has already begun. Some consider them the number one indicator of hazard when a target is present. Cracks most commonly arise from improper wound closure, but can also be from short-term mechanical injury.

   Cracks need to be evaluated very carefully. They may or may not indicate substantial amounts of internal wood decay. Some cracks form as a consequence of massive internal decay, as a tree buckles in the wind. Cracks near major branch unions can also indicate that trees have begun to fail, sometimes without associated heart rot. In other cases, bark cracks are caused by frost or other weather extremes such as lightning and may or may not indicate decay or immediate failure. Careful evaluation using an increment borer or other tools (such as a resistograph, carbide tipped drill bit or tomograph) will help indicate the extent of any associated decay.

   Cracks that indicate high failure potential include:

   - A crack that goes completely through the stem or branch.
   - A stem that has two cracks on the same segment with a cavity or extensive decay on the inside.
   - A stem that has a crack in contact with another defect (canker, decay, weak branch union) or is at the base of a leaning tree.
   - A branch (4” or larger) with any crack.
   - A conifer stem with a single crack with inrolled bark and a cavity or decay inside.

   Cracks that indicate medium failure potential include:

   - A hardwood stem with a single crack with a cavity or decay inside (decay should also be evaluated based on the criteria listed below).

   Cracks that indicate low failure potential include:

   - Trees with a single frost or lightning crack and no internal decay.

   Trees with cracks that are determined to have medium or low failure potential that are not removed should be monitored on a regular schedule and after significant weather events.

b. **Branch unions and forked tops**. A branch union is a fork in the stem or a place where two or more branches join the stem together. Strength of the union is determined by whether the wood is well connected between the branches, or has entrapped (“included”) bark. If bark becomes entrapped by the expanding wood of the branches at the union, it acts as a wedge, preventing the wood of the branches at the union from fusing together. As the branches continue to grow, more and more bark becomes included in the bark wedge inside the tree, while pressure of the expanding wood against the bark wedge increases. Eventually, the remaining woody connections between the branches are no longer able to support the weight of the branch, and the weak union fails. Bark that curves inwardly into a branch union (“inrolled bark”) indicates that included bark is present within the branch union.

Strong branch unions are characterized by a U-shaped connection with branch angles approaching 90 degrees. Bark at this type of union is usually raised, with a roughened bark ridge over a slightly raised patch of “stress wood” from the branch union. Weak unions have an acute (V-shaped) angle with inrolled bark in the junction between the stems. V-shaped unions with a raised bark ridge at the connection (and no other defect) are generally strong. Narrow branch angles are more likely to have inrolled and included bark, particularly when one branch is not clearly larger than the other (as with a forked top).

Forked tops need to be evaluated carefully because they may or may not have high failure potential. Forked tops may be weak because they contain included bark as described above. Forked tops may also form when two or more of the lateral branches take over as a new leader when the old leader is broken or killed. When one lateral branch takes over, the old top is often referred to as a “sucker limb”. Because they are associated with broken or dead tops, these new leaders, which are usually U-shaped, often have internal decay near the point of attachment with the old top. These new leaders become prone to breakage as they become heavier or are exposed to high winds, ice or snow. However, this breakage is less common in pines and incense cedar.

Epicormic branches (also called water sprouts) are new branches that replace injured, pruned, or declining branches. They typically form in response to injury or environmental stress. By their very nature, epicormic branches form weak unions because they are shallowly attached instead of being attached all the way to the center of the stem. They grow and become heavy very quickly. Old, large epicormic branches growing on decaying stems and branches are likely to fail.

Branch unions (including forked tops) that indicate high failure potential include:

- A weak branch union (V-shaped with inrolled bark) that is also cracked, cankered, decayed or streaming pitch. Strong branch unions with these defects, except as listed below, should be assessed on the basis of the associated defects.
- Heavy U-shaped branches of all species except for pines and incense cedar that form when side branches turn up to become leaders. Pines and incense cedar receive a high rating only if an associated defect (cracked, cankered, decayed or streaming pitch) is also present at the branch union.
- Large epicormic branches on decaying stems and branches.

Branch unions (including forked tops) that indicate medium failure potential include:

- A weak (V-shaped) union with inrolled bark.

Branch unions (including forked tops) that indicate low failure potential include:

- Heavy U-shaped branches of pines and incense cedar that form when side branches turn up to become leaders (no additional defect in the branch union).

c. **Decay in stem or branches**. Decay is a leading cause of tree failure, but is difficult to observe in some trees because the health and vigor of the crown is not a reliable indicator of internal decay. Decay is usually concealed inside the bole, roots and/or branches. Indicators of internal decay include wounds, broken or dead tops, cracks, wildlife cavities, conks, mushrooms and the presence of carpenter ants or termites. “Sounding” a tree by hitting it with a mallet or the back end of a hand axe and listening for a hollow sound may also give an initial indication of internal decay.

Decaying trees can be prone to failure, but the presence of decay alone does not indicate that a tree is highly defective. Some decay, especially in the interior, is tolerable. Most of the strength of a tree, like a pipe, is on the outside, so interior wood can be decayed without greatly reducing the strength. Thus, when decay is discovered in a tree, it is important to determine its extent and the amount of remaining sound wood. Drilling into the tree or taking core samples with an increment borer can help assess the amounts of sound and decayed wood. High-tech tools, such as a resistograph or tomograph, can also help detect and assess internal decay.

The One Third Rule: Trees are rated in the highest failure potential category if the remaining undecayed, sound wood shell is less than one third of the radius (radius is one-half of the diameter, as measured with a diameter tape). This is known as the "One Third Rule". For example, if a tree has a 18-inch diameter (9-inch radius), then a minimum of 3-inches of sound wood should be present around the whole circumference to pass the One Third Rule.

Keep in mind that the One Third Rule is only a general guide and there are many exceptions. Local knowledge, conditions and experience must always be considered. For example, if the tree is leaning, or if the decay column is not in the center of the tree or is in a horizontal branch, or if there is a cavity or crack that opens to the outside, then additional sound wood is needed to support the tree or tree part and the amount of sound wood needed to pass the One Third Rule must be increased. Failure potential is also considered high when there is canker-rot in the main stem or the decay is associated with a weak branch union or open crack.

Decay conditions in stems or branches that indicate high failure potential include:

- Less than ⅓ of the tree's radius (or diameter) is sound. This is the One-Third Rule for evaluating failure potential. Additional sound wood is needed if the tree is leaning, if the decay is off-center in the bole or present between four feet above the groundline and the lowest live branch, or is associated with an open cavity.
- A cavity, decay or fruiting body is associated with an open crack or weak branch union.
- Decay in a horizontal branch.

Decay conditions in stems or branches that indicate medium failure potential:

- Failure potential of trees with greater than ⅓ of the tree's radius in sound wood may or may not have medium failure potential, depending on the extent of the decay, species of decay fungus and position within the tree. At the very least, trees with identified decay should be closely monitored on a regular schedule and after significant weather events.

<u>Note</u>: If decay is detected in a tree that has a low failure impact (target) rating, such as one located along a low-use road, but the extent of the decay (whether or not it meets the One Third Rule) cannot be determined because of limited time, access and/or proper equipment, then use the following as a general guideline:

- True fir and hardwoods with known, but unmeasured decay, especially if a cavity is open to the outside, should be considered as having a high failure potential.
- Douglas-fir, incense cedar and pine species with known, but unmeasured decay, especially if a cavity is open to the outside, should be considered as having a medium failure potential.

<u>All trees that have moderate or high failure impact ratings</u> should be thoroughly evaluated with the proper equipment and/or mitigated regardless of species.

Fungal Fruiting Bodies: Fungal fruiting bodies (conks) may or may not indicate high failure potential, depending on the species, size and number of conks. When fruiting bodies are present, it is best to assess associated decay.

Examples of fungal fruiting bodies that indicate high failure potential:

- *Phaeolus schweinitzii* conks (also known as Schweinitzii root and butt rot, velvet top or cow pie fungus) associated with butt swell on Douglas-fir.
- One or more Indian paint fungus (*Echinodontium tinctorium*) conk on true fir or hemlock.
- Five or more red ring rot (*Porodaedalia* (*Phellinus*) *pini*) conks on Douglas-fir, ponderosa pine, Jeffrey pine, lodgepole pine, or more than one on true fir or hemlock.
- One or more quinine (*Fomitopsis officinalis*) conks on Douglas-fir, pines, western larch, spruce or hemlock.
- One or more sulfur fungus (*Laetiporus sulphureus*) conks (also known as “chicken of the woods”) on a wide range of conifers and hardwoods, including Douglas-fir, true firs, pines, hemlocks, spruces, larch, western redcedar, oaks, maples, birch and willow.

Examples of fungal fruiting bodies (conks) that indicate medium failure potential:

- *Phaeolus schweinitzii* conks without associated butt swell on Douglas-fir.
- Fewer than five red ring rot (*Porodaedalea* (*Phellinus*) *pini*) conks on Douglas-fir, ponderosa pine, Jeffrey pine, lodgepole pine, or one on true fir or hemlock.
- Incense cedar pecky rot (*Oligoporus amarus*) conks on incense cedar greater than 150 years old.

d. **Cankers**. A canker is an area of exposed sapwood or dead cambium underneath the bark. Cankers often have decayed wood underneath. Cankers can be caused by fungi, insects, weather, fire or other mechanical damage. Stems or branches often fracture at or near cankers. Cankers caused by fungi can look similar to exposed scars, but depending on the fungal species, fungal cankers can expand over time. Invasion of underlying wood by decay fungi is often the most serious consequence of a canker. However, depending on the tree species, a canker that encompasses more than one third or one half of the circumference of the tree is often hazardous, even if the exposed wood appears sound. Trees with cankers should be evaluated for internal wood decay. When applying the One Third Rule, cankered trees require more sound wood to be stable. In addition, the potential for failure is higher if a canker is accompanied by decay or if it is connected to another defect, such as a lean or crack.

Ramorum canker (also known as sudden oak death) is caused by the fungus-like water mold, *Phytophthora ramorum*. Millions of trees have been killed by ramorum canker in California and Oregon since the mid-1990’s. Affected species include tanoak, California black oak, Shreve’s oak, coast live oak and canyon live oak. Although many other plants are infected by *P. ramorum*, tree-killing bole cankers are only produced in tanoak and the oaks listed above. Trees infected by *P. ramorum* are often rapidly colonized by ambrosia (wood boring) beetles, bark beetles and decay fungi, making them prone to breakage, even when they are still alive.

In fire-injured trees, cankers are caused by lethal heating of tissues resulting in the death of the cambium. Dead cambium is often indicated by deep charring of the bole, where all of the bark is blackened and the bark characteristics are no longer discernible. When assessing defect in an area with deeply-charred trees, the consistency of the relationship between deep char and underlying dead cambium needs to be checked by cutting into the affected area of the bole. If deep char reliably indicates underlying dead cambium, then all areas with dead char may be assumed to be cankered. However, if it does not, then all deeply charred areas have to be checked on all trees that are assessed.

Cankers that indicate high failure potential include:

- Cankers with associated fruiting bodies of decay fungi.
- Cankers with associated internal decay.
- Cankers physically connected to a crack or other defect.
- Single or multiple cankers without decay that affect more than ½ of the tree's circumference, particularly if the cankers are located between four feet above the groundline and the lowest live branch.
- Basal cankers in true fir that affect more than ⅓ of the bole circumference.
- Cankers in oak or tanoak caused by *Phytophthora ramorum* (ramorum canker or sudden oak death) that affect more than ⅓ of the bole circumference, or have associated decay fungi, ambrosia beetles or bark beetles.
- Deep charring in true fir over more than ⅓ of the bole circumference when the relationship between deep char and cambial mortality has been confirmed.
- Deep charring in sugar pine, ponderosa pine, Jeffrey pine, incense cedar or Douglas-fir over ½ of the bole circumference when the relationship between deep char and cambial mortality has been confirmed.

Cankers that indicate medium failure potential include:

- For all species other than true fir, single or multiple cankers without decay that affect less than ½ of the tree's circumference (including fire-caused cankers).
- For true fir, single or multiple cankers without decay that affect less than ⅓ of the bole circumference (including fire-caused cankers).
- For oak or tanoak, cankers caused by *Phytophthora ramorum* (ramorum canker or sudden oak death) without associated decay, ambrosia beetles or bark beetles that affect less than ⅓ of the bole circumference.
- A large old wound or canker with no decay at the base of a leaning tree.

Cankers that indicate low failure potential include:

- True fir with bole swelling from dwarf mistletoe infection, but with no bark sloughing or evidence of decay.
- Lodgepole pine or ponderosa pine with basal (hip) cankers from western gall rust with no bark sloughing or evidence of decay.
- Lodgepole pine or ponderosa pine with elongated stalactiform rust cankers covering less than ⅓ of the bole circumference.

e. **Dead tree, top or branches**. Dead trees are simple to identify and among the most likely to fail. If a target exists, dead trees should be removed immediately. Snag trees for wildlife habitat should not be left if they are tall enough to hit a target. Dead tops and limbs are likewise easy to identify, and should be checked closely for evidence of rot or instability (e.g. exhibiting indicators of decay, previous breakage, wood destruction by woodpeckers or, in some species, sloughing bark). The dead portion of the tree must have the potential to reach a target. Dead tops of true firs tend to decay very quickly and usually require removal. New dead tops in Douglas-fir, spruce, hemlock, and hardwoods are highly susceptible to attack by decay fungi, and their failure potential is higher than other conifer species on the same sites. However, old spike tops in pine, incense cedar, juniper and Douglas-fir that give evidence of long-term persistence are usually dry and resin-impregnated, and are generally not any more hazardous than living portions of the tree. Large dead branches (larger than two inches in diameter) have an obvious potential for failure and should be removed, especially from hardwoods. Broken branches that are hanging or lodged in the crown should be treated immediately if a target is nearby. Note that healthy trees with dead limbs may be pruned rather than removed. Large dead dwarf mistletoe brooms should likewise be removed, while live ones should be removed if they have associated decay or other defect.

Dead tree, top or branch conditions that indicate high failure potential include:

- Any dead tree.
- Dead tops greater than ten feet long or smaller ones with associated decay or other defect (note that old dead tops of pine, incense cedar, juniper or Douglas-fir may not have high failure potential).
- Dead branches greater than two inches in diameter, branches that are hanging or lodged in the crown, large dead dwarf mistletoe brooms and large live dwarf mistletoe brooms with associated decay or defect.

Dead tree, top or branch conditions that indicate medium failure potential include:

- Dead tops less than ten feet long with no associated decay or other defect (note that old dead tops of pine, incense cedar, juniper or Douglas-fir may have lower than medium failure potential).
- Any branch greater than two inches in diameter and more than ⅔ dead (remove the entire branch).
- Live dwarf mistletoe brooms with no associated decay or other defect (monitor closely).

Dead tree, top or branch conditions that indicate low failure potential include:

- Old spike tops in pine, incense cedar, juniper or Douglas-fir that give evidence of long-term persistence.

f. **Trees attacked by bark and/or wood-boring beetles**. Bark beetles have the ability to attack and rapidly kill affected trees. Wood boring beetles typically attack heavily stressed, dying or dead trees. They can introduce wood decay fungi and hasten the rate of decay and failure. Important bark and wood boring beetles in California include mountain pine beetle (*Dendroctonus ponderosae*), Jeffrey pine beetle (*Dendroctonus jeffreyi*), western pine beetle (*Dendroctonus brevicomis*), Douglas-fir beetle (*Dendroctonus pseudotsugae*), fir engraver beetle (*Scolytis ventralis*), pine engraver beetle (*Ips* spp.), and several species of flatheaded (Buprestidae) and roundheaded (Cerambicidae) borers, including the goldspotted oak borer (*Agrilus auroguttatus*) on California black oak, coast live oak and canyon live oak in southern California. Red turpentine beetle (*Dendroctonus valens*) is also important, but rarely kills trees on its own. Trees that are mass-attacked by bark beetles are usually under stress from other physical conditions or diseases, including drought, root disease or dwarf mistletoe cankers. Trees in advanced stages of attack cannot be cured, and will die within six months to a year. After that, they will decay and become highly likely to fail. Because the progression from advanced infestation to failure can be rapid, it is important to identify and remove heavily infested trees with targets, or mitigate the hazard by moving the targets.

Green trees that have evidence of significant bark and/or wood boring beetle activity are considered dead and indicate high failure potential if they possess any combination

of the following factors over at least one third of the bole circumference:

- Pitch tubes with pink or reddish boring dust associated with them (in contrast to clear pitch streamers that indicate successful defense against attack).
- Pouch fungus conks and/or current woodpecker activity (holes into the sapwood and/or bark flaking, specifically excluding injury caused by sapsucker feeding).
- Boring dust or frass (in bark crevices, webbing along the bole, or that accumulates at the base of trees).

Note: This specifically excludes basal attacks by the red turpentine beetle (large pitch tubes associated with coarse boring dust generally restricted to the lower two to three feet of the bole or woodpecker activity restricted to this area) and when the above indicators are only associated with wounds, old fire scars, etc. (Smith and Cluck 2011).

Green trees are also considered dead and indicate high failure potential if they have the following indicator of significant bark and/or wood boring beetle activity:

- 50% or more of the foliage-bearing crown actively fading, as indicated by a uniform change in color over that part of the crown. Dead tops that have no foliage are not part of the living crown and do not count toward this 50%. This also does not include drought-induced needle cast (non-uniform fading restricted to the older needles) or branch mortality ("flagging") caused by dwarf mistletoe/*Cytospora* infections in true fir.

g. **Root damage and root disease**. Root problems are generally difficult to find and assess since tree roots are underground and out of sight. The two major kinds of root problems are physical and biological. Physical problems include undermined, severed, loosened, cracked, broken, exposed, and stem-girdling roots. A variety of activities can cause these root problems, including soil compaction, erosion, flooding or saturation, construction activities, prolonged heavy equipment or foot traffic, etc. Biological problems are generally caused by root disease and decay fungi. Root problems often only become apparent when tree crowns begin to show symptoms such as chlorosis, thinning, terminal growth loss and production of distress cones, or when signs of root failure become obvious, such as soil cracking or mounding, root lifting or breaking, partial windthrow or increased lean. Additional symptoms or signs of root disease include basal resinosis (patches of resin-impregnated wood and/or resin flow at the base of the tree, not associated with insect attack); for some root diseases, unusual swelling of the butt; root decay or butt rot; bark beetle mass attack; the presence of nearby fading, standing dead, windthrown or shattered trees; and the production of certain characteristic mushrooms or conks at root collars and in nearby decayed stumps.

Heterobasidion (annosus) root disease is the most widespread and damaging root disease in California, affecting many species of conifers and a few hardwoods. Pines, incense cedar, western juniper, true firs and giant sequoia are highly susceptible hosts, and failure of these trees in root disease infection centers is common. More complete information on Heterobasidion root disease is in the newly revised Forest Service Handbook R5 Supplement 3409.11, Chapter 60 (effective February 9, 2010). Other common root diseases in California include black stain root disease in Douglas-fir and in pinyon, ponderosa and Jeffrey pine; Armillaria root disease in hardwoods, especially oak (in California, the disease is less damaging in conifers); and Port-Orford-cedar root disease in Port-Orford-cedar. Schweinitzii root and butt rot is another important root and butt decay in many conifers in California.

Presence of root disease in developed recreation areas or along roadways should always be carefully evaluated and managed. When evidence of Heterobasidion root disease is present (as indicated by the presence of uprooted green or chlorotic host trees with roots exhibiting "delaminated" decay or with conks present in old decaying stumps and roots), it is possible that many of the standing susceptible trees in the immediate area are also infected. These infection centers and nearby host trees should be closely examined and considered potentially hazardous. When assessing individual trees in and around known infection centers, it is reasonable to use the condition of the crown as an indicator of advanced decay. Although not always caused by root decay, a thin (declining) crown with a rounded top does indicate poor tree vigor, and often the loss of 80% or more of normal root function. The thinner the crown of a tree in an area where Heterobasidion root disease is present, the more likely it is that the roots have been weakened by decay, and the more likely it is to have high failure potential. However, it is not uncommon for perfectly green, healthy-appearing trees to have the root disease as well.

Root damage and root disease conditions that indicate high failure potential include:

- Recently leaning trees, or trees with evidence of recent root-lifting, soil movement, mounding near the base of the tree, or broken/decayed roots.
- Inadequate root support, with more than ½ of the root system within the drip line severed, broken, undermined or decayed by erosion or excavation.
- Host tree species visibly infected with root disease fungi, adjacent to visibly infected trees or stumps, or with advanced crown symptoms in the immediate area where Heterobasidion root disease has been identified.

Root damage and root disease conditions that indicate medium failure potential include:

- Less than ½ of the root system within the drip line severed, broken, undermined or decayed by erosion or excavation.
- Host tree with few or no crown symptoms within 50 feet of a confirmed root disease-infected tree or stump or within 50 feet of a host tree with advanced crown symptoms.

h. **Leans and poor tree architecture**. Leaning trees deserve special attention because a displaced center of gravity increases the potential for failure and makes other defects of the roots, butt and bole more hazardous. However, lean in a tree can be either due to a tree's long-term responses to light and forces of wind, down-slope soil creep or soil subsidence, or to a recent change that indicates a failure potential. Trees often compensate for a long-term lean by correcting the skyward growth of the leader, giving a bowed appearance. This corrected lean is a sign of a strong root system, indicating that the tree may be fairly stable. A tree without a corrected lean (not bowed) suggests that the lean occurred recently, a potentially more hazardous situation. Recent (uncorrected) leans are particularly hazardous when they occur in combination with soil disturbance, construction, saturated soils, lifting of the root mass behind the leaning tree, large fire scars, or other decay or defects in the tree. The direction of the lean can give a strong indication of where the tree will probably fall.

Trees with an uncorrected lean greater than 10° may be unstable and should be monitored for potential failure. Failure potential is considered high when the tree leans more than 45° or when it leans and has another defect in the main stem.

Poor tree architecture may be caused by past breakage or poor pruning. These defects, including acute branch angles, too many branches arising from a single location, and codominant stems with included bark, may take many years to develop. Sharp bends or crooks in branches are naturally weak and prone to failure. If a tree is topped, multiple weakly attached branches may develop just below the cuts.

Lean and poor architecture conditions that indicate high failure potential include:

- Any tree leaning with an angle greater than 45° from vertical.
- A leaning tree with other contributing defects.
- A freshly leaning tree with recent root lifting, soil movement or mounding near the base.
- Lean associated with unstable soils or cracks in the tree.
- Uncorrected lean compounded by an unbalanced crown shape weighted in the direction of the lean.
- Uncorrected lean at a location with frequent storm or wind injury.

Lean and poor architecture conditions that indicate medium failure potential include:

- Uncorrected lean with an angle between 10°and 45° from vertical without other contributing defects. Monitor closely for changes in the lean.
- Branches with a twist, sharp angle or bend.
- Branches that are lopsided or unbalanced with respect to the rest of the crown, especially if nearby trees were pruned or removed within the last ten years.

Calculating The Hazard Tree Rating Score

As was stated previously, the "7-Point Hazard Tree Rating System" of Mills and Russell has been in use the longest in Region 5, and is based on systems in use by the National Park Service and the Provincial Park System in British Columbia. The updated version presented below is recommended for continued use in developed recreation areas, administrative and other high value sites, and along Forest Service roads and trails.

Inspectors are encouraged to adjust the defect and target rating scales presented in this guide as needed to take into account local conditions, history, observations and experience. Again, changes should be well documented and consultation with your local Forest Health Protection specialist is encouraged.

7-Point Hazard Tree Rating System

Two values are determined for each tree being rated - failure impact (target) and failure potential (tree defect). Both are determined independently and then combined to establish the hazard rating. Point values for failure impact and failure potential are as follows:

1. **Failure Impact (Target)**

   The first value, the failure impact, integrates the likelihood of impact, the amount of damage if failure occurs, and the value of the target (monetary or possibility of injury or death). One of the following values is selected:

   1 point = Low failure impact: minor damage is expected if failure occurs. Probability of impacting a target (exposure time) is low (e.g., transitory exposure only); defective tree or tree parts is small; target is of low value. Examples include highway corridors or improved Forest Service roads with little or sporadic traffic, unimproved roads, turnouts, bicycle paths, or structures with sporadic occupancy, such as storage buildings.

2 points = Medium failure impact: moderate damage is expected if failure occurs. Probability of impacting a target (exposure time) is moderate (e.g., daytime or intermittent exposure only); defective tree or tree parts is sufficient size to cause moderate damage; target is of moderate value. Examples include moderately used paved trails, picnic and other day use areas, interpretive sites such as amphitheaters and kiosks. Moderate to high-use road networks within campgrounds, roadside attractions, such as vista points or historic stops, information stations, visitor centers, fee collection portals, high use daytime parking areas, designated trailhead parking areas, plazas, staging areas and commercial sites, roads and intersections with moderate to high traffic volume, haul routes during periods of commercial use, and active projects along roads where work is stationary (such as culvert replacement and bridge construction).

3 points = High failure impact: extensive damage is expected if failure occurs. Probability of impacting a target (exposure time) is high (e.g., overnight exposure); defective tree or tree parts is of a size to cause extensive damage; target of high value. Examples include campsites, lodges, hotels, dormitories, residences and 24-hour visitor service and restroom facilities.

2. **Failure Potential (Tree Defect)**

The second value, the failure potential, requires the inspector to estimate the likelihood that, prior to the next inspection, the defective tree or tree part will fail during the season when the target is present. Determining the tree failure potential requires an evaluation of the defects and the failure potential of the defect for the tree species involved. Failure potentials of the most common tree defects were discussed previously in the section on “Assessing Defects”.

The following values are applied:

0 points = no defects identified
1 point = low potential for failure: minor defects.
2 points = medium potential for failure: moderate defects.
3 points = high potential for failure: serious defects.

Add 1 point if multiple, interacting defects are present, e.g. leaning tree with other defects.

Score 4 points (the maximum score) if the tree is dead.

When assessing a tree for failure potential, all defects that are present should be recorded on the inspection form. When a tree has several defects, the highest individual defect value is recorded as the overall failure potential value for the tree. However, if multiple defects interact to increase the potential for failure, then an additional point is added. For example, a leaning tree may interact with known or suspected root damage or trunk decay, increasing the stresses on the roots and trunk. Because the potential for failure is increased, an additional point is added to the failure potential value. Conversely, because lean does not increase the potential for dead branches to fail, trees with lean and branch decay would not receive an extra point.

The hazard rating is determined by adding the failure impact and the failure potential values. This can then be used to determine what action may be necessary to reduce the hazard.

HAZARD RATING = FAILURE IMPACT + FAILURE POTENTIAL
(TOTAL SCORE 1-7)

The following actions should be taken based on the hazard rating:

Hazard Rating	Hazard Potential	Suggested Action
1 - 3	Low	No Action or Monitor (document and tag or map tree)
4 - 5	Moderate	Monitor (document and tag and map tree) or Mitigate (remove defective tree, tree part or target)
6 - 7	High	Mitigate Immediately (promptly remove defective tree, tree part or target)

A hazard tree inspection form (Appendix 1) and a tatum guide to failure impact (target) and failure potential (defect) categories (Appendix 2) are included in the back of this guide.

Streamlined Process For Assessment Of Roadside Hazard Trees

It is recognized that there are many miles of Forest Service System roads that may have hazardous trees adjacent to them. Time and economic constraints play a role in determining how many miles of road can be reasonably inspected and treated each year. In addition, because most road segments receive lower failure impact (target) ratings than those in developed recreation areas, the overall hazard ratings tend to be lower. As a result, many highly defective trees along roads may only be rated as a moderate hazard (hazard rating of 5).

Although it is not possible to immediately correct the entire roadside hazard tree problem on a National Forest or Ranger District, a streamlined inspection and marking process may be used to maximize efficiency, correct for the lower hazard scores of roadside trees, and still provide a record of what was accomplished. The process is as follows:

1. Once road segments are prioritized for inspection according to the factors listed in Section 2 ("Identifying and Prioritizing Sites To Be Examined"), the responsible line officer decides what levels of hazard are acceptable for road segments with different levels of use. For example, the line officer may decide that along more highly-used road segments such as at trailheads and parking areas (failure impact score of 2), all trees with a failure potential score of 2, 3 or 4 should be removed or mitigated, while along road segments with less use (failure impact score of 1), only trees with a failure potential score of 3 or 4 should be removed or mitigated. Again, dead trees automatically get a failure potential score of 4.
2. Once the line officer determines the acceptable levels of failure potential for the road segments that are being inspected (according to the different levels of use), inspectors mark for removal or mitigation all trees within striking distance of the road (1 to 1½ tree lengths plus additional slide or roll area, if applicable) that are at or above the acceptable failure potential level. Again, inspectors are encouraged to take local conditions into account when identifying hazard trees.
3. Documentation of the inspection includes the names of the inspectors, the date of the inspection, the locations of the road segments that were inspected, the level of use (failure impact score) and acceptable level of failure potential for each road segment, how many

trees were marked for removal at each road segment, and notes on what kinds of defects were encountered. In order to highlight areas that may need more frequent inspection, a similar tally of the number and condition of any moderately defective trees that were retained along each road segment should also be made.

4. PERFORMING THE NECESSARY ACTIONS TO REDUCE THE HAZARDS

In developed recreation areas and along seasonally-used roads, corrective actions should be performed prior to the primary use season. If needed actions cannot be taken prior to primary use, the responsible official should notify the public of the hazard and determine whether the site or road should be closed until corrective actions can be taken (FSM 2331.5). Closing roads or recreational areas during severe storms can be an effective means of reducing injuries to people and property. Warnings explaining the hazardous condition should be posted.

Hazard trees in road segments with higher levels of use may constitute a considerable adverse effect on public safety and thus require prompt action (FSH 7709.59_41.7) . Work should be scheduled to eliminate hazard trees in areas of highest exposure first. When high priority hazards to road users are identified and those hazards cannot be immediately mitigated, the roads must be closed. In contrast, treatment of hazard trees along roads with lower levels of use is generally not considered time critical. Because of this, strategies utilizing the sale of forest products, class C chain saw certification training, Title II funding, watershed restoration projects or other funding sources as appropriate may be employed to mitigate roadside hazard trees along these roads.

Five types of action are generally available to reduce tree hazard potential:

- Target removal
- Tree removal
- Topping
- Pruning
- Specialized Actions

<u>Target Removal</u>

In certain situations removal of the target from the area of hazard is the easiest and least costly alternative. Moving picnic tables, fire grates, and portable toilets can easily be done. Redirecting the use pattern with barriers and access relocation may also be done. However, the number and distribution of tree hazards in some public use areas may require permanent closure and relocation of the facilities.

<u>Tree Removal</u>

Tree removal may be necessary to adequately reduce hazard potential. **All dead trees that could impact a target should be removed**. Careful analysis of the hazard potential should be made before recommending the removal of live trees, weighing the risks involved against the benefits that are provided. Care must be taken to minimize damage and wounding to residual vegetation. Wounds on residual trees may become defects that could be involved in future failures.

To prevent the introduction of Heterobasidion root disease in developed recreation areas and other high value locations, stumps of live or recently dead trees (that have not lost all of their needles and fine branches) that are larger than three inches across must be treated with a registered borate compound after they are cut (FSH R5 Supplement 3409.11, Chapter 60). This is mandated by FSM R5 Supplement 2303.14, which states: "*To perpetuate the forest environment in and around developed recreation sites, treat all freshly cut coniferous stumps to prevent*

***introduction and spread of Fomes annosus*.” (causal agent of Heterobasidion root disease)**. For maximum effectiveness, it is imperative that the compound be applied as soon after felling as possible, and certainly within four to twenty-four hours after the tree is felled. Along roads, consideration should be given to treating stumps that are larger than fourteen inches across in areas where Heterobasidion annosum is present or is a concern. Two compounds, Sporax® and Cellu-Treat®, are currently registered by the EPA and California for this purpose (EPA Registration numbers 2935-401 and 64405-8, respectively). Application must be done according to the label directions by qualified personnel. Forest Health Protection personnel are available to provide appropriate advice and the annual pesticide safety training that is required in California.

Topping

Removing the top of a hazard tree is the best option under some circumstances. Topping may reduce the height of the tree to the point where it would no longer reach a target if it failed. It can also greatly reduce the weight high in the tree and lower the “sail area” of the crown impacted by wind. Topping a tree can produce a more natural appearing structure than a stump, particularly if the cut top has a jagged shape. Live trees with dead or broken tops can be treated to reduce the hazard without removing the tree. As discussed above, the hazard potential of dead tops varies with tree species.

Once topped, trees should be periodically monitored for increased failure potential from decay fungi that enter through the cut surface.

In some situations, large hardwoods may require crown reduction. Topping of large hardwoods is generally not recommended because decay fungi are likely to enter the pruning wounds and because future pruning may be needed to control the growth of new shoots. Instead, it is recommended that the crowns of large hardwoods be reduced through a planned branch thinning.

Pruning

Pruning can be an effective method of action when branches, dead tops or multiple tops are the main factors of failure potential. Pruning can reduce failure potential and maintain the tree. If done correctly, pruning can also improve the health of the tree. However, improper pruning can produce an architecture with an even higher probability of failure.

Two factors influence the hazard potential of branches and tops: their size and the amount of use in the target zone below the tree part. When pruning is considered, the feasibility of moving or removing the potential target should also be considered. Target reduction may be a cost-effective alternative to more expensive pruning when layout of the site allows this approach.

Specialized Actions

High value trees with defects may merit special actions to reduce the hazard potential and retain the tree. This is particularly true if a tree has great historical, botanical or other special significance. Filling decay cavities with concrete and applying wound dressings are not considered beneficial. Actions that are sometimes employed include cabling, bracing and the use of poles for support. These methods are usually not applicable for large conifers and are usually only used as a last resort. Careful evaluation should be given to these activities prior to their implementation because of their high cost. Actions of this type usually require specialized expertise and professional arborists may need to be hired to evaluate the potential benefits of treatment and to do the work.

5. DOCUMENTING AND MAINTAINING RECORDS OF THE INSPECTION AND FOLLOWUP ACTIONS

Good records are a must for a hazard tree inspection program to meet its objectives and be effective. Every public use site or road that is inspected must have documentation, **even if no hazard trees are identified**.

Documenting the results of hazard tree evaluations and the implementation of followup actions has many advantages:

- It provides an assessment of current hazards and a framework for future vegetation management activities.
- It facilitates the detection and tracking of trends in insect, disease and hazard development.
- It provides a database for the implementation of future monitoring and treatment efforts, as well as a record of their planning and completion.
- It provides a record that inspections and mitigations were performed in the event of tree failure, tort claims or potential litigation.

Many forms have been devised to aid in record keeping. The information collected is similar on all such forms, with the differences reflecting the various hazard rating systems that are used. The following data is collected on all of the forms and reflects the basic information that is needed:

- Tree Number: Identifies tree for tracking purposes.
- Species: Helps locate tree in the future and aids in determining defects and corrective actions.
- DBH: Reflects tree size and potential for damage.
- Tree Height: Helps identify targets within striking distance.
- Tree Location: May be identified by campsite number, azimuth/distance from a landmark, GPS coordinate, or in a roadside inspection, by milepost, side of road and distance from a landmark at the road. Mapping tree locations is very helpful and highly recommended. Trees may also be tagged and numbered in the field. Mapping and/or tagging facilitates future relocation for management action, monitoring and tracking.
- Target: Describes type of target and value.
- Defect: Describes defect(s) present.
- Hazard Rating: Shows component and summed values from rating system.
- Recommended Action: Shows inspector’s determination of what needs to be done.
- Action Completed: Verifies and documents date of action.

The inspection form that is recommended to document hazard tree evaluations in the Pacific Southwest Region, as well as a tatum guide to failure impact (target) and failure potential (defect) categories are in Appendix 1 and 2 in the back of this guide.

It is recognized that time and economic constraints often make it impractical or impossible to collect and record detailed data for every tree in every area that is inspected. This is particularly true for roadside hazard tree evaluations. For this reason, it may be necessary to forego detailed documentation of trees that have little or no target potential or defect. It is, however, important to fully assess and document trees with moderate or high hazard potential. When this occurs, a statement should be added to the assessment form that all trees that are not specifically listed were inspected and had little or no hazard potential.

When the forms are completed, they should be filed by site or area in one location and retained. Retaining the forms can provide useful information on corrective actions taken and types of defects and associated failures. They can also provide useful information to new employees about the long term condition of particular trees and sites (including histories of root disease, fire and storm damage), and may be used to develop or change local policies on tree hazard management.

6. RECORDING TREE FAILURES

Regardless of how intensively tree hazards are managed, tree failure is a natural occurrence. When a tree or tree part fails, the failure should be recorded. Maintaining these records can provide information on the types of trees and conditions that are most likely to cause failure in specific areas in future years. They can also serve as a monitoring system for the tree hazard management program to determine if adjustments to the program are needed.

Documentation of tree failures should include tree species and size, time and location of the incident, defects associated with the failure, the amount of damage and loss, if any, and environmental conditions at the time of the failure. An international tree failure reporting system, the International Tree Failure Database (ITFD), has been established by the US Forest Service, in cooperation with the International Society of Arboriculture. The system uses a paper form for gathering failure data in the field (Appendix 3). Reports are then entered into an online database. A digital data entry program is also available. While one of the main functions of ITFD is to collect important data about trees that have failed, the database can also be used to generate user-specified reports on the characteristics of specific trees or tree species that have failed. This data can then be used to evaluate the effectiveness of your hazard evaluations and improve future predictions.

Training is required to get a username and password to enter tree failure reports online and to generate reports from the database. This training is available on request from the Forest Health Protection personnel in the Regional or Shared Service Area offices. Federal, state and tribal land managers who have not had the training can contact their Forest Health Management service center for information about submitting reports. In addition, Forest Service personnel and other federal or tribal cooperators are welcome to send their hard copy ITFD report forms to their local Forest Health Protection Shared Service Area office, where the data will be entered into the ITFD at no charge.

References

Filip, G.M., J. Biro, K.L. Chadwick, D.J.Goheen, E.M. Goheen, J. S. Hadfield, H.M. Maffei, K.M. Mallams, D.W. Omdal and C.L. Schmitt. 2012. Field guide for hazard tree identification and mitigation in developed sites in Oregon and Washington forests. USDA Forest Service, Forest Health Protection, Portland, OR (in press).

Harvey, R. D. Jr. and P. F. Hessburg. 1992. Long range planning for developed sites in the Pacific Northwest: The context of hazard tree management. USDA Forest Service, Forest Pest Management, Publication No. FPM TP039 92, Portland, OR. 120p.

Johnson, D.W. 1981. Tree hazards: recognition and reduction in recreation areas. USDA Forest Service, Rocky Mountain Region. Technical Report R2-1. 17p.

Mills, L. J., and K. Russell. 1980. Detection and correction of hazard trees in Washington's recreation areas. State of Washington, Department of Natural Resources, Rep. No. 42. 37p.

Schmitt, C. L. 2004. Roadside vegetation management: protocol for prioritizing surveys and recognizing, rating, documenting and treating hazard trees along forested roadways in northeastern Oregon. USDA Forest Service, Pacific Northwest Region. Publication BMPMSC-04-01. 10p.

Smith, S. L. and D.R. Cluck. 2011. Marking guidelines for fire-injured trees in California. USDA Forest Service, Forest Health Protection, Northeastern Shared Service Area, Susanville, CA. Report #RO-11-01. 15p.

Toupin, R., G. Filip, T. Erkert and M. Barger. 2008. Field guide for danger tree identification and response. USDA Forest Service, Pacific Northwest Region. Publication R6-NR-FP-PR-01-08. 64p.

USDA Forest Service and CALFIRE. 2009. California insect and disease training manual. USDA Forest Service, Forest Health Protection, Pacific Southwest Region. 218p.

Wallis, G. W., D. J. Morrison and D. W. Ross. 1980. Tree hazards in recreation sites in British Columbia: management guidelines. British Columbia Ministry of Lands, Parks and Housing, and the Canadian Forestry Service. Joint Rep. No. 13. 52p.

Additional Reading

Albers, J. and E. Hayes. 1993. How to detect, assess and correct hazard trees in recreational areas, revised edition. Minnesota Dept. of Natural Resources, St. Paul, MN. 63p.

American National Standards Institute. 2011. American national standard for tree care operations- tree, shrub, and other woody plant management-standard practices (tree risk assessment a. tree structure assessment). Tree Care Industry association, Inc., Londenderry, NH. 14p.

Bakken, S. 2006. Tree hazard manual: guidelines and standards for the California Department of Parks and Recreation. 40p.

Costello, L.R., B. Hagen, and K.S. Jones. 1999. Recognizing Tree Hazards: A Photographic Guide For Homeowners. University of California Division of Agriculture and Natural Resources.

Harris, R.W., J.R. Clark, and N.P. Matheny. 2004. Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines. (Chapter 16: Tree Hazard Management).

Matheny, N.P. and J.R. Clark. 1994. Photographic Guide to the Evaluation of Hazard Trees in Urban Areas, Second Edition. International Society of Arboriculture, Champaign, IL. 85p.

Minnesota Department of Natural Resources, and USDA Forest Service. 1996. How to recognize hazardous defects in trees. USDA Forest Service, State and Private Forestry, Northeastern Area. Pub No. NA-FR-01-96. 12p.

National Park Service. 2008. Pacific west region directive PW-02: hazard tree management. National Park Service. 23p.

Paine, L.A. 1971. Accident hazard evaluation and control decisions on forested recreation sites. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Research Paper PSW 68. 10p.

Paine, L.A. 1978. Administrative goals and safety standards for hazard control on forested recreation sites. USDA Forest Service USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Research Paper PSW 88. 13p.

Sharon, E. M. 1987. Tree health management: evaluating trees for hazard. Journal of Arboriculture 13 (12):285-293.

Shigo, A.L. 1983. Tree defects: a photo guide. USDA Forest Service General Technical Report NE-82.

Smiley, E.T. and B.R. Fraedrich. 1991. Hazardous Tree Evaluation and Management. Bartlett Tree Research Laboratories.

Smiley, E.T., N. Matheny and S. Lilly. 2011. Tree Risk Assessment. International Society of Arboriculture, Champaign, IL. 81p.

Swiecki, T. J. and E. A. Bernhardt. 2006. A Field Guide to Insects and Diseases of California Oaks. Gen Tech. Rep. PSW-GTR-197. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 151 p.

Trummer, L. and P. Hennon. 2009. Hazard trees in Alaska: a guide to the identification and management of hazard trees in Alaska. USDAForest Service, Alaska Region, Pub. No. R10-TP-142. 62p.

USDA Forest Service. 2011. Vegetation management plan outline for recreation areas. USDA Forest Service, Forest Health Protection, Pacific Southwest Region. 11p.

Wagener, Willis W. 1963. Judging hazard from native trees in California recreational areas: a guide for professional foresters. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Research Paper PSW P1. 29p.

Wood, D. L., T.W. Koerber, R.F. Scharpf, and A. J. Storer. 2003. Pests of the Native California Conifers. Univ. of Calif. Press. 233p.

Appendix 1

Hazard Tree Evaluation Form

USDA Forest Service HAZARD TREE EVALUATION Pacific Southwest Region

Site: ______________________________________ Page: ____ of ________

Date: ______________________ Inspected by: ____

(Each column represents one tree)

Unit (campsite or other)																					
Tree number																					
if used	**Ref. point** (codes on back)																				
if used	**Azimuth**																				
if used	**Distance**																				
Tree species																					
DBH																					
Height																					
Failure Impact (Target) (Score 1-3)																					
Failure Potential (Defect) (Score Each of the Following 0-3): Cracks																					
Branch Unions																					
Stem or Branch Decay																					
Fungal Fruiting Bodies																					
Cankers																					
Dead Tree, Top or Branches (Score 4 If Tree Is Dead)																					
Bark or Wood-Boring Beetles																					
Root Damage or Disease																					
Lean or Poor Architecture																					
Highest Failure Potential Score From Above																					
Multiple Interacting Defects (1 point)																					
Total Failure Potential (Highest Failure Potential Score + Interacting Defects: Score 0-4)																					
Hazard Rating (Failure Impact + Failure Potential: Score 1-7)																					
Recommended Action																					
Action Completed (Initial and Date)																					
Notes																					

Use of the HAZARD TREE EVALUATION Form

Defective trees are potential hazards to people and property in developed forest areas and along Forest Service roads. Indicators of defects are used to identify trees that may fail. Systematic, annual, documented inspections of trees in developed sites and corrective action are recommended to reduce hazards to the public.

The HAZARD TREE EVALUATION form is more than a hazard rating record. It is a record of the overall structural condition of a tree that can be used to determine progression of defects over time and to document the frequency of certain defects. All defects observed should be checked even though only the highest values are used in the hazard rating.

Forms cannot take all situations into account. Trained and experienced evaluation crews are encouraged to exercise judgment in the use of this form. However, if you need to regularly override the form, need training, or have any questions about the process or tree hazard, please contact your local Forest Health Protection staff:

Northern California Shared Service Area (Redding): (530) 226-2436 or (530) 226-2437
Northeastern California Shared Service Area (Susanville: (530) 252-6880 or (530) 252-6431
South Sierra Shared Service Area (Sonora): (209) 532-3671, ext. 242 or 323
Southern California Shared Service Area (San Bernardino): (909) 382-2725 or (909) 382-2871

1. Maps of the sites are helpful in planning and performing hazard tree surveys. All structures should be drawn on the maps. These maps used/created during the survey should be included with the HAZARD TREE EVALUATION forms to indicate which sites were surveyed.
2. Trees are easily and accurately mapped on the HAZARD TREE EVALUATION form by selecting reference points, then recording azimuths and distances to all defective trees on the form. Choose reference points that are permanent structures and unlikely to be moved. For large structures, use a more specific reference point such as the most northern/northwestern edge of the structure. Good **reference points to use are:** permanent picnic tables (codes as “T”), fire pits or grills (“F”), campsite number sign (“#”), latrines (“L”), signs (“S”), benches (“B”), water spigots (“W”), and garbage containers (“G”).
3. Potential hazard of a tree is determined by Failure Impact (Target) and Failure Potential (Defect):

	Definition	Values
Failure Impact (Target)	Failure Impact rating is a combination of the likelihood that a potential target will be hit (assuming the tree fails) and the value of the target.	Potential targets are assigned values of 1 (Low), 2 (Medium) or 3 (High).
Failure Potential (Defect)	A Failure Potential rating is an estimation of the likelihood that a tree will fail based on available indicators.	Defects are assigned values of 0 (None), 1 (Low), 2 (Medium) or 3 (High). The total failure potential score is the highest observed defect value **plus an additional point if multiple interacting defects are present** (maximum score of 4). **Automatic score of 4 if tree is dead.**

4. More than one type of defect may be identified and recorded for any tree.
5. **Calculate hazard rating by adding Failure Impact (Target) and Failure Potential (Defect) values.**

Possible Hazard Ratings: 7 = Highest and 1 = Lowest

Actions: 1-3 = no action or monitor; 4-5 = tag/record/map tree, monitor or mitigate; 6-7 = immediate mitigation

Revised March 2012

Appendix 2

Hazard Tree Evaluation Tatum Guide

Failure Impact (Target)

3 points = High failure impact: extensive damage expected if failure occurs. Probability of impacting a target (exposure time) high (e.g., overnight exposure); defective tree or tree parts large enough to cause extensive damage; target of high value. Examples include campsites, lodges, hotels, dormitories, residences and 24-hour visitor service and restroom facilities.

2 points = Medium failure impact: moderate damage expected if failure occurs. Exposure time moderate (daytime or intermittent only); defective tree or tree parts of sufficient size to cause moderate damage; target of moderate value. Moderately used paved trails, picnic and other day use areas, interpretive sites, amphitheaters and kiosks, moderate to high-use road networks within campgrounds, roadside attractions, such as vista points or historic stops, information stations, visitor centers, fee collection portals, high use daytime parking areas, designated trailhead parking areas, plazas, staging areas and commercial sites, roads and intersections with moderate to high traffic volume, haul routes during periods of commercial use, active projects along roads where work is stationary.

1 point =Low failure impact: Minor damage expected if failure occurs. Exposure time low; defective tree or tree parts is small; target of low value. Highway corridors or improved Forest Service roads with little or sporadic traffic, unimproved roads, turnouts, bicycle paths, or structures with sporadic occupancy, such as storage buildings.

Failure Potential (Defect)

3 points = high potential for failure: serious defects.
2 points = medium potential for failure: moderate defects.
1 point = low potential for failure: minor defects.
0 points = no defect observed

Add 1 point if multiple, interacting defects are present, e.g. leaning tree with other defects.

Score 4 points (the maximum score) if tree is dead.

Cracks

High (3 points):

- Crack goes completely through stem or branch.
- Stem has two cracks on the same segment with a cavity or extensive decay.
- Crack in contact with another defect or is at the base of a leaning tree.
- Branch (4" or larger) with any crack.
- Conifer stem with a single crack with inrolled bark and a cavity or decay inside.

Medium (2 points):

- Hardwood stem with a single crack with a cavity or decay (the decay should also be evaluated based on the "Stem and Branch Decay" criteria below).

Low **(1 point):**

- Trees with a single frost crack and no internal decay.

Branch Unions/Forked Tops

High (3 points):

- Weak branch union (V-shaped with inrolled bark) that is also cracked, cankered, decayed or streaming pitch. Strong (U-shaped) branch unions with these defects, except as listed below, should be assessed on the basis of the associated defects.
- Heavy U-shaped branches of all species except for pines and incense cedar that form when branches turn up to become leaders. Pine and incense cedar receive a high rating only if an associated defect (cracked, cankered, decayed or streaming pitch) is also present at the branch union.
- Large epicormic branches on decaying stems and branches.

Medium (2 points):

- Weak (V-shaped) union with inrolled bark.

Low (1 point):

- Heavy U-shaped branches of pines and incense cedar that form when side branches turn up to become leaders (no additional defect in the branch union).

Stem or Branch Decay

High (3 points):

- Less than ⅓ of the tree's radius (or diameter) is sound. Additional sound wood needed if tree is leaning, decay is off-center or present between four feet above the groundline and the lowest live branch, or is associated with an open cavity.

Stem or Branch Decay (cont.)

High (3 points)

- Cavity, decay or fruiting body associated with an open crack or weak branch union.
- Decay in a horizontal branch.
- True fir and hardwoods with known, but unmeasured decay, especially if a cavity is open to the outside.

Medium (2 points):

- Trees with greater than ⅓ of the tree's radius in sound wood may or may not have medium failure potential, depending on the extent of decay, species of decay fungus and position within the tree. At the very least, trees with identified decay should be closely monitored on a regular schedule and after significant weather events.
- Douglas-fir, incense cedar and pine species with known, but unmeasured decay, especially if a cavity is open to the outside.

Note: <u>All trees with moderate or high failure impact ratings</u> should be thoroughly evaluated for decay with the proper equipment and/or mitigated regardless of the species.

Fungal Fruiting Bodies

High (3 points):

- *Phaeolus schweinitzii* conks associated with butt swell on Douglas-fir.
- One or more Indian paint fungus (*Echinodontium tinctorium*) conks on true fir or hemlock
- Five or more red ring rot *(Porodaedalia (Phellinus) pini*) conks on Douglas-fir, ponderosa pine, Jeffrey pine, lodgepole pine, or more than one on true fir or hemlock.
- One or more quinine (*Fomitopsis officinalis*) conks on Douglas-fir, pines, western larch, spruce or hemlock.
- One or more sulfur fungus (*Laetiporus sulphureus*) conks on a wide range of conifers and hardwoods, including Douglas-fir, true firs, pines, hemlocks, spruces, larch, western redcedar, oaks, maples, birch and willow.

Medium (2 points)

- *P. schweinitzii* conks without associated with butt swell on Douglas-fir.
- Fewer than five red ring rot (*P. pini*) conks on Douglas-fir, ponderosa pine, Jeffrey pine, lodgepole pine, or one on true fir or hemlock.
- Incense cedar pecky rot conks (*Oligoporus* amarus) conks on incense cedar greater than 150 years old.

Cankers

High (3 points):

- Cankers with associated fruiting bodies of decay fungi.
- Cankers with associated internal decay.
- Canker physically connected to a crack or other defect.
- Single or multiple cankers without decay over more than ½ of the tree's circumference, particularly if the cankers are between four feet above the groundline and the lowest live branch.
- Basal cankers in true fir that affect over ⅓ of the bole circumference.

Cankers (cont.)

High (3 points):

- Cankers in oak or tanoak caused by *Phytophthora ramorum* (ramorum canker or sudden oak death) that affect more than ⅓ of the bole circumference, or have associated decay fungi, ambrosia beetles or bark beetles.
- Deep charring in true fir over more than ⅓ of the bole circumference when the relationship between deep char and cambial mortality has been confirmed.
- Deep charring in sugar pine, ponderosa pine, Jeffrey pine, incense cedar or Douglas-fir over ½ of the bole circumference when the relationship between deep char and cambial mortality has been confirmed.

Medium (2 points):

- For all species other than true fir, single or multiple cankers without decay that affect less than ½ of the tree's circumference (including fire-caused cankers).
- For true fir, single or multiple cankers without decay that affect less than ⅓ of the bole circumference (including fire-caused cankers).
- For oak or tanoak, cankers caused by *Phytophthora ramorum* (ramorum canker or sudden oak death) without associated decay, ambrosia beetles or bark beetles that affect less than ⅓ of the bole circumference.
- A large old wound or canker with no decay at the base of a leaning tree.

Low (1 point):

- True fir with bole swelling from dwarf mistletoe with no bark sloughing or evidence of decay.
- Lodgepole pine or ponderosa pine with basal (hip) cankers from western gall rust with no bark sloughing or evidence of decay.
- Lodgepole pine or ponderosa pine with elongated stalactiform rust cankers covering less than ⅓ of the bole circumference.

Dead Tree, Top Or Branches

Extremely High (4 points):

- Dead tree.

High (3 points):

- Dead top greater than ten feet long or smaller ones with associated decay or other defect (note that old dead tops of pine, incense cedar, juniper or Douglas-fir may not have high failure potential).
- Dead branches greater than two inches in diameter, branches that are hanging or lodged in the crown, large dead dwarf mistletoe brooms and large live dwarf mistletoe brooms with associated decay or defect.

Medium (2 points):

- Dead tops less than ten feet long with no associated decay or other defect (note that old dead tops of pine, incense cedar, juniper or Douglas-fir may have lower than medium failure potential).
- Any branch greater than two inches in diameter and more than ⅔ dead (remove the entire branch).
- Live dwarf mistletoe brooms with no associated decay or other defect (monitor closely).

Low (1 point):

- Old spike tops in pine, incense cedar, juniper or Douglas-fir that give evidence of long-term persistence.

Bark and/or Wood Boring Beetle-Attacked Trees

High (3 points) If any of the following over at least ⅓ of the bole circumference (excluding basal attack by red turpentine beetle):

- Pitch tubes with pink or reddish (not clear) boring dust.
- Pouch fungus conks and/or current woodpecker (not sapsucker) activity.
- Boring dust or frass in bark crevices, webbing along the bole, or accumulation of boring dust or frass at the base of the tree.

Bark and/or Wood Boring Beetle-Attacked Trees (cont.)

High (3 points):

If tree has significant bark and/or wood boring beetle activity, as indicated by:

- 50% or more of the foliage-bearing crown actively fading, as indicated by a uniform change in color over that part of the crown. Dead tops that have no foliage do not count toward this 50%. Also does not include drought-induced needle cast (non-uniform fading restricted to the older needles) or branch mortality ("flagging") caused by dwarf mistletoe/*Cytospora* infections in true fir.

Root Damage and Root Disease

High (3 points):

- Recently leaning trees, or with recent root-lifting, soil movement or mounding near the base, or with broken/decayed roots.
- Inadequate root support, with more than half of the root system within the drip line severed, broken, undermined or decayed by erosion or excavation.
- Host tree species visibly infected with root disease fungi, adjacent to visibly infected trees or stumps, or with advanced crown symptoms in the immediate area where Heterobasidion root disease has been identified.

Medium (2 points):

- Less than ½ of the root system within the drip line severed, broken, undermined or decayed by erosion or excavation.
- Host tree with few or no crown symptoms within 50 feet of a confirmed root disease-infected tree or stump or within 50 feet of a host tree with advanced crown symptoms.

Leans and Poor Tree Architecture

High (3 points):

- Leaning with an angle greater than 45° from vertical.
- Leaning with other contributing defects.
- Freshly leaning tree with recent root lifting, soil movement or mounding near the base.
- Lean associated with unstable soils or cracks in the tree.
- Uncorrected lean compounded by unbalanced crown shape weighted in the direction of the lean.
- Uncorrected lean at a location with frequent storm or wind injury.

Medium (2 points):

- Uncorrected lean with an angle between 10°and 45° from vertical without other contributing defects. Monitor closely for changes in the lean.
- Branches with a twist, sharp angle or bend.
- Branches that are lopsided or unbalanced with respect to the rest of the crown, especially if nearby trees were pruned or removed within the last ten years.

Appendix 3
International Tree Failure Database
Report Form

Form ID Number_______________

TREE FAILURE DATABASE - REPORT FORM

*REQUIRED FIELD

1 General Tree Info
2 Failure Type
3 Failure Specifics
4 Structural Defects
5 Decay or Injury
6 Maintenance History
7 Tree Failure Details
8 Weather Conditions
9 Comments & Save

1 Tree Genus*______________________________ Species*______________________________
Cultivar______________________________ Country*______________________________
State/Province*______________________________ County______________________________

DBH*________in/cm Height__________ft/m Age_________years

Tree/Site Ownership: ○ Private ○ Utility ○ Other or unknown
○ Fed./Nat.: (○ NFS ○ BIA ○ BLM ○ DOD ○ NPS)
○ State/Province ○ County ○ Municipal

Address/Site name____

GPS: Latitude______.__________ Longitude_______.__________ (NAD83)

2 FAILURE TYPE* (select one)

○ TRUNK FAILURE ○ BRANCH FAILURE ○ ROOT FAILURE

3 Trunk Failure Specifics

Height of failure above grade*_____ft/m
Dia. at break (inside bark)*________in/cm

4 Defects Associated with Failure

☐ None
☐ Unknown
☐ Failed portion dead
☐ Decay ☐ Canker Species:________
☐ Multiple trunks/codominant stems
☐ Dense Crown ☐ Flush cuts
☐ Topped ☐ One-Sided
☐ Low live crown ratio ☐ Included Bark
☐ Bow ☐ Crook ☐ Sweep/corrected lean
☐ Uncorrected lean
☐ Cracks in wood:
○ Vertical ○ Horizontal
☐ Lightning Injury ☐ Animal Injury
☐ Fire Injury ☐ Insect Injury
☐ Mechanical Injury ☐ Girdling

5 Location of Decay

☐ HEARTWOOD
Avg. sound wood thickness______in/cm
Opening (cavity) at failure? ○ No
○ Yes, opening_____% of trunk circ.
☐ SAPWOOD
Avg. depth of rot______________in/cm
Circumference rotted__________%

Type of Decay

☐ Unknown ☐ Brown rot
☐ Canker rot ☐ White rot

Conks/mushrooms/other signs? ○ No
○ Yes Name:________________
Distance from conk to failure:_______ft/m

6 Hardware

☐ None
☐ Girdling hardware
☐ Other device
☐ Cable ○ Intact ○ Failed
☐ Guying ○ Intact ○ Failed
☐ Prop ○ Intact ○ Failed
☐ Brace/bolt ○ Intact ○ Failed

3 Branch Failure Specifics

Dia. at break (inside bark)*_________in/cm
Total length failed branch___________ft/m
Break at attachment: ○ Yes ○ No
If No, distance from the attachment to break:___________ft.

4 Defects Associated with Failure

☐ None ☐ Unknown
☐ Failed portion dead ☐ Decay
☐ Dense Crown
☐ Heavy lateral limbs/Heavy ends
☐ Included bark ☐ Crook
☐ Failed portion is an epicormic branch
☐ Cracks in wood
☐ Mistletoe or epiphyte
☐ Mechanical Injury ☐ Lightning Injury
☐ Insect Injury ☐ Animal Injury
☐ Canker/Gall

5 Location of Decay

☐ HEARTWOOD
Avg. sound wood thickness_______in/cm
Opening (cavity) at failure? ○ No
○ Yes, opening______% of branch circ.
☐ SAPWOOD
Avg. depth of rot_______________in/cm
Circumference rotted_____________%

Type of Decay

☐ Unknown ☐ Brown rot
☐ Canker rot ☐ White rot

Conks/mushrooms/other signs? ○ No
○ Yes Name:___________________
Distance from conk to failure:________ft/m

6 Hardware

☐ None
☐ Girdling hardware
☐ Other device
☐ Cable ○ Intact ○ Failed
☐ Guying ○ Intact ○ Failed
☐ Prop ○ Intact ○ Failed
☐ Brace/bolt ○ Intact ○ Failed

3 Root Failure Specifics* (select one)

○ **Roots broken**
Dia. of largest broken root________in/cm
Distance from break to trunk______ft/m
Condition of broken roots:
☐ Dead, no decay ☐ Decayed
☐ Live, no decay ☐ Unknown
○ **Roots cut/severed**(not decayed or broken)
Dia. of largest broken root at cut____in/cm
Distance from trunk to cut_________ft/m
% of roots cut_________
○ **Root plate lifted out of ground**
Root plate radius________ft/m
Root plate depth_________in/cm
○ **Root restricted due to:**
☐ Container ☐ Root barrier
☐ Sidewalk/curb ☐ Wall/foundation
☐ Natural Feature ☐ Other
Distance from trunk to restriction____ft/m
% of root zone restricted__________
Root collar girdled? ☐ Yes ☐ No
% circumference girdled_________

Site/Soils Conditions

Soil composition: ○ Sand ○ Silt ○ Loam
○ Clay ○ Rock/gravel ○ Unknown
Soil moisture at time of failure: ☐ Unknown
○ Dry ○ Saturated ○ Moist ○ Flooded
Restricted rooting depth due to:
☐ Poor drainage ☐ Shallow or layered soil
☐ High water table ☐ Compacted ☐ Other
Other Site Conditions:
☐ Soil eroded ☐ Compaction
☐ Grade change ☐ Well surrounds trunk
☐ Fill soil against trunk or planted too deep
Depth of excess soil_________in/cm

4 Defects associated with failure

☐ None ☐ Unknown
☐ Fire scar/injury ☐ Basal wound
☐ Low live crown ratio
☐ Corrected lean (sweep)
☐ Uncorrected lean ☐ Animal Injury
☐ Cracks in trunk prior to failure
☐ Surface roots or root collar wounded

5 Type of Decay

% of roots decayed_________
Conks/mushrooms/other signs?
☐ No ☐ Yes Name:_____________
Avg. sound wood thickness_______in/cm
Type:☐ Unknown ☐ Brown rot ☐ White rot

6 Surface Treatment

☐ Mulch ☐ Bare soil ☐ Turf
☐ Ground cover ☐ Natural forest litter
☐ Gravel/rock ☐ Pavement ☐ Other

Irrigation:
○ Infrequent ○ Frequent ○ Never

7 ADDITIONAL INFORMATION

Tree Condition and Pruning History

Were the defects associated with failure visible before the tree failed? ○ Yes ○ No ○ Unknown At time of failure the tree was: ○ Dead ○ Declining ○ Alive Was there construction around this tree? ○ Yes ○ No If Yes, when_______years ago	PRUNING HISTORY ☐ No pruning ☐ Cleaned ☐ Thinning ☐ Lions-tailed: ○ Proper ○ Excessive ☐ Reduction/Directional pruning: ○ Proper ○ Excessive ☐ Crown raised_________% of height ☐ Topped Diameter of stub at cut________in/cm

Habitat Information

Trees recently removed in the vicinity of the failed tree:
○ Yes ○ No

History of prior failures at site:
○ Yes ○ No

Setting
○ Forest ○ Campground
○ Picnic area ○ Trailhead
○ Other developed forest site
○ Commercial site / Institution
○ Street tree / Median-Urban
○ Road side - Rural
○ Utility right-of-way
○ Yard / Garden
○ Park - Urban ○ Golf course
○ Parking lot ○ Other

Aspect
○ N ○ NE
○ E ○ SE
○ S ○ SW
○ W ○ NW
○ Not applicable / Flat

Slope
○ No slope ○ <5
○ 5-15 ○ 15-30
○ 30-45 ○ >45

Date / Time of Failure

☐ Date / Season Unknown

Date of failure (Mo/Day/Yr):_______________
Time of failure hour___________
○ A.M. ○ P.M. ○ Unknown

OR

Season of failure:
○ Spring ○ Summer ○ Fall ○ Winter
Year________

8 WEATHER AND OTHER FORCES AT TIME OF FAILURE

☐ Unknown
Wind speed (approx.)_________mph/kph
Temperature (approx.)________ °F/°C
Precipitation: ○ None ○ Rain ○ Snow ○ Ice ○ Unknown

9 CAUSE / RESULT OF TREE FAILURE

Why did this failure occur?

Result of tree failure:
☐ None (No damage other than the failure described) ☐ Property damage ☐ Personal injury
☐ Fire ☐ Power outage ☐ Removal of this tree ☐ Loss of other trees ☐ Other damage
Property damage estimate $_________(US) Cleanup costs $_________(US) If personal injury describe below.
Additional Comments (injury, target, damage, etc.):

Cooperator name____Date____________________

Please enter data at: **http://svinetfc2.fs.fed.us/natfdb/**