Hazard Tree Management

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PREFACE

This technical report addresses identification, prioritization, and mitigation of hazard trees in developed sites operated and maintained by the Forest Service in the Rocky Mountain Region (Region 2). Region 2's hazard tree management training provides more information, examples, and a field component.

The purpose of this technical report is to provide procedural information on hazard tree management to Forest Service employees, although the technical report is available for use by other federal and state agencies and concessioners. The Forest Service is not responsible for operation and maintenance of developed sites under a special use authorization. Holders of a special use authorization are responsible for operation and maintenance of the NFS lands covered by their authorization, including but not limited to inspecting, identifying, and mitigating hazard trees on the NFS lands covered by their authorization. See Forest Service Handbook (FSH) 2309.13, Chapter 50 for more information.

This guide supersedes in their entirety previous Rocky Mountain Region technical reports regarding hazard tree management, including:

- Blodgett, J. T., Burns, K. S., and Worrall, J. J. 2017. Guide to Hazard Tree Management. USDA For. Serv., Rocky Mountain Region, For. Health Protection, Tech. Rpt. R2-69.
- Johnson, D. W. 1981. Tree Hazards: Recognition and Reduction in Recreation Sites, USDA For. Serv., Rocky Mountain Region, For. Pest Management, Tech. Rpt. R2-1.

ACKNOWLEDGMENTS

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INTRODUCTION

What is a hazard tree?

Any tree is potentially hazardous since all trees can fail. A hazard tree can be defined as any tree that has a structural defect and could hit a target (*e.g.*, people or property). In other words, the risk of mechanical failure and resulting damage is greater than the benefit the tree provides. Hazard trees are identified by conducting site inspections, rating each tree's risk of failure, and identifying a risk rating threshold. Trees with a risk rating beyond the threshold are considered hazard trees. Hazard tree management is the reduction of risk through inspection, consideration of risk, and mitigation of hazards posed by trees in developed sites.

Where is hazard tree management focused?

Hazard tree management is focused on developed sites where there is a higher potential for loss or damage to people or property if a tree fails. Factors to consider in determining the level of attention to give to a developed site include the scope and scale of development; the amount of use; and the number, species, and condition of trees at the site.

Examples of developed sites operated and maintained by the Forest Service where hazard trees may occur include campgrounds, boat launches, day use areas, picnic sites, fishing sites, informational and interpretive sites, parking areas, ranger stations, storage yards, trailheads, and visitor and work centers. This technical report does not address roadside hazard trees.

COMPONENTS OF EVALUATING HAZARD TREES

Assessing the potential impact zone

The potential impact zone is the area impacted if a tree or part of a tree fails. If a tree or part of a tree is not within striking distance of a target, there is no need to assess it. Generally, the radius around a tree equal to the tree's height is the tree’s potential impact zone. A clinometer marked in degrees, a smartphone application, or a laser can be used to evaluate the potential impact zone around a tree without having to measure tree height and distances manually (**Figure 1**).

To use a clinometer marked in degrees:

> Stand at the edge of the target facing the tree and measure two angles:
> **A:** from horizontal to base of tree (negative if base is below horizontal).
> **A':** from horizontal to top of tree.
> Calculate 2A' – A.
> If the value is <90°, the tree will not reach the target. If the value is >90°, it will reach the target.

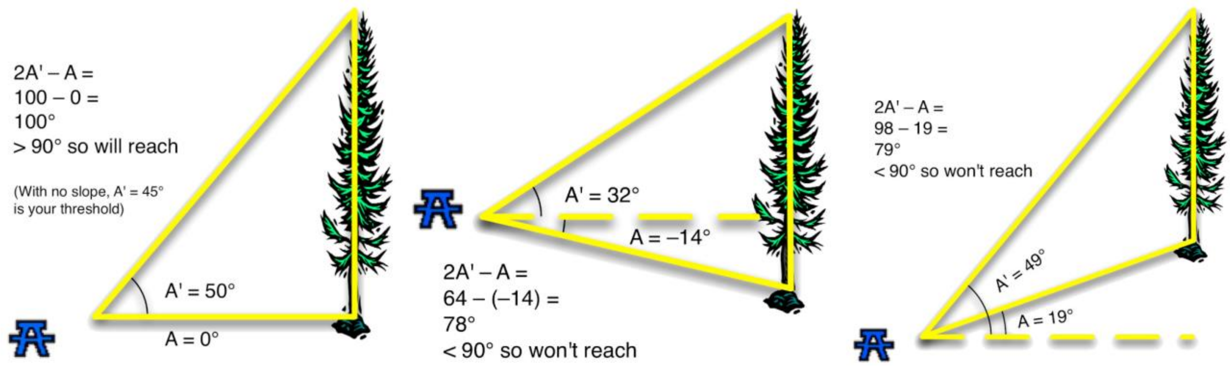

Figure 1. Determining potential impact zone for no slope (left), downhill (middle), and uphill (right).

Calculating the hazard rating

A hazard rating is calculated for each surveyed tree based on two factors: target value and defect value.

Hazard rating = Target value * Defect value

Target value (1-2). A target is something that may be hit if a tree or part of a tree fails. The target value characterizes the probability a tree or part of a tree will hit people or property. The target value is based on how long and how often the potential impact zone may be occupied. The low target value (1) is assigned to trees in areas where targets are moving and thus the probability of injury or damage is lower, such as trees growing along roads or trails in developed sites where people drive or hike through but typically do not stop. The lower target value may also be applied to low-value property such as a wire or wood fence. The high target value (2) is assigned to trees near structures or property and places where people or vehicles congregate or are stationary for a longer time, such as campgrounds, interpretive sites, parking areas, day use areas, and picnic sites (**Figure 2**).

Target Value	Risk of Injury or Damage
1	low-to-moderate
2	high

Defect value (0-3). Tree defects are detectable, structural characteristics that may increase a tree's risk of failure. Defects are caused by many factors such as abiotic events, disease, growth form, mechanical damage, and soil loss around roots. Each defect is assigned a severity value based on its risk of causing failure. Details on rating specific defects are included in the section Recognition and Rating of Defects and summarized in **Table 1**. Defect values range from 0 to 3.

Defect Value	Risk of Causing Failure
0	none or very minor
1	minor
2	moderate
3	severe

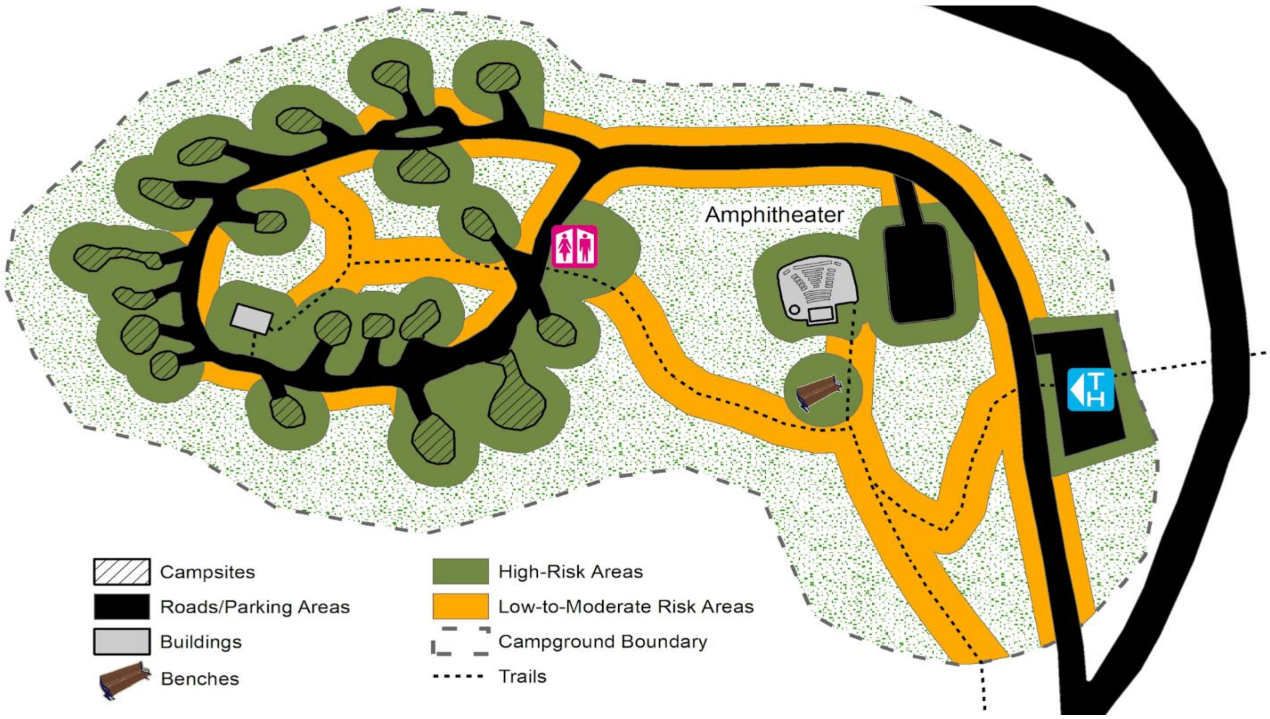

Figure 2. Targets within developed sites can be characterized as low-to-moderate risk (1) or high-risk (2) based on the scope and scale of their development and the potential for property damage or personal injury. A tree's potential impact zone is equal to its height, which is represented by the solid green and orange areas in the diagram.

Hazard rating (0-6, no 5). Hazard rating is calculated by multiplying the target value by the value of the worst defect. Six hazard rating outcomes are possible, ranging from 0 to 6 in order of increasing severity; there is no rating of 5 based on the possible calculations. If a tree in a developed site could strike where people or property are typically stationary and the tree has a severe defect, such as root disease, it would get the highest hazard rating (the target value is 2, the highest defect value is 3, and the hazard rating is 2 * 3 = 6). If a tree has a severe defect, but targets within its potential impact zone are moving, the tree would get a moderate hazard rating (the target value is 1, the highest defect value is 3, and the hazard rating is 1 * 3 = 3). Trees that could potentially hit a target but have no defects get a hazard rating of 0.

RECOGNITION AND RATING OF DEFECTS

Evaluating tree characteristics that present an elevated risk of failure requires knowledge, skill, and experience. The values assigned to specific defects and their severity are based on scientific research and many years of collective observations by hazard tree professionals. Defect values rank the potential that a defect will result in failure of a tree or part of a tree. Defects and indicators of defects are detected by examining a tree. If defect indicators are found, additional assessment using an appropriate tool may be required, such as an increment borer or drill to assess internal defects or a Pulaski to perform a root disease inspection.

Defects and their associated defect values can be found on the Hazard Tree Evaluation Form for Developed Sites at the end of this technical report. They are described in detail in this section and summarized in **Table 1**.

Table 1. Defects and defect values.

	Defect value		
Defects	**1**	**2**	**3**
wound or canker	10-33%	33-50%	>50%
lean	corrected	-	Uncorrected
fork	no included bark	included bark	-
crack or lightning	minor	-	severe or at fork/decay
root disease	-	-	3 only
exposed roots	no decay	<50% with decay	>50% with decay
conk or punk knot	-	-	3 only
open cavity	-	see footnote[a]	≥30% of circumference
sound shell	-	33-60% tree radius	<33% tree radius
dead part	3-5" diam. or broom	5-7"	>7" or dead tree

[a] If the cavity is <30% of stem circumference, use the cavity size to correct the sound shell percentage while evaluating sound shell defect. If the sound shell method cannot be used (*e.g.*, the cavity is too high in a tree), use the moderate defect value (2) for the cavity.

Wounds and cankers

Wounds are areas where bark is dead, often removed, due to short-term physical injury (**Figure 3**). Sometimes dead areas are hidden behind bark, so sounding or probing may be required to detect wounds. Sounding a tree involves hitting the tree with a mallet or blunt side of a hatchet and listening for the muffled or rattling sound that is associated with decayed wood or dead areas under the bark. Wounds in campgrounds are often caused by campers. Axe throwing, chopping, hanging lanterns, fires, and vehicles all cause permanent damage to trees. Animals, construction, logging equipment, and trees hitting other trees are additional causes of wounds. A major concern is that wounds often provide an entry site for decay fungi and canker diseases. Decay fungi weaken wood. The extent of the damage caused by decay fungi, which can be correlated with wound size, varies by tree species. Additionally, structural injury that compromises the wood can increase the chance of tree failure. Callus typically forms on the margins of wounds and is the natural response of trees to injury. If a wound is small, callus margins meet and seal the wound, preventing further pathogen invasion.

Cankers are diseases caused by living pathogens in the bark that kill the phloem (innermost bark) and cambium (**Figure 3**). The vascular cambium consists of the live cells between the wood and phloem of a tree. Cankers, like wounds, seldom affect stem strength unless accompanied by decay or extreme wood distortion. Some cankers spread quickly through the bark, resulting in tree mortality. The common canker diseases (**Table 2**) in Region 2 are described in the *Field Guide to Diseases and Insects of the Rocky Mountain Region* (see suggested reading).

Both wounds and cankers are rated based on the percentage of the stem circumference affected. For multiple lesions, circumference measurements can be added if they are very close together, occur in a decay-susceptible species, or are older or associated with other problems. Small wounds and cankers (especially if not expanding quickly) can be ignored. A canker or wound that involves more than 50% of the circumference can be serious. Trees with fast-spreading, lethal cankers should be rated as dead. Trees with wounds and cankers should also be examined for associated decay (see the section on stem decay below).

Wound/Canker Size as Percentage of Circumference	Defect Value
<10%	0
10-33%	1
33-50%	2
>50%	3

Figure 3. Wound with callus ridge on the margins (left), Cytospora (middle), and black canker (right) in aspen.

Table 2. Canker diseases that occur in Region 2, including rusts that cause cankers. DF = Douglas fir, LPP = lodgepole pine, PP = ponderosa pine, 5P = five-needle pines, QA = aspen, S = spruces.

Disease	Pathogen	Common Hosts	Symptoms	Fruiting
Black canker	*Ceratocystis populicola*	QA	Bark sloughs off and stem slowly flares out, concentric annual callus ridges in wood are exposed, very slow-growing.	Minute, black perithecia, rarely seen.
Comandra blister rust	*Cronartium comandrae*	LPP, PP	Dying branches and/or tops, stem cankers, mortality.	Blisters with yellow-orange spores in spring.
Cryptosphaeria canker	*Cryptosphaeria ligniota*	QA	Long, narrow canker, dead bark adheres tightly, margin is orange-brown, primary killer.	Pimple-like, black heads connected to submerged black layer.
Cytospora canker	*Valsa sordida*	QA	Orange discoloration at margin, bleeding, especially in spring, secondary killer.	Pimple-like, often with white heads.
Cytospora canker	*Valsa kunzei*	S, DF, 5P	Diamond-shaped, resinous cankers with sunken centers and flared margins, dying branches, rarely lethal.	Minute black bodies, rarely seen.
Hypoxylon canker	*Entoleuca mammata*	QA	Irregular shape, bark sloughs off in patches leading to checkered pattern, yellow-orange margin, primary killer but uncommon.	Minute gray pillars beneath blistered periderm, perithecia in small gray-black clusters.
Sooty-bark canker	*Encoelia pruinosa*	QA	Alternating zones with periderm vs. black inner bark exposed, primary killer.	Gray, cup-shaped, shriveled, 0.5-2 mm diameter.
Western gall rust	*Peridermium harknessii*	LPP, PP	Roundish galls on young shoots, or old flared cankers without bark on lower stems of old trees.	Blisters with yellow-orange spores in spring.
White pine blister rust	*Cronartium ribicola*	5P	Dying branches or tops, elongating cankers, mortality.	Blisters with yellow-orange spores in spring.

Leans

Leans are classified into two types. A corrected or natural lean is most pronounced at the base of the tree, but a long curvature (sweep) leads to a nearly vertical top. A lean often occurs when trees grow toward openings in the canopy, such as roads, trails, and creeks (**Figure 4**). As these trees grow, compensating structural wood is formed to support the tree. Thus, corrected lean is usually considered a minor defect. However, failure potential may be higher in trees with extreme lean or when another defect is associated with the lean.

Uncorrected or unnatural lean results from structural damage to the roots or stem (**Figure 4**). Such leans appear to have occurred recently and have not been corrected by negative geotropic top growth. Uncorrected lean is a severe defect. Recent soil movement or uplifting of soil around trees, exposed roots, indicators of stem decay or root diseases, or cracks in roots or the trunk might be visible with uncorrected lean.

Lean	Defect Value
corrected (natural)	1
uncorrected (unnatural)	3

Figure 4. Douglas-fir with corrected lean that grew that way naturally (left; photo: USDA Forest Service). Trees with uncorrected lean are slowly failing due to root problems (middle) and root disease (right).

Forks or stem/branch unions

Tree forks or unions are places where two or more stems or branches join together. These unions can be strong or weak.

Strong unions (**Figure 5**) form when wood connects the stems or branches (often U-shaped). When this happens, a raised, roughened bark ridge is often visible between branches.

Weak unions have a narrow branch angle (V-shaped) between branches (**Figure 5**). When this happens, bark may grow inside the union (included bark). Unlike wood, bark cannot hold branches or forked stems together. The two branches or stems will continue growing in diameter, pressing against each other and pushing apart. Cracks are common when this happens. Cracks indicate the fork has started to fail and are also entry sites for decay fungi. When forks break, they create a large entry site for decay fungi, which increases the likelihood the other fork could break. Weak unions associated with cracks (see the section on cracks and lightning) get a severe defect value.

Stem or Branch Union	Defect Value
strong (U-shaped, no included bark)	1
weak (V-shaped, often with included bark)	2

Figure 5. Examples of strong and weak forks (left; photo: Mike Albers, Minnesota Department of Natural Resources). A weak fork with considerable included bark (center) and a failed weak fork (right).

Cracks and lightning

Cracks are long, narrow, partial separations in bark or wood. Cracks in wood are often an indication that tree failure has already begun. These defects should be examined carefully. Small vertical cracks and cracks only in the bark, such as frost cracks, which are splits in the outer bark or outer wood that occur when trees are subjected to extreme cold, have a minor defect value. Frost cracks often cause damage only to the bark. A probe can be used to check crack depth. Some cracks are not caused by temperature extremes, but are an indicator of internal damage. Large, deep, or horizontal cracks in wood are severe cracks (**Figure 6**) and have a severe defect value. Since cracks are another form of tree wound, they can also provide entry for decay and canker diseases. Cracks associated with forks (**Figure 6**) or decay are serious.

Lightning damage can be variable, ranging from shallow, spiraling damage that just penetrates the bark (**Figure 6**) to explosion of the crown. Lightning damage that is mostly limited to the bark has a minor defect value. If damage is very deep or wide or large chunks of wood are blown out of the trunk, the lightning damage may be considered severe. Lightning furrows should be inspected for decay. Trees may be killed by lightning with little apparent mechanical damage. In such cases, the dead tree defect applies.

Callus may form on both sides of a crack or lightning scar. The callus margins will often meet and seal the damage. Occasionally, the callus curls inward during growth. If this happens, the wound never seals properly. Instead, the bark-covered surfaces of the callus rolls meet, and as the tree grows, the callus sides push against each other, forming an expanding crack.

Crack or Lightning Damage	Defect Value
minor	1
severe or associated with a fork or decay	3

Figure 6. Cracks, especially horizontal cracks, indicate internal defects such as decay in this oak (left). Weak forks often develop cracks indicating they are already failing (middle). Lightning scar in the bark with little structural damage to the wood (right).

Root defects

Roots function as anchors, and defects in the root system greatly reduce strength. Defects in the root system can result in whole-tree failure of both green and declining trees, especially during high wind.

Root diseases. There are many root diseases in Region 2 that cause decay in the roots and lower stems (**Table 3**). Root diseases can be difficult to detect, but are the most common of all root defects. Detailed descriptions of the common root diseases in Region 2 can be found in the *Field Guide to Diseases and Insects of the Rocky Mountain Region* (see suggested reading).

Above-ground symptoms (reaction of the host tree) of root diseases include basal resinosis, decay, overproduction of cones (stress crop), scattered branch dieback, slow terminal growth, thin crowns, yellowing of foliage, and spreading mortality centers. These symptoms are not specific to root diseases. In addition, trees with advanced root decay frequently exhibit no above-ground symptoms. In contrast, signs (fungal structures) are much more helpful in diagnosis. These signs include conks (**Figure 7**), mushrooms, mycelium (fungal tissue), and rhizomorphs. Rhizomorphs are root-like fungal structures made up of strands of hyphae (fungal filaments) that are covered with a protective rind; they spread through the soil, infecting live or dead host roots. If a specific root disease can be diagnosed in a tree, the tree has a severe defect value. Trees with root diseases can have little or no root structure (**Figure 7**), and green tree failures are common even when there is no wind.

Figure 7. Signs and symptoms of Ganoderma root disease. Older (left) and younger (middle) conks and fallen aspen with root and butt rot (right).

Exposed roots. Exposed roots result from construction, excavation, vehicle, animal, or pedestrian traffic, water and wind erosion, partial windthrow, and other means. Ignore minor amounts of soil erosion. If moderate soil erosion occurs, the tree has a minor defect value. Occasionally soil erosion can be severe.

Physical injury to roots can weaken tree structure. Look for significant bark removal, severing, fire damage, or severe erosion. Root wounds result from many of the same causes that can expose roots, and the damage can be below ground. Like wounds in stems, exposed wounds in roots are often colonized by wood decay fungi. Root pathogens can also infect trees through root wounds. The percentage of roots with decay or major physical damage (**Figure 8**) is used to determine the defect value. Although the percentage of roots compromised is used in determining the defect value, if a root disease is detected, the tree has a severe defect value.

Root Defect	**Defect Value**
root disease	3
exposed roots with no decay, severing, or fire damage	1
exposed roots with <50% of roots with decay, severing, or fire damage	2
exposed roots with ≥50% of roots with decay, severing, or fire damage	3

Figure 8. Ponderosa pine with eroded soil and severed roots (left; arrows point toward severed roots). Damage to roots of many spruce species often results in windthrow of green trees (right).

Table 3. Root and butt rots that occur in Region 2. A = aspen, CW = cottonwood, DF = Douglas fir, ES = Engelmann spruce, P = pines, S = spruces, SAF = subalpine fir, WF = white fir, OC = other conifer species, OH = other hardwood species, ( ) = uncommon.

Disease	Pathogen	Common Hosts	Decay
Armillaria root disease	*Armillaria* species (honey mushroom)	All	White rot, stringy-spongy, wet, zone lines.
- - - -[a]	*Coniophora puteana*	ES, SAF, OC	Brown rot, thin pale brown cords in checks.
- - - -	*Flammulina populicola*	QA, CW	White rot, yellow, stringy.
white mottled rot	*Ganoderma applanatum* (artist's conk)	QA, CW, OHW	White rot with mottled white/light tan areas, infrequent zone lines.
annosus root rot	*Heterobasidion irregulare*	P, eastern red cedar	White rot, maybe laminated, stringy, or with pits/pockets, maybe black flecks.
annosus root rot	*Heterobasidion occidentalis*	WF, (SAF, ES)	White rot, maybe laminated, stringy, or with pits/pockets, maybe black flecks.
- - - -	*Lentinellus montanus*	SAF, (S)	White rot.
red root rot (tomentosus and circinatus root rots)	*Onnia tomentosa / leporina*	S (OC)	Reddish stain becoming white pocket rot.
schweinitzii butt rot (red-brown butt rot)	*Phaeolus schweinitzii* (velvet-top or cow-pie fungus)	DF (OC)	Brown rot, may have thin whitish mycelial mats in cracks.
big white pocket rot	*Phellopilus nigrolimitatus*	S (OC)	White pocket rot with large pockets.
- - - -	*Pholiota alnicola*	SAF, ES	White rot, stringy.
- - - -	*Pholiota squarrosa* (scaly Pholiota)	SAF, QA, (ES, OH)	White rot, gray-brown stain becoming light tan, soft then stringy.
- - - -	*Pleurotus* spp.	QA	White rot.
- - - -	*Sistotrema raduloides*	QA	White rot.
- - - -	*Vesiculomyces citrinus*	SAF, ES	White rot, yellowish, stringy, may be pitted and/or rays may remain.

[a] There is no disease name.

Table 3. (2nd page).

Indicators and Comments
Basal resinosis, crown fading/dieback. Mushrooms in clusters late summer or fall, honey-brown cap with fibrils, white spore print. White fans under bark. Rhizomorphs. Kills cambium and sapwood, kills or leads to failure of live trees.
Butt may collapse in partial failure. Fruiting: inconspicuous, after tree dies, very thin, smooth to rough, brownish with white feathery margin, often with white to brown associated cords.
Usually no indicators except ephemeral mushrooms.
Conks usually present, perennial, at tree base, fresh white pore surface turns brown when bruised. May enter root wounds and may spread root-to-root.
Disease center, conks. Only known in Nebraska near Bessey Nursery.
Often in mortality centers because of root-to-root spread, conks perennial, often inside stumps or root channels, usually hidden. May produce “popcorn” conks. Underside white, margin and upper surface rough, brown.
None, fruits during snowmelt on downed logs.
Basal resinosis, conks. Conks are annual, mushroom shaped with central stems, but leathery and with cream to brown pores underneath, cap brown and velvety. Decay may extend up to 10 feet up stem.
Usually no indicators except ephemeral, annual conks on or around tree. Conks usually with stem from buried roots, brownish, velvety, pores underneath, 6-10” diam. Usually occurs in old, scarred trees.
Usually no indicators.
Usually no indicators except ephemeral mushrooms.
Usually no indicators except ephemeral mushrooms.
Usually no indicators except ephemeral mushrooms.
Usually no indicators.
None. Usually fruits on roots of downed trees. Fruiting thin, smooth, white to yellowish with white feathery margin. The disease is more common in spruce-fir than reported.

Stem decay

Stem decay (**Figure 9**) is caused by fungi that reduce wood strength and increase the probability of stem breakage. Some important stem decay fungi in Region 2 are described in **Table 4**, and detailed descriptions and photographs of the most common stem decay fungi are included in *Field Guide to Diseases and Insects of the Rocky Mountain Region* (see suggested reading).

External indicators of stem decay include broken or dead tops and branches, cavities (**Figure 9**), cankers, conks (fruiting bodies of a wood decay fungus; **Figure 10**) and other fungal tissue, cracks, dead rust brooms on the stems of spruces and firs, fire scars, punk knots (branch stubs infected by decay fungi; **Figure 10**), and large wounds. Sounding a tree by hitting it with a mallet or back side of a hatchet is another way to check for decay. Trees with advanced internal decay may sound hollow like a drum. The presence of insects such as carpenter ants and wood borers is also an indicator of decay. Carpenter ants build their homes in decayed wood.

Figure 9. Internal decay (left) and multiple cavities (middle) in spruce. Cottonwood with a large cavity (right).

Figure 10. A conk of the decay fungus *Porodaedalea pini* (*Phellinus pini*) in spruce (left), and a punk knot in pine with minor chopping (middle) and more chopping (right) with a hatchet.

Conks and punk knots indicate extensive internal decay. Trees with these indicators have the highest defect value, and sound shell measurements are not required.

Cavities are openings through the bark and wood into a decay column. They can substantially increase the risk of failure associated with stem decay. Trees with cavities ≥30% of the tree's circumference have the highest defect value. For trees with cavities <30% of the tree's circumference, the sound shell method should be used (see below regarding sound shell). If the sound shell method cannot be used (*e.g.*, the cavity is too high in a tree) use the moderate defect value. However, multiple cavities or other indications of extensive decay might justify using the severe defect value, even if the decay cannot be measured.

Sound shell. Most of the strength of a tree, like a pipe, is on the outside or outer shell. Some decay, especially in the interior, will not lead to failure. The thickness of the sound outer shell of wood (t) should be greater than 33% of the stem radius (R). Studies have shown that failure potential increases quickly below the 33% threshold (**Figure 11**; see Mattheck and Breloer in suggested reading). Trees are therefore rated based on the percentage of the radius that is sound. If the sound shell is less than 33% of the radius, the tree has the highest defect value. If the sound shell is 33% to 60% of the radius, the tree has a moderate defect value.

If decay indicators are present (except as noted above for conks and punk knots), the sound shell percentage should be calculated. An increment core or drill is generally used to assess t. R can be determined with a diameter tape (diameter/2). The t and R values should be assessed at the height where the most decay is expected. The sound shell percentage is $t/R * 100$ (**Figure 12**). If the sound shell percentage is close to 33% or 60%, the tree's wood radius (inside bark) should be used.

When decay columns are off-center (*i.e.*, not centered in the stem), the procedure depends on the relative size of the column (**Figure 12**). If the decay column is less than half the stem diameter at that height, estimate average t around the stem. If the decay column is larger, measure t at the thinnest sound shell, and estimate R as the distance from the center of the decay column to the nearest sound surface.

When a cavity is <30% of the circumference, calculate cavity width (c) as a percentage of the tree circumference (C) (**Figure 12**). This calculation should be made at the height where the cavity is widest. Subtract that percentage from the sound shell percentage: ($t/R * 100$) – ($c/C * 100$). For example, if the sound shell percentage is 48% and a cavity occupies 17% of the circumference, the adjusted sound shell percentage is 48 – 17 = 31%.

Stem Decay Indicator	Defect Value
conk or punk knot	3
cavity ≥30% of circumference	3
cavity <30% of circumference (can't do sound shell)	2
sound shell from 33 to 60% of the radius[a]	2
sound shell <33% of the radius	3

[a] When a cavity is present and <30% of the circumference, adjust the sound shell percentage as described above.

Table 4. Stem decays that occur in Region 2. A = aspen, DF = Douglas fir, ES = Engelmann spruce, F = true firs, LPP = lodgepole pine, PP = ponderosa pine, S = spruces, SAF = subalpine fir, WF = white fir, OC = other conifers.

Disease	Pathogen	Common Hosts	Decay
- - - -[a]	*Amylostereum chaillettii*	SAF, S	White rot, stringy.
- - - -	*Antrodia serialis*	SAF	Brown rot.
Cryptosphaeria canker	*Cryptosphaeria lignyota*	QA	White mottled rot.
red ray rot	*Dichomitus squalens*	PP	White pocket rot, can be difficult to recognize. Begins as red stain, then decay in radial, star pattern. May have black flecks.
rust-red stringy rot	*Echinodontium tinctorium* (Indian paint fungus)	WF (OC)	White rot, but brownish to reddish color, stringy, may be slightly laminated.
- - - -	*Fomitiporia hartigii*	SAF	White rot.
brown crumbly rot	*Fomitopsis pinicola*	conifers	Brown rot, thick fungal mats.
- - - -	*Laurilia sulcata*	ES	White pocket rot, yellowish, may be wet and spongy.
- - - -	*Peniophora polygonia*	QA	White rot, yellow-brown, stringy.
- - - -	*Phellinidium ferrugineofuscum*	ES	White rot, laminated, may have small pits with black flecks and white transverse streaks.
aspen trunk rot, white trunk rot	*Phellinus tremulae*	QA	White rot, firm to spongy (not forming hollows), yellowish tan in some areas, with diffuse zone lines around decay column.
red ring rot	*Porodaedalea pini*	conifers	White pocket rot, may begin in ring pattern, sometimes with abundant zone lines, decay may progress into roots.
red heart rot	*Stereum sanguinolentum* (bleeding Stereum)	SAF, ES	White rot, initial red stain, becomes light brown, dry, friable, with white fungal sheets when advanced.
- - - -	*Veluticeps abietina / fimbriata*	S, F	Brown pocket rot.

[a] There is no disease name.

Table 4. (2nd page).

Indicators
None (fruiting inconspicuous, ephemeral and uncommon).
None (usually fruits after tree dies).
Canker.
Difficult to detect in standing trees. Dead, fallen branches with conks and/or characteristic decay may be near base of tree. Conks whitish, annual, spreading.
Conks perennial, woody, with black, cracked cap, hard teeth underneath. Flesh is bright red. Decay extensive, may leave little sound wood. Cull 16 ft above and below conks.
Conks may appear on underside and base of branches.
Conk, usually on dead trees or dead parts of live trees, occasionally on live trees.
.
.
Conks rare.
Perennial conks usually at branch stubs, triangular in profile, grey-black cracked upper surface, golden-brown pore surface. Bird cavities in decayed trees. Causes 60-75% of stem decay volume in aspen. Conks are present on about 80% of infected trees.
Conks, punk knots. Conks perennial, hard, often attached below branch stubs, dark brown with golden brown flesh and pores. Cull extends 4-5 ft above and 2-4 ft below conks or punk knots.
Usually no indicators, fruits on slash and logs. Conks small, thin, leathery, shelving, grayish, underside smooth. If fresh, it may bleed red. Fungus infects wounds, may cause top-rot in snapped trees.
Conks.

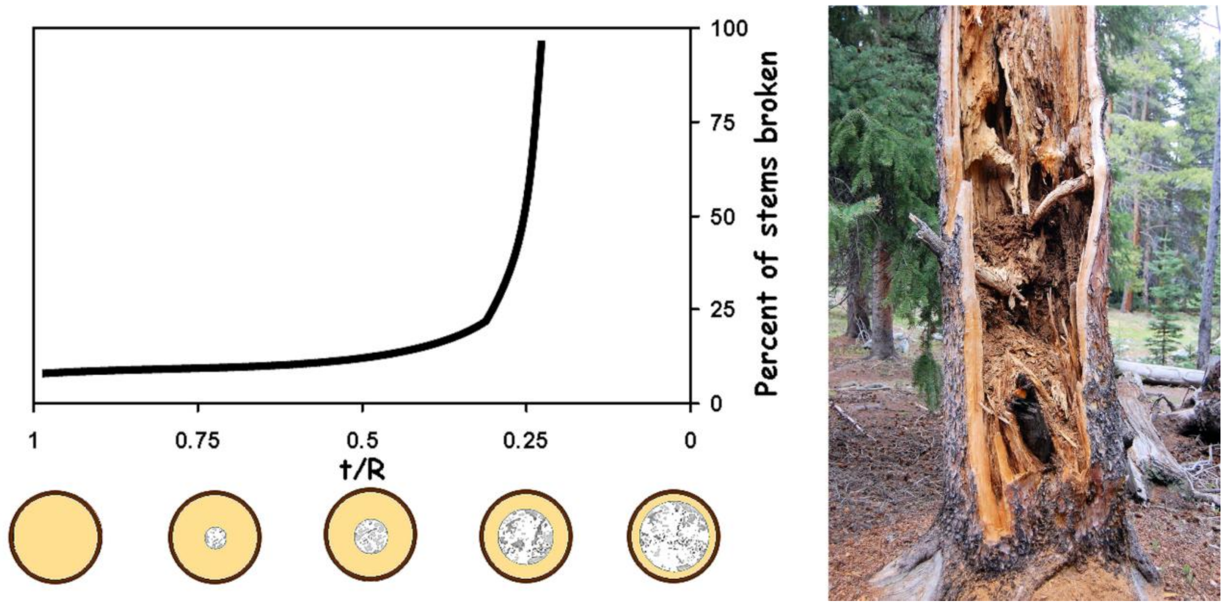

Figure 11. Studies have shown tree failure potential increases exponentially in trees with a sound shell percentage of less than 33% (left/graph). A failed pine tree with a sound shell percentage of less than 33% (right).

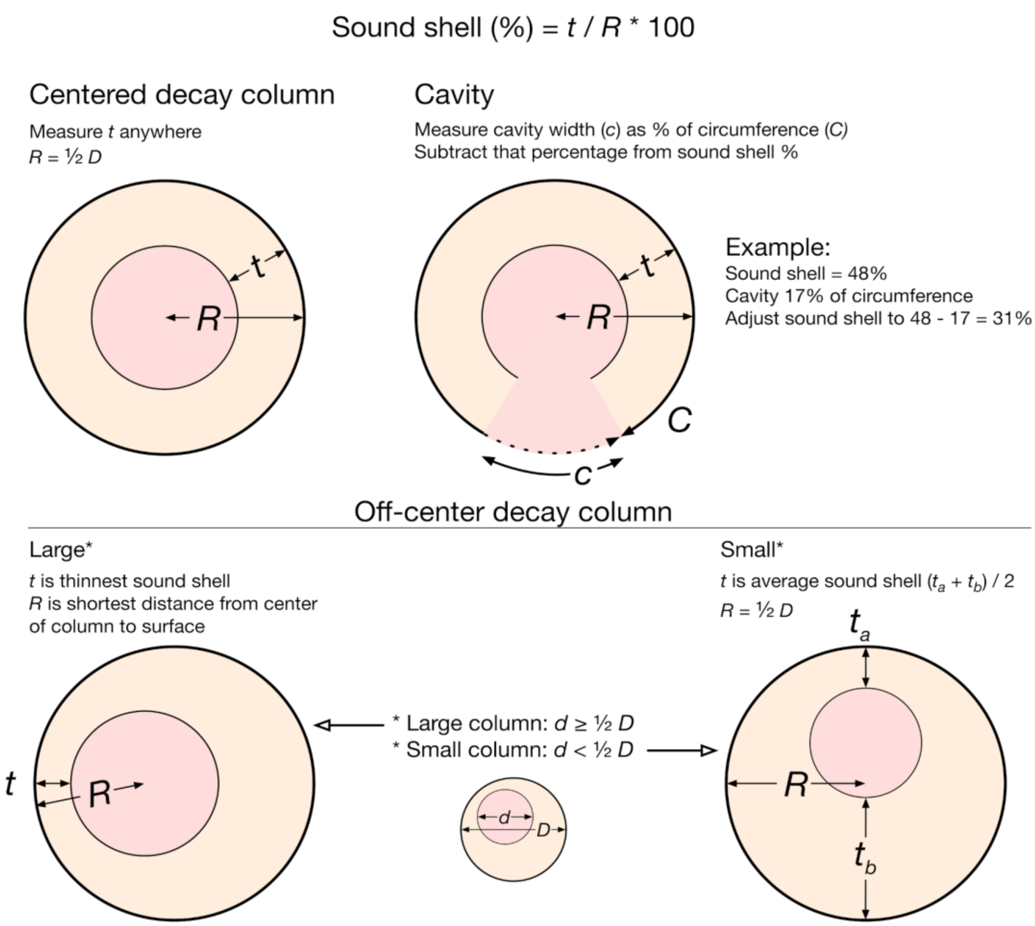

Figure 12. Methods for calculating sound shell percentage in various circumstances.

Dead trees and parts of trees

Snags (*i.e.*, dead trees) are the most obvious and unpredictable type of tree hazard (**Figure 13**). Once a tree dies, it loses its defenses, allowing decay fungi to quickly colonize and weaken wood. Deterioration often occurs most rapidly at the base of trees and in roots where moist conditions favor decay. Wood strength decreases with the amount of decay. Consider removing dead trees with a target.

Dead tops and branches (**Figure 13**), including detached tops and branches hanging in the crown, should be evaluated based on the diameter of the dead part. Diameters are often estimated, but a laser can be used. When possible, a careful evaluation for indicators of decay should be made of dead and broken tops or branches because they are often associated with decay.

Trees with green crowns that will soon die should be rated as dead, including trees with fast-spreading, lethal cankers and trees infested with bark beetles. Bark beetle infestations can be identified by brown boring dust in bark crevices and on the ground next to trees. Pitch tubes may or may not be present depending on the beetle and tree species or the vigor of the tree. Woodpeckers feeding on the trunk may indicate bark beetle infestation, but may also indicate sapsucker feeding. A forest health specialist can be consulted when evaluating potential tree mortality.

Brooms, such as those caused by dwarf mistletoe or rust fungi, are not dangerous unless the brooms are dead or very large. Small brooms may be ignored. Large brooms on branches are a concern, but still have only the minor defect value in most cases since they rarely fail. Dead brooms can be a decay indicator (see earlier suggestions in the stem decay section).

Affected Portion of the Tree	Defect Value
entire tree	3
3-5 inches in diameter or large broom	1
5-7 inches in diameter	2
>7 inches in diameter	3

Figure 13. A dead pine tree is easy to identify (left). Dead and decayed cottonwood tops and branches of various diameters often fall (middle and right).

Factors associated with failure not covered on R2’s hazard tree evaluation form
Risks of failure from sources not included on R2’s hazard tree evaluation form will occasionally be encountered. In such cases, adding a point to the defect value may be appropriate. Forest Service surveyors should apply common sense, based on their training and experience, to evaluate these novel situations. Defect values may be adjusted by experienced, knowledgeable inspectors if the defect values do not reflect the failure patterns common in the area. The defect values in this technical report are guidelines. Local conditions, history, observations, and experience can be considered when rating hazard trees. However, deviations from the guidelines must be well documented.

The following are examples of factors that may be associated with failure and that are not covered on Region 2’s hazard tree evaluation form:

- Multiple defects can occur in the same part of a tree, such as weak unions associated with decay, which may increase the risk of failure when the defects interact synergistically.
- At times, wood decay can be considered together with other defects. For example, a leaning tree can tolerate less decay than an upright tree.
- If a large dead broom occurs on the main stem, dead tree top diameter could be used, even if the top is alive. Alternatively, the defect could be rated like a canker, using the percentage of the circumference impacted. Large dead brooms adjacent to the bole are almost always associated with decay or cankers.
- Sharp bends or crooks and multiple branch unions can result in weak stems and branches.
- Burls are abnormal swellings on stems and branches, often of unknown cause. They are common in lodgepole pine and subalpine fir in some areas, but can be found in other tree species. Typically, they are composed of un-decayed wood and have a low failure potential.
- Crown health or vigor may or may not be an indicator of defect. Trees with green, healthy-looking crowns may have severe defects and fail suddenly. Conversely, trees with unhealthy crowns may have few or no defects.
- Trees with shallow roots often fail, especially when excessive tree removal occurs in stands.
- Under high winds or heavy snow loads, trees may be exposed to extreme physical stress, causing a tree lacking defects to fail.
- The form does not cover stand-related issues, which are addressed in the next section (Defects of Common Trees Species in Developed Sites).

DEFECTS OF COMMON TREE SPECIES IN DEVELOPED SITES

Although some tree species are more prone to defects associated with a high risk of failure, tree species are not considered when assigning a defect value using this technical report. For example, aspen have thin bark making them highly susceptible to damage and subsequent infection by canker and decay fungi. Although it is good to examine aspen carefully for these defect indicators, aspen with no structural defects do not have a higher defect value or hazard tree rating. Still, knowing the defects that are prevalent in the common tree species in Region 2 can help during hazard tree inspections; when determining hazard tree inspection frequency, intensity, and priority; and when choosing sites for development.

Aspen

Aspen stands often contain many defective trees. Due to their thin bark, they are especially susceptible to trunk injuries. Trees in developed sites are easily injured by visitors. These injuries frequently lead to infection by canker and decay fungi. Conks are common in aspen and often indicate extensive decay.

Increment coring may be necessary to quantify the defect. However, cores should be taken only when necessary in aspen, as they produce wounds which are easily infected by canker and decay fungi. Coring can also allow existing internal decay, previously walled off by tree defenses, to move into uninfected tissues that formed after the decay was isolated. Vegetation management strategies aimed at maintaining younger stands and promoting other species may mitigate the risk of defects in this species.

Mixed cover

Due to the inherent differences among tree species, a unique combination of defects can occur in mixed cover types. For example, a mix of aspen and pine often results in a combination of the defects associated with each species.

Pine

Areas with prevalent pine cover are often used for Forest Service campgrounds and picnic areas in Region 2. One major difference between lodgepole pine and ponderosa pine is that lodgepole pine has thin bark which is easily damaged, leading to greater susceptibility to decay. In many parts of Region 2, ponderosa pine tends to have the fewest defects among species common to the region. Dwarf mistletoe is the most common disease of pines in Region 2. Although considered a minor defect, when possible, large mistletoe brooms may be removed to both eliminate the hazard and improve tree vigor. Mistletoe management can improve long-term forest health.

Wood-decay fungi can be common, especially in older lodgepole pines. Indicators of rot include basal fire scars, conks, punk knots, and stem swelling. However, because of the dry climate in Region 2, most wood-decay fungi rarely form conks. Rust cankers are common in pines in some areas, but do not constitute a severe defect unless they weaken or greatly distort stem structure, are large, or are infected by decay fungi.

Lodgepole pine often grows under dense conditions with shallow root systems. Wind-firmness may be compromised when tree density is suddenly reduced, particularly when the basal area is reduced more than 30 percent. Stand treatments that removed beetle-killed trees during the recent mountain pine beetle epidemic caused windthrow problems in many developed sites in Region 2. Consult with a certified silviculturist when planning tree felling to avoid those issues.

Piñon-juniper

Few failures have been reported in these species in Region 2, possibly due in part to the low number of developed sites with this type of cover. In addition, hazards tend to be less prevalent in these species due to their smaller size. Juniper trees are resistant to wood decay and tend to have few defects. Piñon, however, is affected by decay and other diseases and should be inspected carefully.

Riparian
Forested sites along water courses and lakes are often popular for recreation. Spruce (especially blue spruce in Colorado) and cottonwood are common species in these settings. Many river bottom trees are susceptible to windthrow due to high water tables, shallow root systems, and coarse soil structure. Blue spruce with large wounds may have extensive decay. A major concern of cottonwood is its large, spreading crowns, often with dead and decayed branches due to the fluctuating water table. Arborists with bucket trucks are often hired to prune dead branches in cottonwood sites. The main stems of large cottonwood frequently have decay. Consider converting to other tree species where possible and felling older cottonwood with dead or decayed branches and stems.

Spruce and fir
A significant number of tree failures involving spruce and fir have been reported. These species are often not windfirm due to their shallow root systems. Therefore, any damage to the roots, either by physical injury or root disease, can significantly increase the probability of windthrow. Rust brooms are common in both species. Small brooms are not a serious hazard. Decay is very common and severe in old growth spruce and fir stands, especially after stem wounding. Although conks might not be present, the less obvious punk knots can be common, especially in older trees. Subalpine fir is particularly susceptible to decay fungi. Broken tops, frost cracks, and trunk wounds are potential indicators of decay in spruce and fir. Armillaria root disease is also common in spruce and fir stands. Slowly converting to a younger age class will reduce defects in these species.

HAZARD TREE PROGRAM

A hazard tree management program provides a systematic approach for mitigating hazard trees and preventing damage to people or property at developed sites operated and maintained by the Forest Service. Developing such a program involves identifying and prioritizing sites for hazard tree surveys, performing and documenting hazard tree surveys, mitigating hazards, as deemed feasible and appropriate by the local Forest Service official, documenting actions taken, and maintaining records. It may be advisable to designate a Forest Service employee to manage hazard tree activities. Coordinate with other associated Forest Service resource staffs, such as forest health protection, developed recreation site, and forest management personnel, in implementing the program. The Region 2 Forest Health Protection staff is available to assist national forests and ranger districts in Region 2 in planning and developing a hazard tree management program and in training field personnel in hazard tree management at developed sites operated and maintained by the Forest Service.

Identifying and prioritizing developed sites for hazard tree surveys[1]

For purposes of hazard tree surveys, it is helpful to prioritize developed sites operated and maintained by the Forest Service according to risk, taking into account the scope and scale of development, occupancy rates, type and length of use, stand conditions, past tree failures, sources of hazards such as root disease and bark-beetle activity, and other pertinent factors. Frequency and intensity of hazard tree inspections can then be assigned, to the extent deemed feasible and appropriate by the local Forest Service official, based on assessed risks and available resources.

Types of hazard tree surveys include the following:

(1) Annual Survey. An on-site, visual inspection of tree defects that is typically accomplished by a walk-through examination to identify recently killed trees, dead limbs, dead and broken crowns, leaning trees, hollow trees, root-sprung trees, and exposed roots and that may identify the need for an in-depth survey.

(2) In-Depth Survey. An on-site, systematic, visual inspection that focuses on indicators of tree defects, such as stem decay that weakens the vertical integrity of trees or diseases that lead to decay and eventual failure.

To the extent deemed feasible and appropriate by the local Forest Service official, an annual survey of developed sites should be conducted each year and after major disturbances such ice storms, insect infestations, fires, significant rainfalls, severe winds, and other events that may adversely affect trees. An in-depth survey should be conducted periodically as deemed feasible and appropriate by the local Forest Service official.

Annual surveys may be staggered with in-depth surveys of hazard trees at developed sites operated and maintained by the Forest Service. During in-depth surveys of hazard trees, it is suggested that trees meeting the minimum diameter (usually 5 to 7 inches DBH) and with a target be inspected.

Performing and documenting hazard tree surveys

Documenting hazard tree program protocols and surveys is important. The Region 2 Hazard Tree Evaluation Form for Developed Sites guides the surveyor in quantifying hazard ratings for surveyed trees. Using the form ensures basic hazard tree information is gathered, provides program continuity, and creates a record of hazard tree surveys.

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[1] See Forest Service Handbook (FSH) 2309.13, Chapter 50, for guidance on hazard tree management at developed recreation sites operated and maintained by the Forest Service. Chapter 50 provides guidance on pre-season safety inspections and mitigation of risks, including hazard trees, to the extent deemed feasible and appropriate by the local Forest Service official, at developed recreation sites operated and maintained by the Forest Service.

FSH 2309.13, Chapter 50, does not apply to developed sites that are not used for recreational purposes or to developed recreation sites operated and maintained by concessioners on NFS lands. The Forest Service is not responsible for operation and maintenance of developed recreation sites under a special use authorization. Holders of a special use authorization are responsible for operation and maintenance of the NFS lands covered by their authorization, including but not limited to inspecting, identifying, and mitigating hazard trees on the NFS lands covered by their authorization.

The form has instructions and tips on the back. The following resources are available on Region 2’s hazard tree website.

- Hazard Tree Evaluation Form for Developed Sites
  - PDF version.
  - Survey123 e-form for use with ArcGIS online and a user’s guide.
  - Pathfinder Office data dictionary file (DDF) and a user’s guide for use with a Trimble.
- Tree Failure Form
  - PDF version.
  - Survey123 e-form for use with ArcGIS online and a user’s guide.

When performing an in-depth hazard tree survey, canvas the area in a logical, consistent sequence such as clockwise, by campsite number, or by road segment. This approach aids in relocating trees in the future. Basic information such as tree species, DBH, and stem-mapping information, as appropriate, is recorded for each surveyed tree. Then targets and defects are evaluated for each surveyed tree, and its hazard rating is calculated. At the next in-depth survey, the form completed during the previous in-depth survey can be used to help identify trees that need special attention.

Assessing defects and other factors that contribute to tree failure

Trees are evaluated individually. When inspecting a tree, begin at the base of the tree and work upwards toward the crown, recording all defects. Look at the tree from different perspectives: up close, from a distance, and all around it. Assess whether each defect on the form applies.

Based on observed indicators, it may be necessary to check for root disease using a Pulaski. Also based on observed indicators, it may be necessary to core or drill trees to assess the extent and location of internal stem decay. Document drilling or coring of the tree on the form by recording the inches of sound wood present (the sound depth) and whether decay was encountered (**Figure 14**). Use the field at the bottom of the Dead Part section of the form to input a “D” for dead trees (**Figure 14**). This distinguishes dead trees from trees with a large dead top or branch.

The following is an equipment list for performing hazard tree surveys; items marked with an asterisk are optional:

- Region 2 Hazard Tree Evaluation Form for Developed Sites (at the end of this technical report), a Trimble GPS loaded with the Region 2 hazard tree data dictionary file, or a smartphone or tablet with the Survey123 application
- Pencil (or stylus if using a Trimble)*
- Tatum/clipboard*
- Site map*
- Diameter tape
- 100-foot measuring tape*
- Clinometer marked in degrees and 1:66 (or laser rangefinder)
- Compass
- Binoculars*
- Knife
- Hatchet/axe
- Pulaski

- Probe*
- Mallet*
- Camera*
- Tree tags and nails*
- Flagging*
- Cordless drill*
    - 18+ volt
    - Spare batteries
    - 1/8” x 12” drill bit with brad tip and extended 9” flute
- Increment borer
    - WD-40*
    - Beeswax*
    - Sharpening kit and instructions*
- This technical report
- *Field Guide to Diseases and Insects of the Rocky Mountain Region**

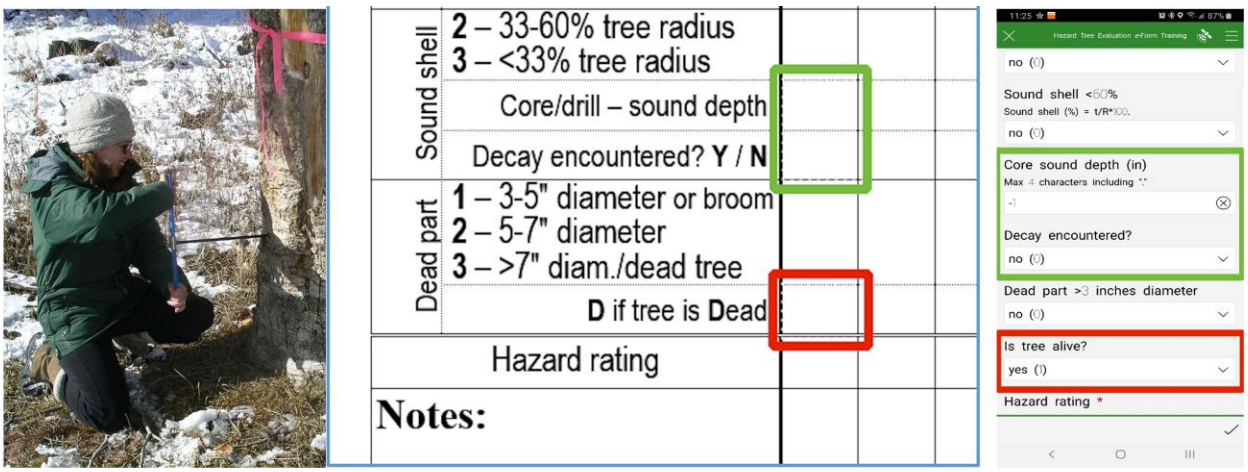

Figure 14. When trees are cored or drilled (left), record the depth of the sound shell and whether decay was encountered in the GREEN box on the paper form (middle) or e-form (right). Also record if the tree is dead in the RED box on paper form (middle) or e-form (right).

Tagging and stem-mapping

Tagging or stem-mapping trees can greatly assist with documentation and mitigation and will facilitate future surveys. Trees may be tagged with a numbered, aluminum tag fixed to the tree with an aluminum nail. Avoid tagging aspen this way, as wounds created by nails may be infected with canker or decay fungi. Tags are best placed near the soil line and facing away from the fire pit or center of the site, which will reduce visibility and aid with relocating tags. If trees are not tagged, consider placing temporary tags, flagging, or paint on trees above a certain hazard rating, so they can be relocated for mitigation, as deemed appropriate by the local Forest Service official.

Although initially time-consuming, stem-mapping will expedite any corrective actions deemed feasible and appropriate by the local Forest Service official and future surveys. Stem-mapping is also very useful in summarizing and interpreting data from surveys. Several stem-mapping approaches are described below.

Mapping trees using azimuth and distance from a reference point. There is space on the hazard tree evaluation form for stem-mapping trees using reference points. It is important to choose reference points that are permanent structures, such as a fire pit, that are unlikely to be moved. For large structures, use a more specific reference point, such as the most northern/northwestern edge of the structure. Reference points may be documented using a GPS system. Azimuth and distance are recorded from the reference point to the trees. Coordinates for the trees can be calculated from reference point coordinates and the azimuth and distance to the trees.

Mapping trees using a laser rangefinder attached to a GPS unit. The reference point, azimuth, and distance method can be greatly expedited with new technology. Laser rangefinders are available that accurately measure distance and azimuth and easily integrate with GPS and GIS systems.

Collecting GPS coordinates for trees. Trees can be mapped individually with a GPS unit (ideally with submeter accuracy). This method works well in open stands, but not in dense stands or stands with heavy canopy. Hazard tree surveys can also be recorded digitally. A data dictionary file is available for downloading that is compatible with Trimble dataloggers. A Survey123 application is available for ArcGIS Online users on smartphones and tablets. Data can then be downloaded in a format that is easy to upload into the Region 2 hazard tree database (see the section on performing and documenting hazard tree surveys).

Hand drawing points on a geo-referenced map. This method involves mapping important landmarks in the site (*e.g.*, roads, campsites, and toilets) with a hand-held GPS unit prior to the survey. Shapefiles are generated for the landmarks, and a map is created and printed in the office. The location of hazard trees or trees that need to be monitored is then hand drawn onto the geo-referenced base map during the survey. The approximate location can be digitized in ArcMap in the office.

Documentation

Documentation is important to track the progress of the hazard tree program, to detect trends in disease and hazard progression in developed sites, and to provide a record of surveys and felling in the event of tree failure. Training of hazard tree surveyors, hazard tree program protocols and deviations from protocols, the prioritization of developed sites and survey schedule, survey data, and any mitigation actions deemed feasible and appropriate by the local Forest Service official should be documented. Deviations from protocols must include a rationale.

Mitigation

Mitigation of hazard trees as deemed feasible and appropriate by the local Forest Service official reduces the probability of serious damage, injury, and costly cleanup action. In many situations hazard mitigation can be accomplished in ways other than by tree felling. For example, permanent tent pads can be constructed to restrict the target area, all or part of a campground or picnic area can be closed, or dangerous limbs can be pruned. Marginally hazardous trees should be monitored over time to assess whether the risk of failure has increased and whether corrective action is needed.

Treatment priority is highest for trees with the highest hazard rating (**Table 5**). There may be other factors that increase the urgency, such as exceptionally severe defects or a concentration of trees with a rating of 6 in a developed site. Where severe hazards are exceptional or abundant, consideration should be given to closing all or part of the site until the hazard can be mitigated.

Hazard tree management may complement other management and resource objectives to achieve common goals. Input from other relevant resource specialists should be sought and included in hazard tree survey planning and implementation. For example, since windthrow of residual standing trees becomes a serious issue as more and more hazard trees are felled at a developed site, it is helpful to seek input from a silviculturist to implement the most appropriate mitigation strategy at the site.

Table 5. Suggested actions, to the extent deemed feasible and appropriate by the local Forest Service official, based on the hazard rating.

Hazard Rating	Risk of Failure	Suggested Action
0-2	Low	No action or monitor
3-4	Moderate	Monitor or mitigate
6	High	Mitigate promptly

Minimizing future hazards

One of the major causes of wounding, resultant disease, and hazard trees in campgrounds is campers. Throwing axes, chopping, hanging lanterns, and dumping hot ashes at the base of trees cause permanent injury that leads to decay and defects. Support campground hosts to encourage campers to care for trees. A sign (**Figure 15**) and public education campaign may help prevent damage to trees at campgrounds. In addition:

- Minimize bole wounding and damage to roots systems during tree management activities such as felling.
- Install and maintain bumpers, as appropriate, to protect trees from vehicles.
- Develop a vegetation management plan that helps maintain tree health and includes planning for regeneration.

Figure 15. Example of a sign to educate campers about the effects of tree damage.

Documentation of trees that fail

Recording tree failures is an effective way to build information on the characteristics of tree species that are hazardous locally. For example, the failure rate may be so high for a certain species that developed sites with those trees are closed or a more favorable tree species is selected as a replacement, or the data may show that wounds on a certain species are less likely to be associated with decay and constitute a lower hazard than wounds on other species. If the data show that trees with minor or moderate defects are commonly failing, adjustments may be needed in evaluating the hazard. Thus, tree failure reporting can serve as a useful monitoring tool for a hazard tree program. A tree failure form (paper and Survey123 e-form) and a user's guide are available for that purpose.

Vegetation management

In the long term, hazard tree management should be considered in the context of vegetation management at developed sites operated and maintained by the Forest Service. Trees cannot be felled without planning for regeneration and replacement. There is no better time than the present to plan for future stands. Vegetation management plans can help reduce disease, insect, and fire risk while providing for vegetation that is suited to the site with a minimum of hazards.

A vegetation management plan need not be lengthy, and it may be feasible to incorporate multiple, similar developed sites into a single plan. It is recommended that a schedule be set for developing and updating vegetation management plans for developed sites operated and maintained by the Forest Service. Forest Service Forest Health Protection personnel, developed recreation site personnel, and forest management personnel can assist national forests and ranger districts in Region 2 with the development of vegetation management plans.

See FSH 2309.13, Chapter 50, for guidance on vegetation management plans for developed recreation sites operated and maintained by the Forest Service.

SUGGESTED READING

Allen K. K., Blodgett J. T., Burns K. S., Cain R. J., Costello S. L., Eager T. J., Harris J. L., Howell B. E., Mask R. A., Schaupp W. C., Jr., Witcosky J. J., and Worrall J. J. 2011. *Field Guide to Diseases and Insects of the Rocky Mountain Region*. Gen. Tech. Rep. RMRS-GTR-241. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 336 pp.

Kane B., Ryan D., and Bloniarz D. V. 2001. Comparing formulae that assess strength loss due to decay in trees. *Journal of Arboriculture* 27(2): 78-87.

Mattheck C. and Breloer H. 1994. The Body Language of Trees. The Stationery Office. London, England. 240 pp.

Site: ______________________________ Page: ____ of _______

Date: ____________________ Inspected by: ______________________________

(Each column represents one tree)

Unit (campsite or other)																					
Tree number																					
if used	Ref. point (codes on back)																				
	Azimuth																				
	Distance																				
Tree species																					
DBH																					
Tar-get	**1** – Trails, roads **2** – People, structures, veh.																				
Wounds/ cankers	**1** – 10-33% circumf. **2** – 33-50% circumf. **3** – >50% circumf.																				
Lean	**1** – corrected (natural) **3** – uncorrected (unnatural)																				
Fork	**1** – strong (no incl. bark, U) **2** – weak (included bark, V)																				
Crack/ lightning	**1** – minor **3** – severe or at fork/decay																				
Root disease	**3** – present																				
Exposed roots	**1** – no decay **2** – <50% roots decayed **3** – >50% roots decayed																				
Conk or punk knt	**3** – present																				
Open Cavity	**1** – <30%,adj. sound shell **2** – <30%, inaccessible **3** – ≥30% of circumf.																				
Sound shell	**2** – 33-60% tree radius **3** – <33% tree radius																				
	Core/drill – sound depth																				
	Decay encountered? **Y** / **N**																				
Dead part	**1** – 3-5" diameter or broom **2** – 5-7" diameter **3** – >7" diam./dead tree																				
	D if tree is **D**ead																				
Hazard rating																					

Notes:

Use of the Hazard Tree Evaluation Form for Developed Sites

Any tree can fail; all trees are potentially hazardous. Hazard trees are defined as trees with structural defects that might hit a target (*e.g.*, people or property). Target rating is based on the probability a target (e.g., people or property) will be hit (assuming the tree fails). Defect rating is an estimated probability a tree will fail based on defects. Defects are detectable, structural characteristics that may increase a tree's risk of failure.

Hazard trees are identified by conducting inspections. This includes rating tree's targets, determining defects or risk of failure, and identifying a risk rating threshold. Trees with a risk rating beyond the threshold are considered hazard trees. Documented inspections of trees in developed sites and corrective action are recommended to reduce hazards.

This form can assist in determining and documenting hazard ratings. It is a record of the condition of trees that can be used to document changes over time and to document frequency of defects at sites. All defects should be checked even though only the highest values are used in the hazard rating.

Evaluation crews should be trained. If training is needed or you have questions, please contact Forest Health Protection staff:

Gunnison Service Center: (970) 641-0471 **Lakewood Service Center**: (303) 236-9541
Rapid City Service Center: (605) 343-1567

- Maps of the sites are helpful in planning and performing hazard tree surveys. All structures should be drawn on maps. The maps used/created during a survey should be included with the forms to indicate which sites were surveyed.
- Trees can be mapped 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").
- See the Web page: http://www.fs.usda.gov/goto/r2/fh/hazard for other mapping and form options.
- Hazard rating is determined by a tree's Target and Defect rating.
  - Targets have a value of 1 or 2.
  - Defects have a value of 0 to 3.
- More than one type of defect may be identified and recorded for a tree.
- Calculate hazard rating by multiplying target value by the value of the worst defect.

Target * Worst Defect = Hazard Rating

Possible Hazard Ratings: 6 = Highest, 4, 3, 2, 1, and 0 = lowest (there is no 5)

See Forest Service Handbook (FSH) 2309.13, Chapter 50, for guidance on hazard tree management at developed recreation sites operated and maintained by the Forest Service. Chapter 50 provides guidance on pre-season safety inspections and mitigation of risks, including hazard trees, to the extent deemed feasible and appropriate by the local Forest Service official, at developed recreation sites operated and maintained by the Forest Service.

Revised May 6, 2021