



United States Department of Agriculture

# Field Guide for Danger-Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington

2016



for the greatest good

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***Front cover photo:*** Danger trees killed in the B&B fire of 2003 along US Highway 20 just east of Santiam Pass, Oregon. Most danger trees were later removed in a joint effort between the USDA Forest Service and the Oregon Department of Transportation.

# **Field Guide for Danger-Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington**

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## Introduction

Working around, walking in, or driving through forested areas exposes people to potentially dangerous (hazardous) trees. This guide presents a framework for identifying risk of tree failure and making decisions in areas where dangerous trees pose a threat to individuals along forest roads or work sites. A tree's stability and structural integrity can be influenced by its location and the extent of structural defects, mechanical damage, insect attack, and disease, as well as work activities and weather conditions. If a tree is unstable or its structural integrity compromised, total or partial failure may occur. During failure events, falling trees or parts may pose a danger to people or vehicles that may be struck by them.

In this guide, we outline steps to identify danger trees and provide a method for documenting survey results and recommended treatments. This guide is for forest-resource managers, road-maintenance engineers, fire-management teams, and pest-management specialists who deal with roads and work sites in forested areas and need to identify and mitigate danger trees. It is a revision of a similar guide: *Field guide for danger tree identification and response, 2008* (10). This guide is not intended for developed sites in forested areas; instead, refer to *Field guide for hazard-tree identification and mitigation on developed sites in Oregon and Washington forests, 2014* (1).

## Guidebook Objectives:

- To provide information to employers and managers that will protect workers and the public from tree-related dangers
- To provide information to “qualified people” that will enable them to properly perform the following:
  - Recognize tree-species groups and defects to determine tree-failure potential
  - Determine a tree's potential-failure zone
  - Understand how an activity could induce a tree to fail
  - Determine how to prioritize survey and treatment areas
  - Document danger-tree evaluations
  - Determine if a tree presents a danger as a result of tree condition, failure potential, potential-failure zone, activity, and exposure duration

In this guide, general tree identification is discussed. Common diseases and defects that contribute to tree failure are presented along with how to identify them. Delineating potential-failure zones is described. Possible activities around trees are grouped into three classifications according to how they may induce tree failure. There is a discussion on how to decide if the tree is a danger, including examples and how to document danger-tree evaluations. Traffic frequency and exposure duration should be considered when determining whether a tree poses a danger to people or vehicles. Finally, there is a discussion of appropriate actions necessary to mitigate the threat posed by danger trees.

In this guide, a **danger tree** or **hazard tree** is any tree or its parts that will fail because of damage, defect, or disease and cause injury or death to people or property.

## Policy and Regulatory Basis

Oregon and Washington, as well as the Federal Occupational Safety & Health Administration (OSHA), have administrative rules about danger trees. The Oregon rules are called *Oregon Occupational Safety and Health Code Division 7 Forest Activities* and apply to all types of forest activities (2). For Washington, the rules are titled *Safety Standards for Logging Operations Chapter 296- 54 WAC* (3). The rules in both states apply to non-federal employers operating on private or public land.



*Danger-tree workshop, 2006, on the Rogue River-Siskiyou National Forest*



*Both moving and parked vehicles can serve as targets.*

Federal OSHA regulations regarding requirements for protecting employees in the course of their work apply to federal agencies. The OSHA “General Duty” standard (29 CFR 960.8) requires agencies to, “... furnish to each employee employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm” (4). Trees with characteristics that indicate instability are considered recognized hazards. Federal agencies are required to identify trees that pose a danger to employees and establish means of protecting employees from danger.

Federal OSHA rules regarding logging operations (29 CFR 1910.266) address specific means of protecting employees who are engaged in logging activities (5). They apply to federal employees.

The health and safety of USDA Forest Service (USFS) employees is addressed by the Health and Safety Code Handbook (6). Section 21.14 focuses on the identification of dangers to employees. It discusses the correction of dangers and what to do if they cannot be corrected.

The Bureau of Land Management (BLM) addresses the health and safety of employees in BLM Manual 2-1, Safety and Health Management; and Handbook 2-2, Safety and Health for Field Operations (7, 8).

Chapter 2 of the BLM Manual 2-1, *Safety and Health Management*, describes the risk and management process that provides management with a systematic method for identifying and managing the risks associated with any BLM operation. Chapter 5 further discusses workplace and hazard assessments (7).

BLM handbook 2-2, *Safety and Health for Field Operations*, reviews the risk management process (29.1), and also provides additional information regarding the hazards of field activities (3.1). It also outlines prevention and mitigation methods (10.2). Section 23.3 specifically discusses the potential hazards of forestry activities. Safety and health requirements for contractor employees (field work) are discussed in section 20 (8).

The Forest Service Handbook (FSM) 7709.59, Chapter 40 contains policy information and responsibilities related to danger-tree hazards along National Forest System roads. The Region 6 supplement to this FSM has more detailed policy information and responsibilities related to danger trees along National Forest System roads in Region 6 (11).

Although neither a regulation nor a policy, Region 6 of the USFS has a Memorandum of Understanding with the Oregon Department of Transportation (ODOT) and the Washington State Department of Transportation (WSDOT) regarding transportation activities, including danger-tree removal, of mutual interest involving highways on, or accessing lands managed by the USFS (14, 15).



*Roadside danger trees, early 1900s*

These policies, regulations, and rules contain language about danger trees. They are the overriding authority on the topic and should be referred to for a full understanding of the policies, regulations, and rules related to danger trees. This document, titled *Field Guide for Danger-Tree Identification and Response along Roads and in Work Sites in Oregon and Washington Forests*, is designed to implement the applicable policies, regulations, and rules. It does not replace them.

## **Employer Responsibilities**

The employer has the responsibility to identify and mitigate dangers to personnel from danger trees. The Oregon OSHA Division 7 Forest Activities Standards requires an evaluation by employers of any tree or snag (dead tree) within reach of a work area to determine if it poses a danger to personnel. If a tree or snag poses a danger, it must be felled, or the work arranged to minimize danger to workers (2).

The Washington Rule 296-54-507 (3) defines management's responsibility. Danger trees within reach of landings, roads, rigging, buildings or work areas shall be either felled before regular operations begin, or work arranged so that employees are not exposed to dangers involved (3).

Before work starts, and as often as necessary, a qualified person must evaluate danger trees within reach of a work area to determine if they pose a danger to personnel. When trees pose a danger they must be felled, or the work must be arranged to minimize danger to workers.

## **Agency Responsibilities for National Forest System Roads**

National Forest System roads are managed for safe passage by road users, including appropriate management of roadside vegetation that involves considerations such as motorist sight distance, clear visibility of road signs, and identification and mitigation of danger trees per section 41.7, paragraph 2 of FSH 7709.59 and related Region 6 supplements.

## **Who is a Qualified Person?**

When an employer or manager is faced with potentially dangerous trees, a qualified person with sufficient knowledge, training, and



*Measuring danger-tree heights, Okanogan-Wenatchee National Forest. When working along roads, warning signs should be posted and bright-orange or reflective clothing worn.*

experience must be available to follow the appropriate process for identifying and mitigating the hazard.

A **qualified person** is defined as a person who has knowledge, training, and experience in identifying danger trees, their potential-failure zones, and the appropriate measures to mitigate the danger. A qualified person has successfully completed a workshop on implementing this field guide.

## **Culturally Modified Trees/Heritage Trees**

Culturally modified trees (heritage trees) are archeological sites that are important to Native American tribes and the general public (Fig. 1). A tree with any human-caused marking or object over 50-years old is considered to be a culturally modified tree. Examples of culturally modified trees include: (1) peeled, cedar trees in riparian zones, (2) trail blazes on trees, (3) bearing trees, (4) salt ground and stock driveway signs on trees, (5) arborglyphs (carved tree initials), (6) marten set traps (carved holes in trunks), and (6) trees with old insulators or wires. Culturally modified trees may be cultural resources. Removal or alterations to a culturally modified tree is subject to review and



**Fig. 1** - If culturally modified trees, such as shown here, are danger trees, they can be treated effectively by cutting the trunk above the carvings.

consultation with the Forest Heritage Program Manager per 36 CFR 800 of the National Historic Preservation Act (NHPA) and E.O. 13175 (Consultation with Tribes).

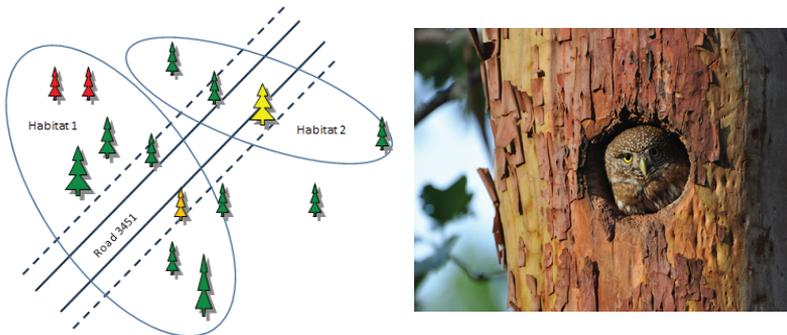
If a culturally modified tree is deemed a danger, that danger will need to be mitigated. Culturally modified trees deemed as danger trees, however, must be mapped and photographed before treatment. If a culturally modified tree is determined to be a danger tree, plot its location on a map or obtain its GPS

coordinates and photograph the tree and associated object. Preferably, a local USFS archeologist should be contacted before a tree is treated. If this is not possible, the recommend treatment is to fell the tree at a place on the trunk above the cultural marking or object, if possible. If not done so before treatment, notify the archeologist soon after treatment, because additional documentation or other mitigation may be necessary. Safety is always the first priority, and always notify a resource expert if mitigation is recommended. There are also NEPA considerations (p. 52) that must be evaluated before mitigation.

## Wildlife Habitat Trees

Dead trees or live, defective trees often are valuable habitat for wildlife such as cavity-nesting birds and mammals. When these trees are dangers and require mitigation, compliance with the Endangered Species Act is required. USFS wildlife biologists are required to report to the US Fish and Wildlife Service if wildlife habitat trees are to be felled on National Forest lands. Wildlife biologists should be consulted about recommended treatments before surveys begin and implementation occurs. There are also NEPA considerations (p. 52) that must be evaluated before mitigation.

Generally, roadside and work site snags, or live, defective trees are a relatively minor part of wildlife habitat compared to the habitat in the surrounding landscape (Fig. 2). R6-USDA Forest Service policy states: “close the facility or parts of the facility if danger trees cannot be felled. Danger trees must be felled if the facility or parts of the facility cannot be closed. Inquire if a local, programmatic, biologic opinion exists that covers this activity.” (11)



**Fig. 2** - Danger trees along roads may be valuable wildlife habitat but are often only a minor part of the overall habitat. Cavities, as in this madrone, often provide habitat for several wildlife species.

## A Process for Danger-Tree Evaluation and Action

There are six steps the qualified person should take when dealing with potential danger trees:

1. Determine tree-species groups, defects, and failure potential.
2. Determine the type of activity.
3. Determine the tree’s potential-failure zone.
4. Determine if the tree poses a danger.
5. Document the danger-tree assessment.
6. Determine what action to take if the tree is a danger.

## How to Survey for Danger Trees

To identify tree species, defects, failure potential, and danger trees, a systematic survey is needed. Forest work sites are generally small compared to roadside areas, so surveys



***To be effective, danger-tree surveys should be done outside of vehicles, as is being done here on the Wallowa-Whitman National Forest.***

usually can be done on the entire work site and every tree evaluated. For roadside surveys, many miles of roads may have danger trees, so it is necessary to prioritize 1) which roads are to be surveyed and 2) the danger-tree treatment workload (see p. 35-37, Tables 2 and 3). During the survey, pay particular attention to areas along roads where people stop, such as roadside vistas or informational signs that are within striking distance of defective trees.

Once the road system has been prioritized, the survey is best done on the ground in a strip along both sides of the road. The width of each survey strip should be 1 ½ times the length of the tallest tree that could strike the road. Surveys from a slow-moving vehicle may identify the obvious danger trees next to the road, such as dead trees, but often will miss the more subtle indicators on live trees that suggest imminent-failure potential, such as cow-pie conks (Schweinitzii, p. 67), quinine conks (p. 86), or windthrow 50 ft. from the road that may indicate Heterobasidion root disease (p. 62) in the surrounding live trees. High-priority trees should be marked for removal during the survey and addressed as soon as possible. Close the affected road segment if high-priority danger trees cannot be mitigated in a timely matter. **If treatment is delayed and marked trees are involved in an accident, defending such inaction in court is usually unsuccessful.**

Danger-tree evaluations should be performed by two or more surveyors at the same time. Begin the survey by one person evaluating each tree from a distance to allow comparison of the vigor and overall appearance of trees relative to their nearest neighbors. The view from a distance allows the examiners to detect dead trees, branches or tops and live-crown symptoms of root disease that can include reduced lateral branch and terminal growth, thinning crowns, chlorosis, and distress-cone crops. Evidence of defoliator activity, mistletoe infection (p. 76), stem conks, and bark beetle attack often are detected initially from a distance and involves inspecting multiple trees from different vantage points.

While one person is examining each tree from a distance, a second person should examine the area in the vicinity of each tree for obvious and subtle evidence of past and current pathogen and insect attack, or other damaging agents. Stand-level clues may be easily overlooked while driving without careful evaluation and consideration. Nearby stumps and old roots should be examined for evidence of advanced decay and conks of root and butt pathogens. Broken-out tops lying on the ground, and windthrown or wind-shattered trees should be examined to determine the causal agents. Conks, mushrooms, and other fruiting bodies on and around trees should be identified since these are primary indicators of decay. Their identification often leads to detection

and correct diagnosis of disease in adjacent, apparently healthy trees. If signs and symptoms indicate decay and a potential hazard, trees should be examined more thoroughly to determine the extent that the disease has compromised structural integrity.



***Conks on the boles of decayed trees, such as this quinine conk on larch, are generally easy to see when surveying.***

**Systematic tree examination** begins around the base of the tree, then proceeds to the butt, bole, limbs, and top. All sides of each tree should be examined carefully. If basal resinosis, crown symptoms, conks, or evidence of decay indicates a root disease problem, examination of several roots with a drill, ax, or pulaski is

warranted. Lightly tapping suspect trees with an axe or rubber mallet may detect decay columns, hollows, and dead sapwood under the bark. This is only practical for trees with relatively thin bark. Trees that sound hollow can then be examined in more detail with drills or increment borers, but this should only be done for trees where the exposure duration for people or property is >15 minutes (p. 46); for example, a bus stop or scenic vista. Binoculars may be necessary to inspect tops and upper boles of suspect or symptomatic trees.

If root disease symptoms are evident or suspect due to proximity to confirmed infection centers, the root collar, butt, and major lateral roots of suspected trees should be inspected for fruiting bodies, ectotrophic mycelium, mycelial fans under the bark, stain or decay in the wood, or other signs of the causal agent. A pulaski can be used to uncover roots (out to a distance of one yard, if needed) and to remove bark for further examination. At least two major roots should be examined for root disease if preliminary evidence suggests that it may be present. The roots that are most likely infected should be checked first. These include those closest to infected (hollow) stumps, windthrown trees, or obvious root disease centers. If a large area of root disease is suspected, consult a forest pathologist for a positive identification.



*Root disease centers are difficult to diagnose without examining the roots of symptomatic trees or adjacent, windthrown trees.*



***Pouch-fungus conks on this dead Douglas-fir may indicate imminent-failure potential if associated with other indicators such as heartrot conks.***

The bole above the lower butt is the next logical section to examine. From this point upward, visually examine the bole and branches to detect and estimate the extent of defect. Again, signs of past injury or fungal fruiting bodies should be the target of observation. By the time old-growth trees exhibit fruiting bodies of stem-decay fungi, decay levels are often substantial. Fruiting bodies generally develop at the site of old, branch stubs or wounds. Absence of conks, however, does not necessarily mean that a tree is free from decay.

Tree tops and branches should be examined thoroughly. Free-hanging branches should be evaluated and treated as needed. Dead tops and branches should be examined for decay and instability

as indicated by conks, cracked wood, exposed decay, woodpecker activity, or nesting cavities. Binoculars are useful for this assessment.

## **Step 1 – Determine Tree-Species Groups, Defects, and Failure Potential**

### **Important Tree-Species Groups in Oregon and Washington**

When determining potential-danger trees, it is important to be able to identify the most common tree-species groups along forest roads and work sites in Oregon and Washington. Diseases and defects that result in tree failure are more serious in certain tree-species groups. The following is a brief description of the major, native, tree-species groups in Oregon and Washington forests:

#### **Alders (*Alnus* spp.)**

Four species occur in the Pacific Northwest (red, white, thinleaf, and Sitka). *Leaves* are 1½-6 in. long, alternate, simple, unlobed, narrow to elliptical, and finely toothed to coarsely double-toothed. *Fruits* are cone-



**Western white pine with branch killing from blister rust**

like clusters, 1/3-1 in. long and on stalks. *Bark* is thin, smooth and **patchy white and gray**.

**Aspen** (*Populus tremuloides*)

There is only one species of aspen in the Pacific Northwest (quaking aspen). *Leaves* are 1-3 in. long, alternate, simple, unlobed, and nearly **circular** to heart-shaped with a pointed tip, straight base, and finely toothed margins. *Fruits* are capsules, 1/4 in. long, in hanging clusters that split open at maturity to release tiny, white-hairy seeds. *Bark* is **white to yellow-white, thin, and smooth** when young with black, warty patches with age.

**Cedars** (*Calocedrus, Chamaecyparis, Thuja* spp.)

Four species occur in the Pacific Northwest (western red, incense, Port-Orford, and Alaska yellow). *Needles* are **scale-like** and appressed to the twig. *Cones* are 1/2-1 in. long and are either round or long and thin. *Bark* is **stringy or flaky** and gray to brown. Incense cedar occurs only in Oregon. Port-Orford-cedar occurs naturally only in SW Oregon. Alaska yellow cedar grows only at high elevation. True cedars (*Cedrus* spp.) are not native to the Pacific Northwest.

**Cottonwood** (*Populus balsamifera* ssp. *trichocarpa*)

There is only one cottonwood species native to the Pacific Northwest (black cottonwood). *Leaves* are 3-6 in. long, alternate, simple, unlobed,

and **arrowhead-shaped** with pointed tips and fine, blunt teeth along the margins. *Fruits* are ¼ in. long, round capsules that split in three at maturity to release tiny, white-hairy seeds in late spring. *Bark* is gray with corky ridges and deep furrows in older trees.



**Fig. 3** - The inner bark of Douglas-fir resembles the color of bacon.

### **Douglas-fir**

*(Pseudotsuga menziesii)*

One species occurs in the Pacific Northwest.

*Needles* are about 1 in. long with a blunt tip and spirally arranged around the twig but may be two-ranked in the shade.

**Buds are sharp-pointed.**

*Cones* are 3-4 in. long with **3-pronged bracts**

that are longer than the scales. The cones hang down from the twig. *Bark* has resin

blisters when young, but deeply furrowed and reddish-brown when old. When cut, the older, **inner bark is a mottled-brown and yellow** color that resembles bacon (Fig. 3).

### **Hemlocks** (*Tsuga* spp.)

Two species occur in the Pacific Northwest (western and mountain).

*Needles* are under 1 in. long and in groups that appear to be either **star-like** (mountain hemlock) or tend to **stick out of the sides** of the twig (western hemlock). Terminal-branch tips have a **natural bend**. *Cones* hang down, are 1-3 in. long, and are cylindrical or egg-shaped. *Bark* is gray to brown with either narrow or flattened ridges.

### **Junipers** (*Juniperus* spp.)

Three species occur in the Pacific Northwest (Rocky Mountain, western, and common). *Needles* are either **scale-like or awl-like**. *Cones* are semi-fleshy, bluish, or reddish-brown called "**juniper berries**". *Bark* is gray-brown to reddish-brown and broken into narrow, flat, interlacing ridges. Native junipers occur only east of the Cascade crest.

### **Larches** (*Larix* spp.)

Two species occur in the Pacific Northwest (western and subalpine). *Needles* are 1-2 in. long and borne on woody pegs in **clusters of 20-40**. They fall off in the winter. *Cones* are 1-2 in. long with **papery bracts** that are longer than the scales. *Bark* is reddish-orange and flakes off in irregularly shaped pieces. Subalpine larch occurs naturally only in Washington and at high elevations.

### **Madrone** (*Arbutus menziesii*)

One species occurs in the Pacific Northwest (Pacific madrone). *Leaves* are 3-6 in. long, simple, evergreen, and elliptical with a bluntly pointed tip. *Fruits* are clustered, and berries are round and orange-red or yellow. *Bark* is very distinctive with newer bark being chartreuse in color and aging to gray, lilac, or pink, and finally to **red or orange**.

### **Maples** (*Acer* spp.)

Three species occur in the Pacific Northwest (bigleaf, vine, and Rocky Mountain). *Leaves* are 2-12 in. long, **opposite**, simple, and lobed. *Fruits* are paired, **winged samaras**,  $\frac{3}{4}$ -1½ in. long. *Bark* is **gray and becomes fissured with age**.

### **Myrtle or Bay (Laurel)** (*Umbellularia californica*)

One species occurs in the Pacific Northwest in SW Oregon (Oregon myrtle or California bay). *Leaves* are 2-5 in. long, **lanced-shaped** or narrowly elliptic with pointed tips and untoothed margins. Leaves are stiff, leathery, shiny, and dark yellow-green above and paler beneath and **smell like camphor when crushed**. *Fruits* are  $\frac{3}{4}$ -1 in. long, round, hard, and an olive-like drupe that is green ripening to dark-purplish brown. *Bark* is brown, thin, and breaks into plates that shed with age.

### **Oaks** (*Quercus* spp.)

Three species occur in the Pacific Northwest (Oregon white, canyon live, and California black). Leaves are 1-8 in. long, alternate, and simple. *Fruits* are **acorns**,  $\frac{1}{2}$ -1½ in. long, ovoid to oblong, and enclosed within a cup with scales. *Bark* is thick and somewhat scaly. Oregon white oak is the most abundant oak species in the Pacific Northwest. Canyon live oak and black oak occur naturally only in SW Oregon.

### **Pines** (*Pinus* spp.)

Seven species occur in the Pacific Northwest (ponderosa, Jeffrey, lodgepole, knobcone, western white, sugar, and whitebark). *Needles* are 1-10 in. long and are in **bundles of 2, 3, or 5 needles**. Ponderosa pine has 3 needles per bundle, whereas western white pine has 5 needles

per bundle that have white lines on 2 of 3 sides of the needle. Sugar pine also has five needles per bundle that have white lines on all three sides of the needle. Cones are 1-20 in. long with thick scales. *Bark* is gray to reddish brown and either furrowed or scaly. Jeffrey, knobcone, and sugar pines occur naturally only in Oregon.

### **Redwood** (*Sequoia sempervirens*)

One species occurs in the Pacific Northwest (coast redwood). *Needles* are ¼-1 in. long, most are flat-pointed, dark-green above with two white bands beneath and arranged in two rows. *Cones* are ¾-1 in. long, brown, ovoid and hang from the ends of green twigs. *Bark* is **thick, fibrous, and reddish-brown**. Redwood occurs naturally only in SW Oregon, but ornamental trees occur throughout western Oregon and Washington.

### **Spruces** (*Picea* spp.)

Three species occur in the Pacific Northwest (Sitka, Engelmann, and Brewer). *Needles* are 1 in. long and **sharp to touch**. *Cones* are 1-4 in. long, hang down, and have thin scales with jagged edges. *Bark* is thin, gray-brown, and **scaly**. Engelmann spruce occurs only east of the Cascade crest. Sitka spruce occurs naturally only along the Pacific coast and Puget Sound. Brewer spruce occurs naturally only in SW Oregon.

### **Tanoak** (*Notholithocarpus densiflorus*)

One species of tanoak occurs in the Pacific Northwest and is confined naturally to SW Oregon. *Leaves* are 2-5 in. long, elliptic with margins un-toothed or with one tooth per side vein and edges that often curl under. Leaves are stiff, leathery, evergreen, shiny, dark green with a thin coat of wool above and waxy-coated with a dense coat of wool beneath. *Fruits* are a single or double acorn, ¾-1 in. long and ½-1 in. wide, ovoid, glossy, or pointed maturing to yellow-brown and in a **shallow cup densely covered with bristles**. *Bark* on young trees is mottled-gray and smooth that forms plates when older.

### **True firs** (*Abies* spp.)

Six species occur in the Pacific Northwest (grand, white, Pacific silver, subalpine, noble, and Shasta red). *Needles* are 1-2 in. long and either spirally arranged or flat on the twig. *Cones* are 2-9 in. long and are **perched upright** on the twig. *Bark* when young has resin plasters. Older bark is gray to brown, and when cut, the older, **inner bark is purple** in color (Fig. 4) except for white fir which has inner bark like Douglas-fir (like bacon). Shasta red fir and white fir (*A. concolor*) occur naturally only in Oregon.



**Fig. 4** - The inner bark of most true firs is usually purple in color.

## Tree-Failure Potential

Failure potential is defined as the likelihood that a tree or its parts will fail during a certain time period. For roadside and work site danger trees, there are three levels of failure potential: low, likely, and imminent. They are defined as follows:

### Low-failure potential

*Trees or their parts are defective or decayed, but it would take considerable effort to make them fail. These trees or parts have a **low** probability of failure **within 10 years**.*

### Likely failure potential

*Trees or their parts are defective or decayed, but it would take moderate effort to make them fail. These trees or parts have a **high** probability of failure **within 3 to 5 years**.*

### Imminent-failure potential

*Trees or their parts are so defective or decayed that it would take little effort to make them fail. These trees or parts have a **high** probability of failure **within one year**.*

Failure potential is a function of tree condition. Trees with likely or imminent potential to fail may be classed as danger trees depending on the activity and whether the activity is within the tree's potential-failure zone (p. 46). In order to define the potential-failure zones, it is necessary to determine which tree part is likely to fail: entire tree, top, branch, or bark.

Trees with disease or defect require an evaluation to assign a potential-failure rating to them. The following are indicators for trees with imminent, likely, or low-failure potential (Table 1).



*Fire-damaged trees and vehicle loss, Willamette National Forest*

**Table 1. Failure indicators for imminent, likely, and low-failure potentials for trees along forest roads and work sites in Oregon and Washington.**

	Failure Indicator	Failure Potential		
		Imminent	Likely	Low
Dead Trees	<b>Old dead trees (≥5 years) No foliage or fine branches; bark is absent or falling off</b>	All tree species except cedar, juniper, larch, or large (≥20 in. dbh) Douglas-fir	Cedar, juniper, larch, or large Douglas-fir with no other visible indicators	None
	<b>Recent dead trees (&lt;5 years) All or some foliage; fine branches; bark mostly intact</b>	All trees <10 in. dbh	All trees ≥10 in. dbh except cedar, juniper, larch, or large Douglas-fir	Cedar, juniper, larch, or large Douglas-fir
	<b>Recent dead trees in root disease centers (p. 59-66)</b>	All tree species except cedar	Cedar	None
Roots	<b>Live trees in laminated root rot centers (p. 64)</b> <i>Phellinus sulphurascens</i>	Trees <b>with</b> signs or symptoms (ectotrophic mycelium or laminated decay; foliage thinning or yellowing)	<b>Douglas-fir, mountain hemlock, or true firs without</b> signs or symptoms and < <b>25ft.</b> from an infected tree or stump	<b>Douglas-fir, mountain hemlock, or true firs without</b> signs or symptoms and > <b>25ft.</b> from an infected tree or stump; All other species <i>without</i> signs or symptoms
	<b>Live trees in Armillaria or Heterobasidium root disease centers</b> <i>Armillaria</i> spp. (p. 60) <i>Heterobasidium</i> spp. (p. 62)	Trees <b>with</b> signs or symptoms (mycelial fans, resinosis, staining, conks, or wounds with decay; foliage thinning or yellowing) <b>and</b> adjacent (≤50 ft.) to windthrown trees with root disease	Trees <b>with</b> signs or symptoms but <b>not</b> adjacent to windthrown trees with root disease	Trees without signs or symptoms
	<b>Live trees in black stain or Port-Orford-cedar root disease centers</b> <i>Leptographium wageneri</i> (p. 62) <i>Phytophthora lateralis</i> (p. 65)	None	None	All trees
	<b>Live trees with undermined or severed roots (p. 66)</b>	Trees with < <b>50%</b> of the structural roots remaining in the ground	Trees with <b>50 to 75%</b> of the structural roots remaining in the ground	Trees with > <b>75%</b> of the structural roots remaining in the ground

Failure Indicator		Failure Potential		
		Imminent	Likely	Low
Butt	Butt rot (p. 66-69 ) <i>Schweinitzii</i> (cow-pie conk) <i>Tomentosus</i> (spruce rot conk) <i>Ganoderma</i> (artist's and varnish conks)	Trees with $\geq 1$ conk(s) <b>associated with</b> open cracks or exposed decay	Trees with $\geq 1$ conk(s) <b>not associated with</b> open cracks or exposed decay	Trees with butt swell but no conks
	Living, fire-damaged trees for recent (<5yr) fire damage; use bole-wounds for old fire damage (p. 70)	<b>True fir, hemlock, spruce, or hardwoods</b> with >50% of the bole cross-sectional area burned and consumed, or more than one quadrant of burned and consumed structural roots <b>Douglas-fir, pine, cedar, juniper, or larch</b> with >75% of the bole cross-sectional area burned and consumed, or more than one quadrant of burned and consumed structural roots	<b>True fir, hemlock, spruce, or hardwoods</b> with 25 to 50% of the bole cross-sectional area burned and consumed, or one quadrant of burned and consumed structural roots <b>Douglas-fir, pine, cedar, juniper, or larch</b> with 50 to 75% of the bole cross-sectional area burned and consumed, or one quadrant of burned and consumed structural roots	<b>True fir, hemlock, spruce, or hardwoods</b> with <25% of the bole cross-sectional area burned and consumed, and no burned and consumed structural roots <b>Douglas-fir, pine, cedar, juniper, or larch</b> with <50% of the bole cross-sectional area burned and consumed, and no burned and consumed structural roots
Bole/Stem	Bole wounds mistletoe cankers, fungal cankers, or old fire wounds ( $\geq 5$ years) (p. 71-80)	<b>True fir, hemlock, spruce, or hardwoods</b> with <50% cross-section of bole with sound wood <b>Douglas-fir, pine, cedar, juniper, or larch</b> with <25% cross-section with sound wood	<b>True fir, hemlock, spruce, or hardwoods</b> with 50 to 75% cross-section of bole with sound wood <b>Douglas-fir, pine, cedar, juniper, or larch</b> with 25 to 50% cross-section with sound wood	<b>True fir, hemlock, spruce, or hardwoods</b> with >75% cross-section of bole with sound wood <b>Douglas-fir, pine, cedar, juniper, or larch</b> with >50% cross-section with sound wood
	Frost cracks (p. 82)	None	Trees with <b>weeping</b> cracks	Trees without weeping cracks
	Bole cracks (p. 82)	Trees with open splits or cracks with independent movement or exposed rot	Trees with open splits or cracks <b>without</b> movement or exposed decay	Trees with sealed cracks
	Burls (p. 82)	None	None	All trees

Failure Indicator	Failure Potential		
	Imminent	Likely	Low
<b>Quinine conks (p. 86)</b> <i>Laricifomes officinalis</i>	Trees with $\geq 1$ conk(s)	None	None
<b>Indian paint fungus conks (p. 92)</b> <i>Echinodontium tinctorium</i>	Trees with <b>multiple, large</b> ( $\geq 6$ in. wide) conks; <b>Single, large</b> conk or <b>multiple, small</b> conks <b>associated with</b> open cracks or exposed rot	Trees with <b>single, large</b> conk or <b>multiple, small</b> conks <b>not associated with</b> open cracks or exposed rot	Trees with a <b>single, small</b> conk
<b>Red ring rot conks, white speck (p. 90)</b> <i>Porodaedalea pini</i>	Trees with $\geq 1$ conk(s) <b>associated with</b> extensive advanced decay <sup>1</sup> such as open cracks or exposed rot	<b>True fir, hemlock, spruce, or hardwoods</b> with $\geq 1$ conk(s) <b>not associated with</b> extensive advanced decay; <b>Douglas-fir, pine, cedar, juniper, or larch</b> with $\geq 3$ large conks ( $\geq 6$ in. wide) within a 3-ft.-long trunk cylinder	<b>Douglas-fir, pine, cedar, juniper, or larch</b> with $\geq 3$ large conks not within a 3-ft.-long trunk cylinder; $\leq 2$ large conks within a 3-ft.-long trunk cylinder; any number or location of small conks
<b>Other heart-rot conks (p. 84-93)</b>	Trees with $\geq 1$ conk(s) <b>associated with</b> open cracks or exposed rot	Trees with $\geq 1$ conk(s) <b>not associated with</b> open cracks or exposed rot	None
<b>Sap-rot conks</b> <i>Cryptosporus volvatus</i> (pouch conk) (p. 95) <i>Fomitopsis pinicola</i> (red-belt conk) (p. 94)	<b>Dead trees</b> with $\geq 1$ red-belt conk(s)	<b>Live trees</b> with $\geq 1$ red-belt conk(s) usually associated with bole wounds	<b>Live trees</b> with $\geq 1$ pouch conk(s); check for extent of dead bark and sound wood

Conks

Failure Indicator	Failure Potential		
	Imminent	Likely	Low
Tops and Branches	Forked or multiple tops or stems (p. 97)	Trees with any fork <b>associated with</b> open cracks, decay, or conks* (tops are imminent FP, not the whole tree unless fork is at the base)	Trees with <b>U-shaped forks</b> and no open cracks, decay, or conks*; V-shaped forks with <b>no</b> embedded bark, open cracks, decay, or conks* (tops are low FP, not the whole tree unless fork is at the base)
	Dead tops or branches ( $\geq 3$ in. diameter) (p. 96)	True fir, hemlock, spruce, or hardwoods $\geq 5$ years dead or with <b>red-belt conks</b> (tops and branches are imminent FP, not the whole tree)	<b>Cedar, larch, juniper, or pine; Douglas-fir</b> $< 5$ years dead (tops and branches are low FP, not the whole tree)
*Any conk except for red ring rot conks ( <i>P. pini</i> ) on forked Douglas-fir, pine, cedar, juniper, or larch.			
Tops and Branches	Detached tops, branches ( $\geq 3$ in. diameter), or bark ( $\geq 1$ ft.) (p. 96)	<b>All detached parts</b> (parts are imminent FP, not the whole tree)	None
	Dwarf mistletoe brooms (p. 98)	None	Trees with <b>small, dead</b> brooms or live brooms (broom is low FP, not the whole tree)
	Cottonwood branches (p. 97)	Trees with large ( $\geq 3$ in. diam.) <b>dead</b> branches (branches are imminent FP, not the whole tree)	Trees with large, live branches with no evidence of decay or past breakage

Failure Indicator	Failure Potential		
	Imminent	Likely	Low
Whole Tree	Broken or uprooted trees supported by other trees (p. 99)	None	None
	Leaning and/or root-sprung trees (p. 99)	Trees with recent leans $\geq 15$ degrees or old, uncorrected leans <b>without</b> freshly disturbed soil or root damage	Trees with old, <b>corrected</b> leans
	Height to diameter ratio (p. 100)	Trees with recent (<5yr) leans $\geq 15$ degrees or old, uncorrected leans <b>with</b> freshly disturbed soil or root damage	Trees with <b>80 to 100</b> H:D ratio
	Multiple indicators (p. 113)	Trees with <b>&gt;100</b> H:D ratio <sup>2</sup> Two or more likely-FP indicators with synergistic effects: one condition (indicator) worsens the other (i.e. recently killed true fir with a large, Indian paint fungus conk)	Trees with <b>&lt;80</b> H:D ratio Two or more low-FP indicators without synergistic effects (i.e. top-killed cedar with two <i>P. pini</i> conks on the live bole)

<sup>1</sup>Firm wood with white speck or firm wood with red discoloration is not considered advanced decay from *P. pini*. Advanced decay is very soft and crumbly.

<sup>2</sup>To calculate H:D ratio, divide the total tree height in feet by the diameter breast height (dbh) in feet.

> means is greater than; < means is less than

## Step 2 – Determine the Type of Activity

Exposure to danger trees is prohibited by state safety laws. Not all activities expose people to the same risks. Some activities can induce tree failure, such as operating heavy machinery around an unstable tree. Some activities have an increased risk due to the length of exposure to a tree with defects. The type of activity is extremely important when determining if a tree is a danger to people or property.

There are three categories of activities:

1. Traffic on roads
2. Non-motorized activities that do not touch the tree
3. Motorized activities near the tree or activities that may cause the tree to be contacted

Road traffic may or may not influence tree failure. This category is included because trees may fail and fall on vehicles or people congregated along roads, or they may fail and fall on roads and be driven into at a later time.

Non-motorized activities such as walking by a tree or other non-tree contact activities are not likely to induce a tree to fail. A tree may fail due to either its condition or weather. Activities involving non-motorized, non-tree contact include planting trees, standing near a sign, walking

on a trail, or doing resource surveys.



***Wounded Douglas-fir, like this one on the Rogue River-Siskiyou National Forest, may indicate internal decay. The amount of sound wood remaining will determine tree-failure potential.***

Motorized activities or non-motorized activities that may contact the tree or otherwise influence its integrity, include operating a grader, culvert work, measuring tree diameters, examining dead roots, tree

falling, road or trail construction, and helicopter operations. All of these activities may induce a tree to fail.

## 1) Traffic on roads

Oregon OSHA Division 7, 437-007-0500 Roads (6). On those portions of roads under the direct control of the employer: (a) all danger trees that can fall or slide onto roadways must be felled.

Washington 296-54-531 Truck roads (3)(a) safe roadways. The following applies to roads under the control of the employer. All danger trees shall be felled a safe distance back from the roadway (3).

There are three types of exposure: intermittent, short duration, and long duration. **Intermittent exposure** includes traffic driving by a defective tree. **Short-duration exposure** includes either stopping next to a defective tree, or stopping at an intersection that is next to a defective tree for up to 15 minutes. **Long-duration exposure** includes exposure to defective trees while parked at a trailhead, repairing a road, or working on a log landing for more than 15 minutes.

Another aspect of exposure along roads is traffic frequency. Roads that have a higher traffic frequency expose more people to a danger tree than roads with a lower traffic frequency.

The longer that people or property are exposed to a danger tree, the greater the opportunity for the failed tree to impact them. If exposure duration and traffic frequency are reduced, the opportunity for the tree to impact people or property is also reduced. The qualified person should consider traffic frequency and exposure duration when determining whether a tree poses a danger. For specific direction, refer to agency policy about danger trees along roads (11).

## 2) Non-motorized, non-tree-contact activities

Non-motorized, non-tree contact activities involve walking or conducting activities near trees without touching them. The premise behind these activity types is that trees are much less likely to fail if they are not contacted, and people are more likely to recognize tree dangers if they are not focused on operating vehicles or machinery. Examples include tree planting, noxious-weed control, surveying, walking along a trail, or standing at a bus stop.

With this type of activity, it is important to recognize trees that have an imminent-failure potential. Since these trees may fail at any time, they pose a danger regardless of the activity type. Because these trees expose people to dangers, only qualified employees under the direct supervision of the employer should enter the tree's potential-failure zone.

There will also be trees that have a likely potential to fail. In order to determine if the tree is a danger, the qualified person needs to evaluate the tree condition, type of activity, and whether or not the person will be within the potential-failure zone. If the qualified person determines that a tree with likely failure-potential does not represent a danger, people should work or walk through the potential-failure zone quickly so as to minimize exposure time and avoid tree contact. If the tree is a danger, it should be removed or the activity should be excluded from within the potential-failure zone.

### **3) Motorized or tree-contact activities**

Motorized activities and those activities that may contact the tree include riparian restoration, logging (all types), increment coring, tree falling, tree climbing, site preparation, road or trail construction, and



***Motorized activity can cause trees or parts to fail, as with this tree-falling activity near Ashford, WA.***

helicopter operations. The premise behind this activity type is that vibration due to machine operation, air movement in the case of a helicopter, or tree contact by a person, machine, log, or operating line, may induce tree failure. As a result of noise or worker focus on the job task, the person might not recognize the danger or notice the failure beginning to take place and miss the opportunity to escape.

### **Prioritizing Roads for Survey and Treatment**

There are many miles of roads that may have danger trees adjacent to them. It is not possible to correct all danger-tree problems on a National or State Forest within a few months or even years, so it is necessary to prioritize the danger-tree survey and treatment workload. The priority for which roads should be surveyed is based on the frequency of road usage and maintenance level (Table 2). Maintenance-level 5, 4, and 3 roads, in that order, should be surveyed first; maintenance-level 2 and 1 roads should be surveyed last.

The treatment priority within a surveyed road segment should be highest where people or vehicles are most likely to be impacted by danger trees (Fig. 5). Consideration of exposure level and traffic frequency provides a way to prioritize the danger-tree workload (Table 3).

**Table 2. USDA Forest Service road-maintenance levels and survey priority with level-5 roads receiving the highest priority.**

<b>Maintenance Level</b>					
<b>Parameters</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Traffic type</b>	Open for non-motorized uses; closed to vehicles licensed to be on the public road system	Administrative, permitted, dispersed recreation, specialized commercial haul; maintained for high-clearance vehicles	All National Forest traffic, general use, commercial haul, maintained for passenger cars		



***A maintenance level-3 road with danger trees, Gifford Pinchot National Forest.***

**Table 3. Road-treatment priority for danger trees**

Facility	Exposure Duration	Failure Potential	Road Segment Priority	Priority Within Road System
<p><b>Areas where people stop and congregate such as parking areas or active projects/ contracts along the road where work is stationary such as culvert replacement and bridge construction.</b></p>	Long			Highest
<p><b>Intersections along operational maintenance level 3-5 roads; scenic vistas, geologic points of interest, where people are encouraged to stop</b></p>	Short	<i>Imminent</i>	High	
<p><b>Areas along roads with high traffic volumes such as operational maintenance level 3-5 roads not within intersections. Limited sight-distance areas should be evaluated closely, as trees that have failed and are in the traveled way in these areas may be a surprise to drivers.</b></p>	Intermittent but High Frequency			
<p><b>Haul routes</b></p>				Lowest

Facility	Exposure Duration	Failure Potential	Road Segment Priority	Priority Within Road System
<p>Areas where people stop and congregate such as parking areas or active projects/ contracts along the road where work is stationary such as culvert replacement and bridge construction.</p> <p>Intersections along operational maintenance level 3-5 roads; scenic vistas, geologic points of interest, where people are encouraged to stop</p> <p>Areas along roads with high traffic volumes such as operational maintenance level 3-5 roads not within intersections. Limited sight distance areas should be evaluated closely, as trees that have failed and are in the traveled way in these areas may be a surprise to drivers.</p> <p>Haul routes</p>	<p>Long</p> <p>Short</p> <p>Intermittent but High frequency</p>	<p><i>Likely</i></p>	<p>Medium</p>	<p>Highest</p>  <p>Lowest</p>
<p>Areas with low traffic volumes, such as operational maintenance level-2 roads</p>	<p>All</p>	<p>Imminent or Likely</p>	<p>Low</p>	



**Fig. 5** - A road segment with a parking lot that should receive high priority for treatment. Note several trees with imminent-failure potential that are dangers as well as those with likely failure potential that also are danger trees in this case with short or long exposure durations.

### **Step 3 - Determine the Tree's Potential-Failure Zone**

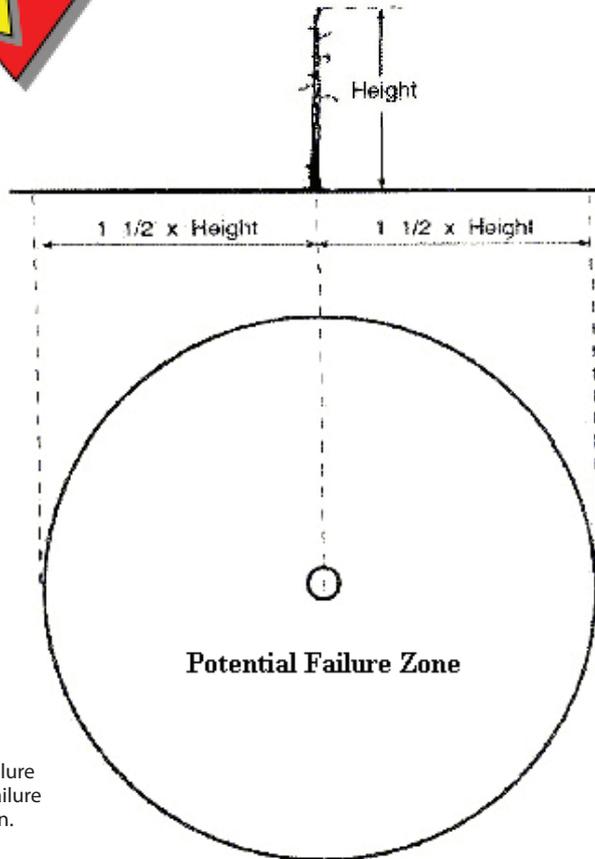
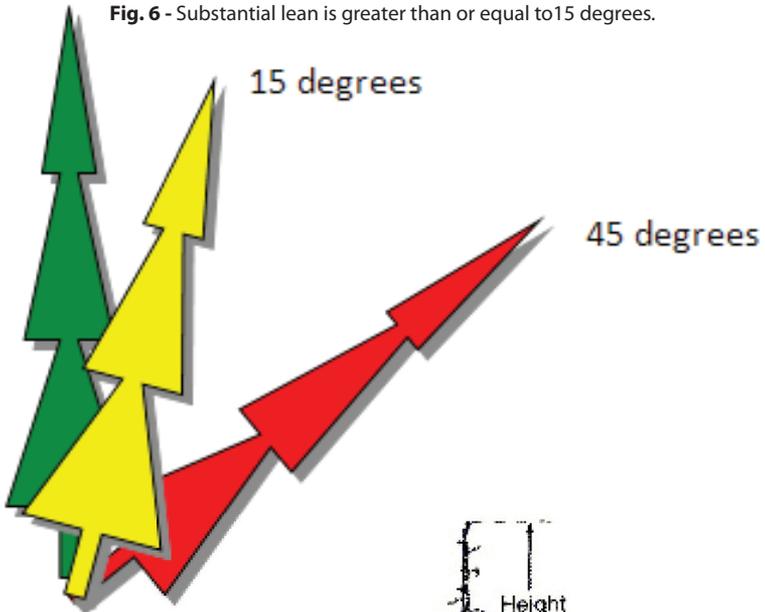
The potential-failure zone is the area on the ground that could be reached by any part of a failed tree. When a tree fails, the tree or its parts may slide or roll. When a tree fails, it may strike other trees or debris on the ground and propel material a considerable distance. This is especially true for dead trees, tops, or branches. The qualified person needs to be aware of these situations when determining the potential-failure zones.

#### **Total Tree Failure – Potential-Failure Zone**

When determining the potential-failure zone for total tree failure, the following conditions must be evaluated: (1) ground slope angle, (2) direction of lean ( $\geq 15$  degrees), and (3) tree height.

Leans  $< 15$  degrees are too difficult to accurately predict the natural fall direction (Fig. 6). Such leaning trees should be assumed to fall in any direction.

**Fig. 6** - Substantial lean is greater than or equal to 15 degrees.



**Fig. 7** - Potential-failure zone for total tree failure with no slope or lean.

## Level or sloped ground with no lean

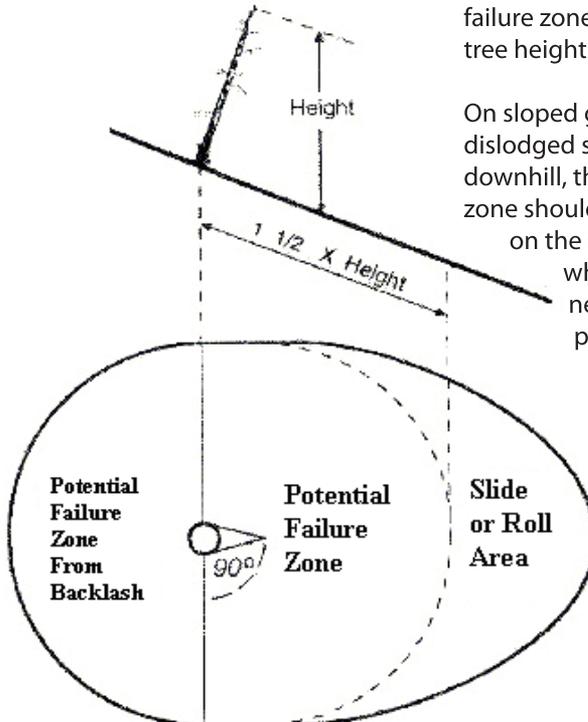
On level ground, the potential-failure zone is a circle around the tree with a radius equal to  $1\frac{1}{2}$  times the total tree height (Fig. 7). On sloped ground, the failure zone downhill from the tree should be extended whatever distance is necessary to protect people from sliding or rolling trees (Fig. 8).

## Level or sloped ground with lean in any direction

The potential-failure zone has a radius equal to  $1\frac{1}{2}$  times the tree height, beginning at the tree base, then extending towards the direction of the lean and out 90 degrees on either side of the tree from the lean direction (Fig. 8).

The area behind the lean is not within the full-failure zone. Be aware, however, that if equipment, lines, moving logs, falling trees, or severe winds contact a likely or imminent-failure potential tree, the contact could force a backlash opposite to the lean and extend the potential-

failure zone about  $\frac{1}{2}$  times the tree height.



On sloped ground, where the dislodged section may roll downhill, the potential-failure zone should be extended on the downhill side for whatever distance is necessary to protect people.

**Fig. 8** – Potential-failure zone for total tree failure with slope and lean.

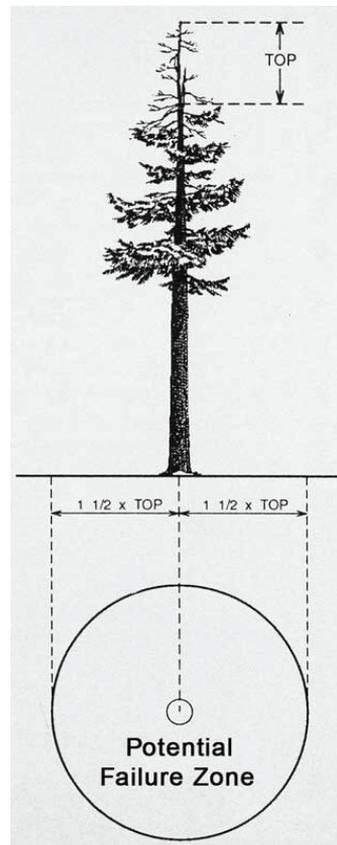
## Tree-Part Failure – Potential-Failure Zone

The area on-the-ground that could be reached by a dislodged top, branch, slab, or chunk is called the potential-failure zone for a part failure. When determining the zone, evaluate the following conditions:

- Ground slope angle
- Amount and direction of lean  $\geq 15$  degrees
- Length of the part that could dislodge

### Level or sloped ground with no lean

Determine the length of the part that could dislodge. On level ground, the potential-failure zone forms a circle around the tree with a radius equal to at least  $1\frac{1}{2}$  times the length of the dislodged part (Fig. 9). This extra area accounts for parts that may slide along branches should they fail. On sloped ground where the dislodged part may slide or roll downhill, the failure zone should be extended on the down-hill side for whatever distance is necessary to protect people.



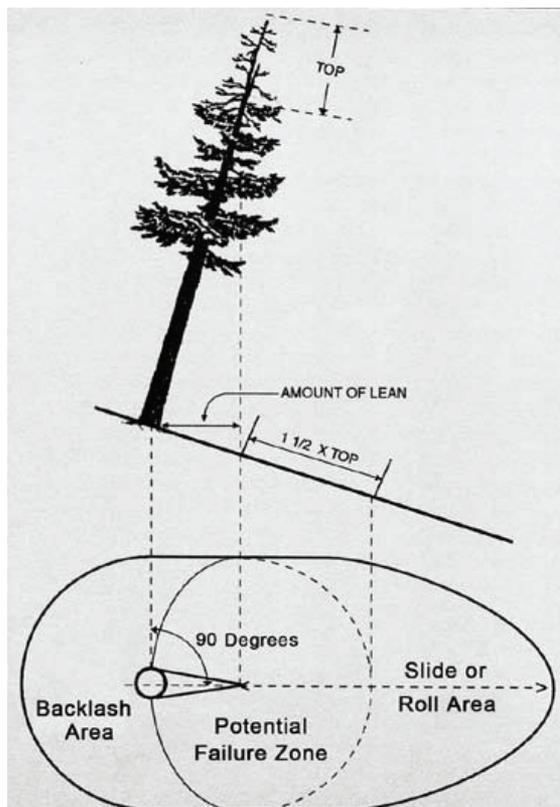
**Fig. 9** – Potential-failure zone for top failure with no slope or lean.

## Level or sloped ground with lean in any direction

Determine the length of the part that could dislodge. Determine the amount of lean (horizontal distance from where the part could dislodge relative to the base). The potential-failure zone is the distance determined by adding  $1\frac{1}{2}$  times the length of the dislodged part to the lean amount. This distance would be applied to an area beginning at the tree base then extending towards the direction of the lean and out 90 degrees on either side of the tree from the lean direction.

The area behind the lean is not within the potential-failure zone. Be aware, however, that if equipment, lines, moving logs, falling timber, or severe winds contact a likely or imminent-failure potential tree, the contact could force a backlash opposite to the lean and extend the potential-failure zone about the length of dislodged part. On sloped ground where the dislodged part may slide or roll downhill,

the potential-failure zone is extended on the downhill side for whatever distance is necessary to protect people (Fig. 10).



**Fig. 10** - Potential-failure zone for top failure with slope and lean.

## Step 4 – Determine if the Tree Poses a Danger

A tree is identified as a danger tree based on failure potential, type of activity, exposure duration, and the potential-failure zone. Not all trees with a likely or imminent potential to fail are danger trees (Table 4 and Fig. 11). For instance, if the activity is outside of the potential-failure zone, the tree is not considered a danger. If the activity is mechanized with short or long exposure, the tree has likely failure potential, and the work is within the potential-failure zone, the tree is a danger. The following should be considered in determining if the tree poses a danger:

- Evaluate the tree and determine its condition and failure potential.
- Identify the potential-failure zone and determine if the activity is within the failure zone.
- Determine the exposure duration (intermittent, short, or long).

All trees or parts with imminent-failure potential are a danger if they will strike a road or target (Table 4 and Fig. 11). Trees or parts with likely failure potential that will strike a road or target may be a danger



***Danger trees along a summer-home road, Mt. Hood National Forest. Pull-outs and parking spurs should have a higher priority for survey and treatment.***

depending on the exposure duration. If the exposure duration is intermittent, such as a drive-by or walk-by, the tree or part is not considered a danger. If the exposure duration is short (<15 min.) or long ( $\geq$ 15 min.), then the tree is a danger and should be treated (Table 4 and Fig. 11).

## Large Areas of Recently Killed Trees

Severe wildfires or beetle epidemics can kill trees over hundreds of acres within a short time period. Because most of the trees are recently killed (<5 years), they have a likely failure potential unless they are small trees <10 in. dbh; are cedar, juniper, larch, or large Douglas-fir; or they have root disease or certain defects (Table 1). For most recently killed trees, exposure duration along roads mainly is intermittent (drive-by traffic) and therefore the trees are not a danger. However, due to the large number of recently killed trees in these situations, there is a higher risk of tree failures occurring, because stands are often more open following large disturbances, and trees may be more prone to windthrow or wind-shatter. After five years, most of these trees (except cedar, juniper, larch, or large Douglas-fir) will have imminent-failure potential and therefore will become danger trees. The challenge is deciding when to treat such trees that are not now a danger but will become danger trees in five years. Waiting five years for thousands of trees to become dangers presents at least three problems for forestland managers: 1) some trees



***Fire-killed trees were felled along this road on the Okanogan-Wenatchee National Forest.***

may fail before they have been dead for five years, 2) older, dead trees have less commercial value because of decay and defect than recently killed trees, and 3) older, dead trees are more dangerous to fell because of increased decay and defect.

Most USDA Forest Service managers have dealt with this dilemma by felling all of the recently killed trees and danger trees within striking distance of a road system after a thorough consultation with an evaluation team of natural-resource experts, approval from the appropriate line officers, and addressing all NEPA considerations (p. 52). In some cases, line officers have decided to remove live trees that have a very low-probability of survival post-fire (e.g., trees with  $\geq 90\%$  crown scorch or consumption) within striking distance of roads that would most likely become dangers in the future. This usually requires a different level of NEPA than a road maintenance CE (p. 52-55). Roads should be closed following large disturbances if the risk of danger trees to human safety is unacceptable prior to mitigation. Creative financing is usually needed to fund these large projects if there is little or no income generated from the felled trees. Burned Area Emergency Response (BAER) funds have been used to treat fire-killed trees along roads as recommended in the Region 6 transportation policy (11). Guidelines have been published to determine the survival probability of fire-injured, living conifers in northeastern Oregon and elsewhere with probable applicability to other areas in Oregon and Washington (12, 13).



***These fire-killed trees were removed using Burned Area Emergency Response (BAER) funds on the Okanogan-Wenatchee National Forest.***

**Table 4. How to determine if a tree with imminent or likely failure potential is a danger.**

Tree-failure potential is:	Road or activity is:	Tree is:
Imminent	Within the potential-failure zone	A danger
Likely	Within the potential-failure zone	
	<ul style="list-style-type: none"> <li>• and duration of exposure is <b>intermittent</b> (i.e. walk-by or drive-by)</li> </ul>	Not a danger
	<ul style="list-style-type: none"> <li>• and duration of exposure is <b>short or long</b> (i.e. bus stop or log landing)</li> </ul>	May be a danger



**Fig. 11** –Trees with likely failure potential and within striking distance can be dangers if exposure duration is short or long, as when people have stopped to read this roadside sign.

The following three examples illustrate the process a qualified person should take when evaluating potential-danger trees:

### ***Example 1***

**Scenario 1.** Assume there is a skyline logging operation. You as the qualified person notice that behind the landing, the standing trees look abnormally yellow (chlorotic). There is a history of dying trees in the area combined with some live trees with sparse crowns. You don't notice any windthrow but do observe basal resin and bark staining in a few standing trees. When you chop at the root collar and pull the bark away, you discover white, latex-like, mycelial fans.

You conclude that the live but chlorotic trees have *Armillaria* root disease (p. 60) and have a likely failure potential. Next, you determine that the landing is within the potential-failure zone of the trees. The activity is motorized, and while it is not likely that any machinery will strike the trees, wind and vibration may induce them to fail. You recognize that the landing crew will be within the potential-failure zone of the trees for a long time. Your conclusion is that the trees pose a danger and need to be felled or the landing moved.

**Scenario 2.** Assume there is a tree-planting operation in the unit logged near the landing previously discussed. You, as the qualified person, notice that around the unit boundary, many of the standing trees look chlorotic. You don't notice any windthrow but do notice several honey-colored mushrooms around the base of several of the trees along with basal resin and bark staining. When you chop at the root collar and pull the bark away you discover white, latex-like, mycelial fans.

You conclude that the live trees have *Armillaria* root disease and have a likely potential to fail. Next, you determine that the planting job site is within the potential-failure zone of the root diseased trees. The activity is tree planting, and it is not likely that any equipment will strike the trees and cause them to fail. Your conclusion is that the *Armillaria* root-diseased trees do not pose a danger to workers, so the area around them can be planted. You require that the planting crew work rapidly through the area and avoid the area on a windy day.

### ***Example 2***

Assume you are evaluating trees along a haul-route road. You notice two very similar white fir trees in two separate locations. Each tree has several, large, Indian paint fungus conks on the bole (p. 92). You

conclude the trees have substantial heart rot and have an imminent-potential for failure. One tree is on the far side of a curve at the bottom of a long, steep grade. The other is along a straight stretch of road. Exposure will be intermittent. Next, you determine the potential-failure zone and realize that the portion of the road traveled is within the potential-failure zone. You consider that when the trees fail they may not actually hit any traffic, but that traffic may run into them, especially the one on the curve. You conclude that the trees pose a danger and need to be removed.

### ***Example 3***

You are evaluating a tree-planting operation. The unit being planted has many dead and a few large, live trees scattered about. You notice that the bark appears loose on most of the dead trees. One of the green trees has a recent lean, and you suspect it is root sprung since there is evidence of recent soil cracking around the tree base. You also notice that some leaning, dead trees are hung up in the crown of other trees. On the other side of the unit, there are a few live trees standing straight with heart-rot conks on their boles.

You conclude that the leaning, root-sprung trees, the trees that are hung up, and the trees with the loose bark have imminent-failure



***White fir killed by *Armillaria* root disease on the Fremont-Winema National Forest. Most of the dead trees here are danger trees, regardless of activity type or exposure duration.***

potential. Because these trees have an imminent-failure potential, and their potential-failure zones include the area to be planted, you conclude that the trees are a danger. The areas within the failure zones cannot be safely planted without removing the danger by felling the trees. The danger trees need to be felled, or the planting crews need to avoid planting in the tree-failure zones.

The straight, green trees with heart rot are determined to have a likely potential for failure. The exposure under them will be of intermittent duration, and the activity around them is not likely to cause the trees to fail, since there will be no vibration or tree contact. You decide to let a crew plant under them if they move through rapidly and avoid contacting the trees.

## Step 5 - Document the Danger-Tree Assessment

A record that an inspection was performed along a forest road or work site is necessary to provide evidence that a survey was completed. Documenting trees with imminent or likely failure potential can provide evidence that a tree was examined and a decision made to mitigate or not mitigate the hazard. A map of the approximate location of the danger trees is always helpful. A tree-record form (pp. 50-51) must be completed for trees with imminent or likely failure potential. Healthy-appearing trees with low-failure potential may be inspected but are rarely recorded. A tree-record form that lists trees with elevated hazard and their recommended treatment is given to the line officer or supervisor. Documenting the major defects at each road segment



***Documenting danger trees, Okanogan-Wenatchee National Forest***

or work site makes future surveys more efficient and is a record of performance in the event of litigation. From a legal standpoint, **if a survey is not documented, then it was never completed.**





## Step 6 – Determine What Action to Take if the Tree is a Danger

Our objective is to minimize exposure to danger trees. If after considering the tree condition and activity and recording your observations, it is determined that a tree poses a danger, the tree must either be felled or the activity arranged so that the danger is mitigated. If culturally modified or wildlife trees are involved, archeologists or wildlife biologists must be informed of the intended action. Present your observations and recommendations to your supervisor. Decisions to mitigate danger trees are the responsibility of the supervisor or line officer. As a qualified person, you have completed your responsibilities. Methods of mitigating danger trees are discussed in *Danger tree mitigation guidelines for managers, 2011* (16).

## NEPA (National Environmental Policy Act) Considerations

The following section outlines some considerations for implementing the National Environmental Policy Act (NEPA) for danger-tree management. Coordinate with local NEPA, Endangered Species Act (ESA) and Cultural Resource specialists for more information.



***Danger-tree mitigation on the Mt. Hood National Forest. The felled trees were used for stream-enhancement projects.***

In general, NEPA applies to all decisions made by the USDA Forest Service that could affect the human environment. However, the level of documentation required varies depending on the scope and scale of a proposed action. Complexity and documentation requirements are proportional to the size of a project's footprint and the duration of the project's potential effects.

### ***Emergency Situations***

36 CFR 220.4 notes that a responsible official may take actions necessary to control the immediate impacts of the emergency and are urgently needed to mitigate harm to life, property, or important natural or cultural resources. This may require action (e.g., felling a danger tree) before ordinary NEPA documentation requirements can be met. Any foreseeable adverse environmental effects would be mitigated to the extent practical.

Unless there is a determination that an emergency exists, danger-tree management requires environmental review and documentation prior to action on the ground.

### ***Connected Actions***

Danger-tree management may be connected to other actions proposed by the Forest Service, such as vegetation management. Connected actions would ordinarily be considered together in a single NEPA analysis. In such cases, danger-tree management would be listed as a mitigation measure or connected action. Danger-tree mitigation should extend through the life of the connected project. Adaptive-management criteria may be analyzed to ensure that foreseeable danger trees are addressed through the life of a project. If danger trees are to be sold after felling, the sale of forest products would be a connected action.

### ***Categorical Exclusions***

The primary NEPA documents are Environmental Assessments (EA) and Environmental Impact Statements (EIS). However, some routine actions taken by the Forest Service may be "categorically excluded" from documentation in an EA or EIS. Categorical exclusion refers to categories of actions that the Forest Service has determined would not individually or cumulatively have a significant effect on the human environment. As long as there is an applicable category, and there are no extraordinary resource conditions, the project may be categorically excluded from documentation in an EA or EIS.

Danger-tree management could fall under the following categories of actions that can be taken with little documentation. These categories do not require preparation of any decision documentation (e.g., decision memo). However, some public involvement is usually required and high public interest could influence the level of documentation required and a responsible official could elect to prepare a decision memo for the following categories:

- 36 CFR 220.6(d)(3) Repair and maintenance of administrative sites.
- 36 CFR 220.6(d)(4) Repair and maintenance of roads, trails and landline boundaries.
- 36 CFR 220.6(d)(5) Repair and maintenance of recreation sites and facilities

Extraordinary resource conditions that might warrant further analysis and documentation in an EA or an EIS are:

- (1) Federally listed, threatened, or endangered species or designated critical habitat, species proposed for Federal listing or proposed critical habitat, or Forest Service sensitive species;
- (2) Flood plains, wetlands, or municipal watersheds;
- (3) Congressionally designated areas, such as wilderness, wilderness study areas, or national recreation areas;
- (4) Inventoried roadless areas or potential wilderness areas;
- (5) Research natural areas;
- (6) American Indian and Alaska Native religious or cultural sites, and
- (7) Archaeological sites, or historic properties or areas.

***In riparian areas, water-quality best-management practices (BMP) and monitoring may be required for mitigating danger trees.***



The mere presence of one or more of these resource conditions does not preclude use of a categorical exclusion (CE). In considering extraordinary circumstances, the degree of the potential effects on the listed resources (or uncertainty) influences whether the project may be categorically excluded.

Danger-tree mitigation could be connected to other actions that may be categorically excluded and also require documentation in a decision memo. Some examples include:

- 36 CFR 220.6(e)(1) Construction or Reconstruction of Trails
- 36 CFR 220.6(e)(2) Additional construction or reconstruction of existing telephone or utility lines in a designated corridor
- 36 CFR 220.6(e)(6) Timber stand and/or wildlife habitat improvement activities that do not include the use of herbicides or do not require more than 1 mile of low standard road construction.
- 36 CFR 220.6(e)(11) Post-fire rehabilitation activities, not to exceed 4,200 acres (such as tree planting, fence replacement, habitat restoration, heritage site restoration, repair of roads and trails, and repair of damage to minor facilities such as campgrounds), to repair or improve lands unlikely to recover to a management approved condition from wildland fire damage, or to repair or replace minor facilities damaged by fire.
- 36 CFR 220.6(e)(12) Harvest of live trees not to exceed 70 acres, requiring no more than ½ mile of temporary road construction.
- 36 CFR 220.6(3)(13) Salvage of dead and/or dying trees not to exceed 250 acres, requiring no more than ½ mile of temporary road construction.
- 36 CFR 220.6(e)(14) Commercial and non-commercial sanitation harvest of trees to control insects or disease not to exceed 250 acres, requiring no more than ½ mile of temporary road construction, including removal of infested/infected trees and adjacent live uninfested/uninfected trees as determined necessary to control the spread of insects or disease.

## **Relationship to Endangered Species Act**

The degree of potential effects to federally listed, threatened, or endangered species or designated critical habitat, species proposed for Federal listing or proposed critical habitat, or Forest Service sensitive species influences whether a project may be categorically excluded from documentation in an EA or EIS. It also influences ESA Section 7

Consultation requirements. Actions that may affect federally listed, threatened, or endangered species or designated critical habitat, species proposed for Federal listing or proposed critical habitat require consultation with either the US Fish and Wildlife Service (most fish, wildlife, plants) or the National Marine Fisheries Service (anadromous fish).

Consultation is not required if a local biologist finds a project would have no effect on any federally listed, threatened, or endangered species or designated critical habitat, or any species proposed for Federal listing or proposed critical habitat.

The level of consultation is influenced by the degree of impact. For projects that may affect but are not likely to adversely affect federally listed, threatened, or endangered species or designated critical habitat, or species proposed for Federal listing or proposed critical habitat, informal consultation can be conducted relatively quickly. For projects that may have an adverse effect, regulatory agencies must issue a biological opinion.

In some cases, programmatic consultation has been conducted which would negate the need for consultation on an individual project.

## **Riparian Areas**

If danger trees are to be removed within a riparian area, water-quality best-management practices (BMP) and monitoring may be required. Some water courses are listed as water-quality limited and may have special mitigation requirements.

Other areas are considered key watersheds or priority watersheds, which may influence project design or documentation requirements.



***Scenic roadside overlooks, such as this one near Mt. St. Helens, may require special consideration when treating danger trees.***

## Effects on Heritage Resources

Consultation with State Historic Preservation Offices (SHPO) and/or consultation with tribal governments may be required. In some cases, there has been programmatic consultation with SHPO which negates the need for consultation on an individual project.

## Land and Resource Management Plans and Special Management Areas

Some places may require special consideration, for instance, older forest-management areas, wild and scenic river corridors, research natural areas, botanical areas, and scenic overlooks.

## Tree Defect and Disease Identification

It is important to be able to identify diseases and defects that affect tree-failure potential (Tables 5 and 6). Detailed information about disease and defect identification in Oregon and Washington forests can be found in *Field guide to the common diseases and insect pests of Oregon and Washington conifers* (9).

**Table 5. Important tree diseases and their chief conifer host-species groups (resinous and non-resinous) associated with danger trees in Oregon and Washington**

	Douglas fir	True fir	Hemlock	Spruce	Pine	Larch	Cedar	Juniper
<b>Resinous</b>	X			partial	X	X		
Root Rots								
Armillaria	X	X	X	X	X			
Black stain	X				X			
Heterobasidion		X	X		X			
Laminated	X	X	X					
P.O. cedar							X	
Butt Rots								
Ganoderma			X					
Schweinitzii	X			X	X	X		
Toментosa				X				
Heart Rots								
Brown top	X							
Brown trunk	X		X		X	X		
Cedar pecky							X	
Heterobasidion		X	X					

	Douglas fir	True fir	Hemlock	Spruce	Pine	Larch	Cedar	Juniper
Heart Rots								
Pencil							X	
Juniper pocket								X
Red ring	X	X	X	X	X	X		X
Rust-red stringy		X	X					
Sap rots								
Brown crumbly	X	X	X	X	X	X		
Gray-brown	X	X	X	X	X	X		
Cankers								
Atropellis					X			
Comandra rust					X			
Cytospora		X						
Mistletoe	X	X	X		X	X		X
Red ring rot		X						
Western gall rust					X			
White pine blister rust					X			

**Table 6. Important tree diseases and their chief hardwood host-species groups associated with danger trees in Oregon and Washington**

	Alder	Aspen	Cottonwood	Maple	Madrone	Myrtle	Oak	Tanoak
Root Rots								
<b>Armillaria</b>	X	X	X	X	X	X	X	X
<b>Heterobasidion</b>					X			
Butt Rots								
<b>Ganoderma</b>		X	X			X	X	
Heart Rots								
<b>Aspen trunk</b>		X						
<b>Hardwood trunk</b>			X	X	X		X	
Sap rots								
<b>Brown crumbly</b>	X	X	X	X	X	X	X	X
Cankers								
<b>Cytospora</b>		X						
<b>Mistletoe</b>							X	
<b>Nectria</b>		X						
<b>Ramorum</b>								X

Tree condition and visible indicators often determine failure potential. There are several factors that should be included in that evaluation. Following is a presentation of significant disease and defect indicators in Oregon and Washington.

## **Dead Trees**

Tree-failure potential increases proportionately with the number of years a tree has been dead as sap-rotting fungi decay the roots, boles, and tops of dead trees. This decay process is slower for resinous species such as Douglas-fir, pine, and larch, because resin (pitch) inhibits fungal growth and insect attack (Table 5). Decay is also slower in cedar and juniper that have decay-inhibiting compounds in their wood. Decay is much faster in the sapwood than in the heartwood of dead trees. Heartwood also has compounds that inhibit decay by some sap-rotting fungi. Smaller dead trees, tops, and branches with proportionately more sapwood decay faster than larger dead trees or tree parts with proportionately more heartwood. This information is based on observed fall-down rates and decay of dead trees and tops by species and size classes (17, 18).

Recently killed trees often retain all or some of their foliage and fine branches (Table 1). Bark remains mostly intact except maybe for thin-barked species such as lodgepole pine. Trees that have been dead five or more years, usually have no foliage or fine branches. Bark is often absent or beginning to slough off.

For a recently (<5 years) fire-damaged tree, where green needles may still be present, inspect the cambium at the root collar to determine if it is alive or dead. For most species, a tree is considered dead, even if the crown is green, when at least three of the four quadrants around the base of the root collar have cambium, inner bark, or phloem that are discolored and dead. Large ponderosa pines are considered dead only after all four quadrants of the cambium and inner bark are dead (12).

## **Root Defects**

### **Root Diseases**

Root diseases or root rots often cause a tree to fail. Sites with root rots will have danger-tree problems for decades unless properly treated, because these diseases can remain on the site for hundreds of years and spread slowly through the forest. Root diseases are difficult to diagnose, and a forest pathologist may need to be consulted.

- **General symptoms and indicators:**

- Decline of the entire live crown is characterized by yellowing foliage, dying branches, premature shedding of older needles, and terminal and lateral shoot-growth reduction (Fig. 12).
- Distress-cone crops may be present.
- Basal resin flow (Fig. 14) or bark staining may be present.
- Mushrooms or conks often occur on the roots or at the root collar of infected trees (Fig. 17).
- Windthrow of surrounding trees generally is present (Fig. 13).
- Groups or pockets of trees are often affected with dead and dying trees of various sizes and levels of decay on the site.
- Bark beetles often attack trees stressed by root disease.

Important root diseases commonly associated with danger trees include:

- **Armillaria root disease** caused by *Armillaria* spp.
  - Armillaria root disease is caused by several species of *Armillaria*, but *Armillaria ostoyae* is the most damaging.



**Fig. 12** – Dead and dying trees often are caused by root disease.



**Fig. 13** - Windthrow is often associated with root disease.

- Armillaria affects many tree species (Tables 5 and 6) and is often found on weakened and stressed trees.
- Root decay may be extensive; trees with Armillaria root disease should not be considered wind firm.
- Unlike laminated root rot, Armillaria-killed trees most often die standing.
- Trees adjacent to a disease center may not show symptoms of infection.
- Infected trees may have abundant resin flow or bark staining at the root collar (Fig. 14).
- White, latex-like, mycelial fans often are found under the bark of infected roots and at the root collar (Fig. 15).
- Rhizomorphs or fungal “shoestrings” that resemble small, black roots, may be present under the bark or on infected roots.
- Honey-colored mushrooms may be found at the base of infected trees in the fall.
- Advanced decay is yellow, stringy, and water-soaked.
- **Tree-failure potential** varies with the presence of disease signs and symptoms and evidence of adjacent, windthrown trees with root disease (Table 1).



**Fig. 14** - Resin flow at the root collar often is associated with Armillaria root disease.



**Fig. 15** - Mycelial fans of the fungus, *Armillaria ostoyae*, under the bark of an infected Douglas-fir.

- **Black stain root disease** caused by *Leptographium wagneri*
  - Black stain root disease kills all ages of **pine** east of the Cascade crest and young **Douglas-fir** west of the Cascades.
  - The disease causes a vascular wilt and is not a wood decayer.
  - Trees rarely fail until after they die.
  - A characteristic sign at the tree base is a brown to purplish-black stain in older sapwood that fades with time in dead trees.
  - Black stain root disease often is associated with soil disturbance along roads and with soil compaction.
  - The disease is spread by root grafts and root-feeding insects that are attracted to stressed trees.
  - Live trees in black stain root disease centers have **low-failure potential**; dead trees have **imminent-failure potential** (Table 1).
  
- **Heterobasidion root disease** caused by *Heterobasidion* spp.
  - Heterobasidion root disease, formally called annosus root disease caused by *H. annosum*, is especially damaging to **grand fir**, **white fir**, and **hemlock**.

- Two species of *Heterobasidion* are now recognized: *H. occidentale* on true firs and hemlocks and *H. irregulare* on pines.
- It is one of the most difficult root diseases to identify.
- Infected trees may exhibit symptoms of root disease or they may not have symptoms if the decay is confined to the butt and lower bole (common in hemlock and spruce).
- Conks are perennial with woody or leathery, dark- to chestnut-brown, upper surfaces; white, pore-less margins; and creamy-white undersurfaces with small, round, regular pores (Fig. 17). Conks may appear as small pustules on roots.
- Conks may be found above ground in old stumps or in root crotches of living trees, or below ground on portions of roots in the duff layer or upper reaches of the soil.
- Incipient decay is a light-brown to reddish stain in the outer heartwood.
- Advanced decay is white and stringy (Fig. 16) to laminated in true fir. Elongated pits occur only on one side of the laminations. Setal hyphae are not present in the infected wood.
- Black flecks the size of rice grains may be observed in the advanced decay.
- In western hemlock, a water-soaked pattern occurs with the advanced decay.



**Fig. 16** - White, stringy decay associated with *Heterobasidion* root disease in a hemlock stump.



**Fig. 17** – Conks associated with *Heterobasidion* root disease

- Root and butt decay predispose trees to windthrow and stem breakage.
- **Failure potential** varies with the presence of disease signs and symptoms and evidence of adjacent, windthrown trees with root disease (Table 1).
- **Laminated root rot** caused by *Phellinus sulphurascens*
  - The pathogen was formerly called *Phellinus weirii* which now is the name of the causal agent of laminated root rot of cedars.
  - Primary hosts are **Douglas-fir, white/grand fir, and mountain hemlock.**
  - **Laminated root rot is the most dangerous root disease associated with tree failure in the Pacific Northwest.**
  - The disease can readily affect even the healthiest trees in the stand and often causes green trees to fail due to extensively decayed root systems (Fig. 13).
  - Laminated root rot is distinguished from other root diseases by the presence of red, setal hyphae in the decayed wood or in mycelium that, with a hand lens, look like tiny, reddish whiskers (Fig. 19).



**Fig. 18** - Laminated decay caused by *Phellinus sulphurascens*



**Fig. 19** - Setal hyphae, the red-brown, fuzzy material shown here, are diagnostic for laminated root rot.

- Decayed wood is laminated with pitting on both sides of the laminations (Fig. 18).
  - Mycelium on the surface of infected roots, called ectotrophic mycelium, can be found on live and recently killed trees.
  - Conks are difficult to find and occur infrequently on the undersides of infected roots or logs.
  - Root disease pockets can be small to several acres in size characterized by abundant windthrow with almost no roots (root balls) (Fig. 13).
  - Trees adjacent to an infection center may not show symptoms of infection, making them difficult to rate for failure potential.
  - **Failure potential** varies depending on tree species and distance from adjacent, infected trees or stumps (Table 1).
- **Port-Orford-cedar root disease** caused by *Phytophthora lateralis*
    - This is an introduced disease and has caused widespread mortality of **Port-Orford-cedar** (POC) throughout its native and ornamental range.
    - The disease typically causes a cinnamon-colored stain in the inner bark of roots and lower stems.
    - The disease is common along roads, watercourses, and in poorly drained areas.
    - Live trees in POC root disease centers have **low-failure potential**; dead trees have **likely failure potential** (Table 1).



**Fig. 20** - Undermined and severed roots, as seen here, can result in tree failure.

## Undermined or Severed Roots

- Root disturbance often is seen as undermined or severed roots (Fig. 20).
- A compromised root system predisposes a tree to fall.
- Undermined roots often are associated with roads or are adjacent to streams or rivers.
- The result of extreme undermining is tree failure from insufficient anchorage.
- **Failure potential** varies with the amount of structural roots remaining in the ground (Table 1).

## Lower-Trunk (Butt) Defects

### Butt Rots

Butt rots often result in tree failures. Sites with butt rots may have danger-tree problems for decades unless treated, because, like root disease, butt rots may persist in infected trees for decades. Butt rots are difficult to diagnose, and a forest pathologist may need to be consulted.

- **General symptoms and indicators:**
  - Butt rot often occurs without causing crown symptoms.
  - Mushrooms or conks may occur on the roots, at the root collar, or at the base of infected trees (Fig. 21).
  - Windthrow or wind-shatter of surrounding trees is generally present.
  - Groups or pockets of trees may be affected but usually only individual trees are decayed.
  - The incidence of butt rot sometimes increases with the amount of tree wounding.

Important butt rots commonly associated with danger trees include:

- **Ganoderma root and butt rot** is caused by *Ganoderma tsugae* (lacquer fungus or varnish conk) or *G. applanatum* (artist's conk)
- Ganoderma root and butt rot affects many conifer and hardwood species but is more common in hardwoods, especially Oregon myrtle.



**Fig. 21** - Ganoderma root and butt rot is associated with the artist's conk, as seen on this infected stump.

- The rot occurs in wounded, live trees and dead or broken trees.
  - The artist's conk has a dark, upper surface and a white underside that stains brown when marked (Fig. 21).
  - The varnish conk has a shiny, brown, upper surface; white underside; and often a stem or stalk.
  - The decay associated with both conks is a white, spongy rot with black flecks.
  - **Failure potential** varies with the amount of butt decay and the presence of disease signs and symptoms (Table 1).
- **Schweinitzii root and butt rot** caused by *Phaeolus schweinitzii* (velvet-top or cow-pie fungus).
    - This root and butt rot affects many tree species. However, it is found primarily on large, old **Douglas-fir** and **Sitka spruce**.
    - Fresh fruiting bodies are velvety to the touch and have a brightly colored, yellow margin. As they age, they become brittle and turn dark brown (Fig. 22).

- Trees with rot may have fruiting bodies growing on or near the butt.
- While conks may be absent, trees with extensive decay may have pronounced butt swell (Fig. 23).
- On the westside of the Cascade Range, butt decay may be indicated by fruiting bodies or swollen butts, but these indicators are not reliable to determine the amount of decay. Use these indicators to look for other indicators of severe decay such as open cracks or exposed rot (Table 1).
- On the eastside of the Cascade Range, Schweinitzii root and butt rot may be common, but it is often present without indicators, especially on dry sites. As such, it is discovered less often until significant wind events and tree failures have occurred or cause the trunk to crack.
- Decay of the butt extending as much as 30 feet up the bole occurs when trees are >50- years old.
- Trees with extensive butt rot often fail under high-wind conditions, leaving a characteristic barber-chair and shattered butt.
- Once trees with fruiting bodies have been identified or butt swell recognized, those susceptible trees immediately adjacent to them also should be evaluated.
- Tree mortality is unusual unless associated with Armillaria root disease.
- **Failure potential** varies with the amount of butt decay and the presence of disease signs and symptoms (Table 1).



**Fig. 22** - Older conks of *Phaeolus schweinitzii* often resemble “cow pies”.



**Fig. 23** - Butt swell of Douglas-fir often is associated with root and butt decay caused by *Phaeolus schweinitzii*.

- **Tomentosus root and butt rot** caused by *Onnia tomentosa*
  - The fungus that causes the disease was formerly named *Inonotus tomentosus*.
  - Tomentosus root and butt rot is found most commonly in **Engelmann spruce** (Fig. 24).
  - It typically does not cause extensive damage but is locally important in the Cascade and Blue Mountains.
  - This disease may be difficult to detect, even in trees with extensive butt rot.
  - Trees with crown symptoms rarely occur and make the disease difficult to detect.
  - Mushrooms are small, cinnamon-colored, leathery, and may appear in the fall near the base of infected trees (Fig. 25).
  - When infected trees are mature, they are more likely to be severely rotted in the roots and butt.
  - Advanced decay is a white pocket rot.
  - **Failure potential** varies with the amount of butt decay and the presence of disease signs and symptoms (Table 1).



**Fig.24** – Wind-shattered spruce caused by *Onnia tomentosa*.



**Fig. 25** - Mushrooms of the causal fungus, *Onnia tomentosa*.

## Fire-Caused Damage

- Tree roots, boles, or limbs may be so badly burned that portions of them are missing which may cause the tree or limb to break and fall (Fig. 26).
- Root systems may be damaged by fire, and the entire tree may fall.
- Before burning, a tree may have had signs or symptoms, such as conks, frost-crack weeping, basal resinosis, or dead tops that may have burned, thus eliminating the indicators of root disease, heart rot, or previous dead tops. Therefore, the tree may be more unstable than the visible indicators suggest.
- Large pines, larch, or Douglas-fir with old, basal, fire scars may have compensated for any defect or decay by increasing their butt diameter; such trees rarely fail.
- Fire-damaged trees may still have green crowns but dead cambiums at their base, essentially a dead tree (12).
- Long-lasting and smoldering fires at the bases of large pines usually kill the fine roots and eventually the entire tree.
- **Failure potential** is determined by tree species (resinous or non-resinous), the amount of sound-wood remaining, and time since tree death (Table 1).



**Fig. 26** - Fire-damaged trees have failure potentials that depend on the amount of sound wood remaining. This pine has imminent-failure potential.

# Bole (Trunk) Defects

## Wounded Live Trees

Tree wounds are injuries that break the bark of the bole or branch (Fig. 27). Wounds occurring on live tree roots and root collars can result in root disease. Tree wounds are caused by a variety of factors: vehicles, people, falling trees or rocks, weather, fire, animals, or insect attack. New wounds on living tree boles, especially large, deep wounds, can be entry points for stem decay or canker-causing fungi. Wounds on true firs can activate dormant spores of decay fungi, such as the Indian paint fungus (p. 92). Wounds on non-resinous tree species (Table 1) generally result in more decay than do wounds on resinous species. Fresh wounds on Douglas-fir or ponderosa pine often are covered with resin.

After a live tree is wounded, the wood-infecting microorganisms may be confined to compartments within the tree through a process called compartmentalization (19). New wood formed annually after the wound occurs is relatively free of decay-causing micro-organisms, unless another wound occurs. The infected wood within the compartments may eventually become a decayed or hollow cylinder surrounded by healthy-appearing wood. This healthy-appearing wood is referred to as the sound rind, and its thickness determines the failure potential of the affected tree (see appendix, p. 115). A wounded tree with a sound-rind thickness <20% of the tree's diameter inside bark has imminent-failure potential. Over time, the tree may seal the wound with new wood resulting in a scar. The rate of wound sealing is a function of tree-growth rate and vigor. The decay process in live trees generally is very slow, and it may take decades for freshly wounded trees to form decay columns that result in a minimum sound-rind thickness (p. 115, 117).

**Sound-rind thickness measurements** are routinely taken on danger trees in developed sites to determine failure potential but are not commonly taken during roadside or work site evaluations. Determining sound-rind thickness of potential danger trees should be done, if necessary, at places



**Fig. 27** - Tree bole with an open wound exposing the sapwood.

along roads or at work sites where people congregate for  $\geq 15$  minutes (i.e. scenic vistas, school-bus stops, log landings, buildings, etc.). Sound-rind thickness usually is measured with an increment borer or electric drill at three or more places on the trunk and averaged. Refer to the Appendix, p.115, 117, for sound-rind-thickness tables for wounded and unwounded trees. Trees with sound-rind thickness below minimum values have imminent-failure potential.

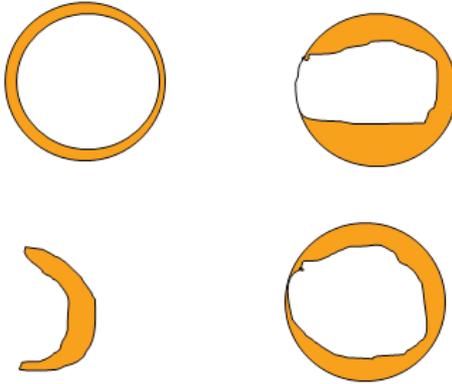
## Fungal and Mistletoe Cankers

Fungal cankers frequently occur on the boles of pine species, especially ponderosa and lodgepole pines.

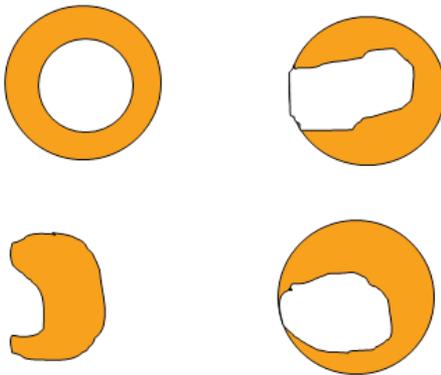
- **General symptoms and indicators:**

- Canker fungi cause top-kill, branch death, and stem malformation (Fig. 29).
- Stem malformations increase stem breakage and can be decayed by other fungi.
- Mistletoe cankers are caused by dwarf or true mistletoe infection of the bole (Fig. 31). Cankers are especially common on grand and white fir, western and mountain hemlock, white oak, and occasionally western larch.
- Mistletoe cankers can become decayed and result in tree failure.
- Non-resinous tree species, such as true fir, hemlock, spruce, or hardwoods with cankers or wounds, are more likely to fail than resinous species.
- Douglas-fir, cedar, pine, and larch are less likely to fail because of resin-impregnated or decay-resistant wood.
- Resinous wood around bole cankers and wounds usually remains sound.
- **Failure potential** does not significantly increase until the face of the canker is deeply sunken, and the cross-section of the bole with sound wood is below a critical threshold (Fig. 28, Table 1).

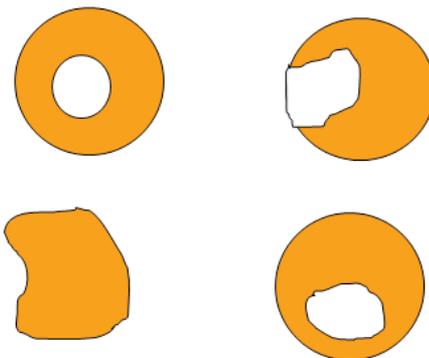
<50% bole cross-section is sound



50 to 75% bole cross-section is sound



>75% bole cross-section is sound



**Fig. 28** - Various bole cross-sectional areas showing percentage of sound-wood remaining. For non-resinous species, <50% of the bole with sound wood would have imminent-failure potential (Table 1).

Important cankers associated with danger trees in Oregon and Washington include:

- **Atropellis canker** caused by either *Atropellis piniphila* or *A. pinicola*
  - This canker frequently appears on the boles of pines, especially **lodgepole pine**.
  - Resinous wood around these cankers usually remains sound, and failure potential does not significantly increase until cankers become old, long, and wide, and the face of the canker is deeply sunken relative to what would have been the normal bole circumference at that point (Fig. 29).
  - When the cankers result in <25% cross-section of the bole with sound wood, **failure potential is imminent** (Table 1).
  - Tree failure is most likely to occur in heavily infected stands where trees have multiple cankers or two or more cankers at the same height.



**Fig. 29** - Atropellis canker is a common disease of lodgepole pine that can result in tree failure.

- **Comandra blister rust** caused by *Cronartium comandrae*
  - Occurs on **ponderosa pine** and occasionally lodgepole pine in Oregon and Washington.
  - Mortality can occur, especially in young, infected trees.
  - Large, infected pines often have dead tops that progressively die back from the top of the tree (Fig. 30).
  - Infected and dead tops are relatively decay resistant because of the copious resin associated with infection.
  - These dead tops have **low-failure potential**, even after several years, and rarely fail.
  - All dead tops should be examined carefully for open cracks, conks, cavities, or other defects that indicate higher failure potential.



**Fig. 30** - Dead tops of ponderosa pine, caused by Comandra blister rust, are often resin-soaked, decay-resistant, and therefore of low-failure potential.

- **Cytospora canker** caused by *Cytospora chrysosperma* on hardwoods and *C. abietis* on **true firs**
  - Cankers occur on boles, branches, and twigs and form elongated areas of dead wood within well-defined borders.
  - Several years after infection, dead bark lifts away from the bole and sloughs off.
  - When the canker results in <50% cross-section of the bole with sound wood, **failure potential is imminent** (Table 1).
  
- **Mistletoe cankers** caused by dwarf mistletoe (*Arceuthobium* spp.) infection, and true mistletoe (*Phoradendron* spp.) infection
  - Dwarf mistletoe-bole infections are especially common on **grand/white fir, western hemlock, and western larch** (Fig. 31).
  - True mistletoe-bole and branch infections are common on **oaks** (Fig. 32), incense-cedars, and junipers.
  - While bark and cambium tissues are still alive in the area of the initial swelling, boles and branches are not often significantly weakened, and failure potential is very low.
  - In time, however, the cambium and overlying bark in the oldest part of the swelling die and form a canker that is subsequently decayed by opportunistic fungi and attacked by wood borers.
  - Any of the fungi that function as wound parasites can decay mistletoe-induced bole cankers.
  - **Failure potential** varies depending on tree species and the amount of sound-wood remaining at the canker (Table 1).
  
- **Nectria canker** caused by *Nectria cinnabarina*
  - Nectria canker occurs on many hardwood species.
  - Sunken cankers are associated with wounds or develop at the base of dying branches.
  - Cankers can girdle and kill stems, and when bark dies, it appears dry and cracked with age.
  - When the cankers result in <50% cross-section of the bole with sound wood, **failure potential is imminent** (Table 1).



**Fig. 31** - Dwarf mistletoe-bole infections are especially common on grand and white fir, hemlock, and larch.

**Fig. 32** - True mistletoe-bole and branch infections can cause cankers and decay in oaks.

- **Ramorum canker** caused by *Phytophthora ramorum*
  - The causal agent, a fungus-like water mold, was introduced into southern Oregon around 2000.
  - Ramorum canker is also called sudden oak death.
  - This disease causes significant mortality of **tanoaks** in Oregon; Oregon white oak is not affected.
  - Ramorum canker is mentioned in the context of danger trees not so much for the bole canker that it causes, but because of the relatively rapid death of its principal host in Oregon, tanoak (Fig. 33).
  - Although other tree species can serve as foliar hosts in the PNW: maple, madrone, myrtle, redwood, and Douglas-fir, none of these species has had bole cankers or have been killed, as yet, by the causal agent in Oregon or Washington.
  - Infected trees are rapidly colonized by decay fungi, and trunk failures can occur even before trees die.
  - Recently infected and dead tanoaks have **imminent-failure potential**.



**Fig. 33** - Ramorum canker, as seen here, is an introduced disease that kills tanoak in southwest Oregon.

- **Red ring rot canker** caused by *Porodaedalea cancriformans*
  - The former name of the causal fungus was *Phellinus cancriformans*.
  - This disease occurs in southwestern and west-central Oregon on **true firs** (Table 5).
  - The conks of the fungus are small and numerous with their upper surfaces being rough, dark, and furrowed (butterfly conks).
  - The conks closely resemble *P. pini* conks (p. 90) but are smaller and occur in groups.
  - The conks grow from a sunken area on the trunk with decayed wood beneath (a canker).
  - Substantial amounts of stem breakage are associated with this fungus.
  - When cankers result in <50% cross-section of the bole with sound wood, **failure potential is imminent** (Table 1).
  
- **Western gall rust** caused by *Endocronartium harknessii*
  - This rust is common on **lodgepole** and **knobcone pines**.

- The disease can be found on **ponderosa pine**, especially near water courses.
- The disease causes branch flagging, bole breakage, topkill, and mortality of young trees.
- The galls are small to large, round to pear-shaped swellings on branches and boles.
- “Hip cankers” result when the main stem flattens and broadens as it grows around bole infections (Fig. 34).
- When stem failures occur, they typically happen directly above the canker near the intersection of the deformed wood and normal wood (Fig. 34).
- Trees with galls on the main stem or “hip cankers” develop progressively and increase the tree’s failure potential as the percentage of sound wood in the bole decreases.
- When the cankers result in <25% cross-section of the bole with sound wood, **failure potential is imminent** (Table 1).



**Fig. 34** - Lodgepole pine with western gall rust can break if the stem cross-sectional area of sound wood falls below a critical threshold, as in this tree on the right.

- **White pine blister rust** caused by *Cronartium ribicola*
  - This rust is found throughout the range of **5-needle pines** in Oregon and Washington.
  - The causal fungus causes branch flagging, top-kill, and death usually of pines <8 in. dbh (Fig. 35).
  - Mountain pine beetles often attack larger and older, infected trees.
  - After needle infection in the spring, spindle-shaped swellings form on branches. Bright, yellow-orange pustules (aecia) with aeciospores are produced from raised blisters on the bark.
  - Cankers result in dead, roughened bark that has margins that appear greenish-yellow to orange.
  - Heavy pitch flow often occurs with bole cankers.
  - Infected, dead tops and branches are relatively decay resistant because of the copious resin associated with infection.
  - Blister-rust-killed tops and branches have **low-failure potential**, even after several years and rarely break and fall.
  - All dead tops should be examined carefully for open cracks, conks, cavities, or other defects that indicate higher failure potential.



**Fig. 35** - Tree tops killed by white pine blister rust are often resin-soaked with little decay and have low-failure potential.

## Burls

- Burls are abnormal swellings on stems and branches (Fig. 36).
- Usually, burls are composed of sound wood and indicate **low-failure potential**. (Table 1).
- Burls vary in size up to several feet in diameter.
- Their cause is mostly unknown, but burls are common among high-elevation lodgepole pine and subalpine fir or low-elevation maples and other hardwoods.
- When high in the tree or covered with moss or lichens, burls sometimes resemble conks and therefore require careful examination with binoculars.



**Fig. 36** - Burls are often large, woody growths of unknown cause that sometimes resemble conks but indicate low-failure potential.

# Cracks and Structural Defects

- Cracks and structural defects in the main stem may cause a tree or its parts to fail.
- Dangerous cracks show movement of the wood on either side of the crack and have **imminent-failure potential** (Table 1).
- Open cracks may be associated with substantial decay.
- Cracks and defects with significant decay are more likely to fail.
- Cracks form by tension and compression failure when trees with extensive heart rot bend back and forth under the stress of high winds. The result is a vertical crack in the bole between the ground and where the heart rot is greatest.
- Cracks may be formed by lightning strikes. Damage from lightning can be highly variable, ranging from shallow, spiraling furrows that just penetrate the bark, to cracks that may be several inches wide and penetrate deep into the wood.
- Under the influence of frequent high winds, trees often develop shake or separations in the lowest section of the butt. The twisting action of the wind first causes separations to develop along the growth rings.
- Frost cracks are formed by the action of extreme cold (Fig. 37).
- Frost cracks appear on bark as raised, nearly vertical, callus lines that extend to the ground where frosty air is coldest.
- Frost cracks begin at the tree base, usually from an old wound, and seldom go higher than 5 feet up the bole.
- Healed frost cracks that are not weeping seldom result in tree failure and have **low-failure potential** (Table 1).
- Frost cracks that are weeping have **likely failure potential** (Fig. 37).



**Fig. 37** - Frost cracks often indicate low-failure potential, unless they are weeping, as shown here, then failure potential is likely.

## Heart Rots

Heart rots, also known as stem decays, occur in living trees and may compromise bole integrity leading to tree failure.

- **General symptoms and indicators of heart rot**
  - Old injuries to a tree may have resulted in internal decay.
  - Larger wounds, wounds that are in contact with the ground, and older wounds are often associated with a greater amount of decay.
  - Resinous tree species are less prone to decay than non-resinous species (Table 5).
  - Heart rots are most abundant in mature and old-growth trees, regardless of their size.
  - Trees with wounds opening to the outside have a much greater potential for failure than trees having equivalent rinds of sound wood but no open wounds.
  - Heart-rot fungi generally need an opening to the heartwood to invade the host. Entry points can be old wounds, branch stubs, or fire scars.
  - When heart rot is extensive within the bole of a tree, it may be indicated by conks, punk knots, or other indicators (Fig. 38).



**Fig. 38** - Heart rots compromise tree stability by reducing the amount of sound rind, as seen here in this wounded spruce that had a *Fomitopsis pinicola* conk at its base.

- Cavity excavation by woodpeckers may indicate heart rot in the tree (Fig. 44).
- The presence of carpenter ant or termite activity can indicate heart rot, especially in wounded trees.
- Heart rots may be present when there are few or no external indicators, making identification difficult.
- Trees with split boles or open or bleeding, frost cracks are likely to have extensive decay (Fig. 37).

Important heart rots associated with danger trees in Oregon and Washington include:

- **Aspen trunk rot** caused by *Phellinus tremulae*
  - This heart rot is found only in **quaking aspen**, but a related heart rot, hardwood trunk rot (p. 87), affects many hardwood species.
  - Conks are perennial, hard, woody, and generally triangular-shaped (Fig. 39).
  - Incipient decay has a yellow-white zone in the heartwood and is usually surrounded by a yellow-green to brown margin.
  - Advanced decay is soft and yellow-white with fine, black, zone lines.
  - **Failure potential** varies depending on the presence of conks and evidence of extensive decay such as open cracks or exposed rot (Table 1).
  
- **Brown top rot** caused by *Fomitopsis cajanderi* (rose-colored conk)
  - This heart rot affects most conifers and causes a brown-cubical heart rot in living trees, especially **Douglas-fir**.
  - It is found often in trees with substantial top damage.
  - Conks are perennial, woody, bracket-like to hoof-shaped with pink to rose-colored undersurfaces and inner tissue. The upper surface is brown to black and usually cracked and rough.
  - Early wood decay is a faint brownish or a yellow-brown stain, sometimes with greenish-black zone lines.
  - Advanced decay is yellow to reddish-brown, soft, and with irregular cubes. Thin, mycelial felts may be present in cracks between the cubes.



**Fig. 39** - Conk of *Phellinus tremulae* indicates internal decay in this aspen.

- The amount of decay is proportional to the diameter of the broken stem.
- **Failure potential** varies depending on the presence of conks and evidence of extensive decay such as open cracks or exposed rot (Table 1).



**Fig. 40** - Advanced decay caused by *Laricifomes officinalis* is a brown-cubical rot.

- **Brown trunk rot** caused by *Laricifomes officinalis* (quinine conk or the chalky fungus).
  - Several conifer species are affected, and infection often results in severe stem decay.
  - The fungus, formerly called *Fomitopsis officinalis*, enters through trunk wounds or basal, fire scars.
  - Conks are rare but unmistakable. They are hard, perennial, hoof-shaped to pendulous, and often quite large (1 to 2 ft. long) (Fig. 41).
  - Conks have a chalky white to grayish-upper surface. Pores are round, and the under surface of the conk is chalky white.
  - The interior of most conks is soft and crumbly.



**Fig. 41** - Quinine conk of *Laricifomes officinalis* indicates considerable stem decay, as seen in Fig. 40.

- Conks develop at branch stubs, over old wounds, or at old, top breaks.
  - Punk knots may occur at large, older, branch stubs that have usually rotted and fallen off. Punk knots often exude a yellowish-brown material that stains the bark.
  - A single conk indicates severe stem decay.
  - Decay is a dry, brown-cubical rot with thick, white, mycelial sheets in the decay shrinkage cracks (Fig. 40).
  - Trees with one or more conks have **imminent-failure potential** (Table 1).
- **Hardwood trunk rot** caused by *Phellinus igniarius* (false-tinder fungus)
    - This rot occurs in many hardwood species (Table 6).
    - Conks are perennial, woody, and generally hoof-shaped.
    - The upper surface of the conk is gray-black to black and rough when old (Fig. 42). The under surface is brown with small, regular pores.
    - Early decay has a yellow-white zone in the heartwood and is usually surrounded by a yellow-green margin.
    - Advanced decay is soft and yellow-white with fine, black, zone lines.
    - **Failure potential** varies depending on the presence of conks and evidence of extensive decay, such as open cracks or exposed rot (Table 1).



**Fig. 42.** Conk of *Phellinus igniarius* on a decayed hardwood.

- **Heterobasidion stem decay** caused by *Heterobasidion occidentale*
  - The fungus that causes Heterobasidion root disease (p. 62) also can cause decay in the trunks of infected trees, especially **true firs** and **hemlocks**.
  - In western Washington and Oregon, the fungus more commonly causes a butt decay rather than causing root disease centers.
  - Infection occurs by airborne spores through trunk wounds.
  - Butt and stem decay predispose trees to windthrow and stem breakage.
  - **Failure potential** varies depending on the amount of sound-wood remaining at the site of the wound (Table 1).
  
- **Incense-cedar pecky rot** caused by *Oligoporus amarus*
  - This heart rot is very common in *mature incense-cedar*, especially trees >40-inches dbh, and trees with basal wounds or old, dead limbs.



**Fig. 43** – A conk of *Oligoporus amarus* on this incense-cedar indicates internal decay but low-failure potential.

- Tree failure is not common even with advanced decay.
  - Decay is not limited to the butt log; it may occur along the entire length of the bole.
  - In severely damaged trees, most of the heartwood is decayed.
  - Conks occur rarely and indicate a decayed tree. Conks are annual and fruit at knots in summer or autumn.
  - Conks are hoof-shaped to half-bell shaped, tan to buff-colored on the upper surface, bright sulfur-yellow on the underside with small tubes that exude clear drops of a yellow liquid (Fig. 43).
  - Insects, birds, and squirrels destroy conks, leaving a “shot-hole cup” that is apparent at and below the knot where a conk was attached.
  - Large, open knots or branch stubs indicate decay.
  - Woodpecker activity indicates old, conk locations and decayed trees.
  - Unless there are other failure indicators, living trees with conks have **low-failure potential**.
- **Juniper pocket rot** caused by *Pyrofomes demidoffii*
    - This heart rot only affects juniper and is the major cause of decay in living junipers, especially old trees.
    - The upper surface of the woody, hoof-shaped conk is dark brown to black. The lower pore surface is light brown.
    - Advanced decay has numerous, large pockets that are lined with yellow-white fibers that join to form a stringy rot.
    - **Failure potential** varies depending on the presence of open cracks and exposed decay in the bole (Table 1).
  - **Redcedar pencil rot** caused by *Postia sericiomollis*
    - This heart rot only affects **western redcedar**, and the decay is usually confined to the lowest 40 feet of the trunk.
    - Conks are annual, thin, flat, white crusts that are not common.

- Advanced decay is a brown-cubical, pocket rot that appears as long, thin pencils of brown-cubical decay.
  - Decayed trees are often used by cavity-nesting birds, and the cavities are a good indicator of advanced decay (Fig. 44).
  - **Failure potential** varies depending on the amount of sound-wood remaining near the open cavity (Table 1).
- **Red ring rot or white speck** caused by *Porodaedalia pini* (ring-scale fungus)
    - The causal fungus was formerly known as *Phellinus pini*.
    - Red ring rot is the most common heart rot of Pacific Northwest conifers affecting **Douglas-firs, pines, larches, hemlocks, true firs, and spruces.**
    - Conks are hoof-shaped with cinnamon-brown to tan, pore surfaces (Fig. 45). Pores are irregularly shaped, and the interior of the conk has the same cinnamon-brown coloration as the pore surface.
    - Conks form at branch stubs or over old knots.
    - On hemlocks especially, but occasionally on other



**Fig. 44** – Cavity (at arrow) created by birds indicates heart rot in this western redcedar.

species, conks may be abundant on the undersides of branches (“limb conk” or “butterfly conk”).

- Punk knots are common on severely decayed trees and are evidence that a conk is about to form at an old, branch stub, or that a conk was once present at the site but has since fallen off.
- Punk knots and conks indicate the same amount of decay.
- Decay is a white pocket rot that may occur in rings separated by sound wood until decay is advanced.
- Unlike other rots, wood decayed by this fungus, often called whitespeck, initially maintains some strength against failure (Fig. 46).
- Large ( $\geq 6$  in. wide) conks indicate more decay; smaller conks usually indicate less decay, unless the apparent small conks are remnants of larger conks that have fallen off.
- When trees have many large conks in close proximity, damage to the heartwood is extensive and **failure potential is likely** (Table 1).
- With few or single conks, **failure potential is low**.
- **Failure potential** also varies with tree species and visual evidence of advanced decay.



**Fig. 45** - Conk of *P. pini* often indicates only low-failure potential.

**Fig. 46** - Wood decay caused by *P. pini*, commonly called whitespeck, is relatively sound compared to wood decay caused by other fungi.



- **Rust red stringy rot** caused by *Echinodontium tinctorium* (Indian paint fungus).
  - This is the most damaging heart rot of mature **true firs** and **hemlocks** east of the Cascade crest.
  - It occurs less frequently in western hemlock west of the Cascades.
  - Trees with a single conk have as much as 40 feet of continuous decay.
  - When decay is advanced, large hoof-shaped conks with a spiny, lower surface are produced (Fig. 47).
  - Conks have a fissured, upper surface, and are rough, dull black, hard and woody.
  - The interior of the conk and the point of attachment to the tree or branch stub are rusty-red to bright orange-red.
  - Conks appear on the bole at the site of old branches and stubs.
  - Conks with weeping, frost cracks or open cracks indicate extensive decay.
  - Decay is a rust-red-stringy decay that may result in hollow stems (Fig. 48).
  - **Failure potential** varies with evidence of advanced decay and the size and number of conks on the bole (Table 1).



**Fig. 47** - Conks of the Indian paint fungus are common on true firs and hemlocks.



**Fig. 48** - Decay caused by the Indian paint fungus can result in tree failure.

## Sap Rots

- **General symptoms and indicators of sap rots.**
  - Most sap-rotting fungi cause rapid decay of dead sapwood only.
  - When these fungi have fully decayed all the available sapwood, they have completed their job.
  - Sap-rotting fungi compete poorly with other fungi and are seldom found past the heartwood/sapwood interface.
  - Sap rots can completely decay tree tops that are often all sapwood.
  - In living trees, sap rots occur on tissue killed by other agents, usually bark beetles, mechanical damage, or weather damage.
  - On dead trees, especially those killed by root diseases, fire, and/or bark beetles, sap rot is sure to occur, and the rate of sapwood decay can be rapid.
  - On some true firs and often hemlocks, sapwood is fully rotted within 2 years.
  - On other conifers, it may take as many as 3 to 5 years for sap-rotting fungi to decay all of the available sapwood.

- On living hardwoods, damage may be significant. For example, on many poplars, maples, and alders, sapwood is decayed very rapidly once it is dead, and there may be few obvious external indicators.
- **Brown crumbly rot** caused by *Fomitopsis pinicola* (red-belt conk)
  - This is the most common sap rot of dead wood and slash in Oregon and Washington
  - The fungus commonly causes a sap rot of trees and occasionally a heart rot of living trees, especially those with trunk wounds (Fig. 38).
  - Conks are leathery to woody, perennial, and bracket-shaped (Fig. 49).
  - When young, conks are white and round.
  - As the conk matures, the upper surface turns dark-gray to black, the lower surface remains white, and a conspicuous, reddish margin develops between the two surfaces.
  - Advanced decay is light reddish-brown and forms a crumbly mass of rough, small cubes with mycelial felts between the shrinkage cracks.
  - Live trees with conks and wounds usually have **likely failure potential**, but failure potential can be imminent depending on tree species and the amount of sound wood remaining at the wound.
  - Dead trees with conks have **imminent-failure potential** (Table 1).



**Fig. 49** – This conk of *Fomitopsis pinicola* is very common on dead wood and may also be found on wounded, live trees.

- **Gray-brown sap rot** caused by *Cryptoporus volvatus* (pouch fungus)
  - This is common sap rot of conifers killed by bark beetles or fire.
  - Conks are annual, leathery, and produced on trees the first year after tree death.
  - Fresh conks are small, round, initially soft and fleshy, yellow-brown to golden-brown with pore surfaces covered with a hard membrane (Fig. 50).
  - Conks bleach to dirty-white after one year.
  - When many, little, white or gray conks appear completely around the stem, the sapwood may be fully rotted.
  - Spores of the pouch fungus are spread by all major species of tree-killing bark beetles.
  - Advanced decay has gray areas that develop in the sapwood beneath the conks.
  - Live trees with conks and wounds have **low-failure potential**.
  - Dead trees with conks have **likely to imminent-failure potential**, depending on how long the tree has been dead (Table 1) .



**Fig. 50** - These pouch fungus conks can indicate considerable sap rot. Note the cream-colored new conks on the left and the dirty-white old conks on the right

# Crown Defects

## Dead tops and branches; detached tops, limbs, and bark

- Dead tops and branches can be caused by several agents including insects, dwarf mistletoe, rust fungi, animals, or weather.
- Dead tops and large branches ( $\geq 3$  in., large-end diameter) with evidence of decay are dangerous tree parts because they may break apart, fail, and cause extensive damage to structures and people (Fig. 51).
- Dead tops and branches of cedar, juniper, or larch rarely fail.
- Pine tops and branches killed by rust fungi such as white pine blister rust or comandra rust have extensive resin soaking, are very decay resistant, and do not often fail.
- Dead tops and branches killed by insects differ from rust-killed tops and branches because they are killed all at once rather than progressively, contain sap-rot fungi, and are more likely to decay and fail than rust-killed tops or branches.
- Dead tops and branches of **Douglas-fir, larch, or pine** are resinous and more resistant to failure.
- Dead tops and branches of **true fir, hemlock, spruce, or hardwoods** are non-resinous, are highly susceptible to attack by decay fungi, and are more likely to fail than other tree species.
- Dead tops without bark are more likely to fail than recently killed tops.
- The **failure potential** of dead tops depends on tree species and the amount of wood decay, which is a function of time since death (Table 1).

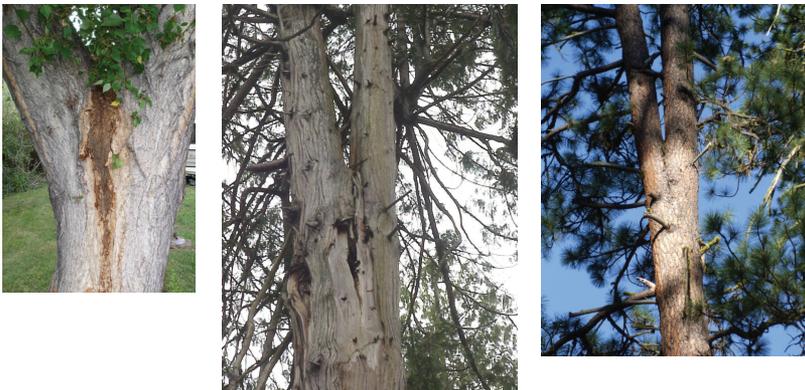


**Fig. 51** - Dead tops can be caused by many agents including dwarf mistletoe, as shown here.

- Detached tops, limbs, or bark ( $\geq 1$  ft<sup>2</sup>) often fall; are extremely dangerous; and have **imminent-failure potential**.
- Live, large branches on mature cottonwoods can fail especially if previous breakage has occurred.
- Cottonwood **failure potential** varies with the amount of visible branch decay and breakage (Table 1).

## Forked or Multiple Tops or Trunks

- Live trees with forked tops or trunks, or multiple (candelabra) tops can fail at the base of the fork.
- Forked tops with crotches that are tightly V-shaped can split and break from the green weight of foliage, heavy snow loads, wind, or internal decay. This also occurs in hardwoods with large, spreading crowns.
- Trees with forked tops or trunks should be examined for open cracks, embedded bark (Fig. 53), and mushrooms or conks that indicate weakening and predisposition to failure or infection by decay fungi (Fig. 52).
- Stem breakage often occurs in ponderosa pine at V-shaped forks with embedded bark.
- After breakage the remaining stem also may fail depending on the amount of sound-wood remaining at its base (see **bole wounds**, Table 1).



**Fig. 52** - Forked tops shown on this hardwood that are weeping and cracked (left) and this cedar with open cracks (middle) have imminent-failure potential. The ponderosa pine (right) with only embedded bark has likely failure potential.

- **Failure potential** varies with these factors (Table 1).
- Forked tops that are U-shaped are less prone to fail than V-shaped forks and therefore have low-failure potential, unless other indicators are present.



**Fig. 53** – An example of embedded bark as seen just below the forked stem.

## Dwarf Mistletoe Brooms

- Dwarf mistletoes are parasitic plants that cause branches of some tree species to become misshapen.
- These deformed branches are called witches-brooms (Fig. 54).
- Large ( $\geq 10$  ft. in diameter), dead, dwarf mistletoe brooms, especially on Douglas-fir, can become weighted with snow and ice and fail.
- Such brooms have **likely failure potential**.
- Live brooms and small, dead brooms have **low-failure potential** (Table 1).



**Fig. 54** - Live, dwarf-mistletoe brooms, even large ones as shown here on Douglas-fir, have low-failure potential.

# Whole-Tree Defects

## Wind or snow-loading

- Wind or snow-loading may increase the chances that a tree with decay or defect will fail.
- It is prudent to assume that as wind or snow-loading increases, the potential for a tree or its parts to fail also increases.

## Broken or uprooted trees supported by other trees

- Damaged roots and heart rots predispose trees to failure in the event of high winds.
- High winds, saturated soils, and soil disturbances often lead to loosening, cracking, or breaking of roots.
- All live or dead, broken or uprooted trees supported by other trees have imminent-failure potential (Table 1).

## Leaning and/or root-sprung trees

- Root-sprung trees are likely to fall because the roots are compromised by being partially pulled out of the ground.
- Root-sprung trees are dangerous and are seen as “failures in progress.”
- Tree leans are classified as recent, old, corrected, or uncorrected.
- Trees with recent (<5 years) leans  $\geq 15$  degrees may have soil and litter not in contact with the base of the tree on the side away from the lean resulting in a conspicuous gap (Fig. 55).
- Recent lean may indicate rooting problems that may cause the tree to fall.
- Cracks, mounds, or ridges of recently heaved soil may be adjacent to major lateral roots of leaning trees.
- Leaning trees  $\geq 15$  degrees should be examined for evidence of root and butt rot.
- Recently leaning trees are tilted over their entire length (uncorrected lean). Since there is no evidence of subsequent reinforcement of the root system, trees with recent leans with soil lifting and cracking have **imminent-failure potential** (Table 1).
- Recently leaning trees without soil lifting and cracking have **likely failure potential**.



**Fig. 55** - New cracks in the soil around leaning trees indicate imminent-failure potential.



**Fig. 56** - Old leans with righted or corrected tops have low-failure potential.

- Corrected leaning trees are those that are leaned over but have subsequently grown a vertical top in the time since the lean occurred (Fig. 56).
- Over time, trees with corrected leans develop tension and compression wood at stress points to aid in their support. They also often develop a reinforced root system.
- Trees with corrected leans have **low-failure potential** (Table 1).

## Height-to-diameter ratios

- Live trees with a high height-to-diameter ratio (skinny trees) may fail depending on the ratio (Fig. 57).
- These trees can break or bend permanently usually from snow or ice loading in the winter, especially if dwarf mistletoe brooms are present.
- To calculate height-to-diameter ratio, estimate the total tree height in feet and divide by the diameter at breast height (dbh) measured to the nearest foot.
- For example, a tree 100 ft. tall and 1 ft. dbh would have a height-to-diameter ratio of 100.
- Trees with a height to diameter ratio  $>100$  have **imminent-failure potential** (Table 1).



**Fig. 57** - Trees with high height-to-diameter ratios (skinny trees), such as these lodgepole pines, are more prone to stem breakage from snow, ice, or wind.

## **Insect-Caused Damage**

- Forest insects can weaken roots, stems, tops, or branches and result in fungal decay and physical degradation.
- Insects interact with fungal pathogens to cause damage or directly kill trees or their parts.
- Bark beetles are the most important insects that result in tree mortality.
- Bark beetles most commonly associated with danger trees in the Pacific Northwest include the Douglas-fir beetle, fir engraver, spruce beetle, mountain pine beetle, western pine beetle, and pine engraver.

- Bark beetles frequently attack trees that are stressed from root disease, bole damage, defoliation, or drought.
- Symptoms of bark beetle attack include boring dust, pitch streams, galleries under the bark, fading or red crowns, dead tops, or group mortality (Fig. 58).
- Wood borers are similar to bark beetles but prefer even weaker trees than bark beetles.
- Bark beetles and wood borers introduce sap-rot fungi into dying and dead trees.
- Carpenter ants and termites can severely weaken trees that are already decayed.
- The balsam woolly adelgid causes widespread mortality of subalpine fir and, in some cases, pacific silver fir and westside grand fir. Tree failure eventually may occur in infested live trees with little green-crown remaining.
- Defoliating insects, such as the western spruce budworm and the Douglas-fir tussock moth, can kill tops or entire trees.



**Fig. 58** - Bark beetle attack is often indicated by pitch flow and boring dust as seen on this infested pine

## Multiple Defects

- Trees are often encountered with two or more (multiple) defects.
- The potential for tree failure may increase dramatically with the combined effects of multiple defects.
- In the case of multiple indicators, one condition (indicator) often worsens another; they interact synergistically. Multiple indicators are in contact with each other.
- Examples of multiple defects that indicate increased potential for failure include:
  - Heart rot and cankers, stem injury, or sap rot
  - Root rot and lean
  - Cracked forks and heart rot
  - Recently killed tree and butt rot
  - Leaning trees with hollow stems (Fig. 59)



**Fig. 59** – Multiple, likely failure indicators can imply imminent-failure potential, such as this maple with hollow, leaning stems.



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***Citation example: (9, Pg 15) means page 15 in Goheen and Willhite 2006.***



***Danger-tree workshop, 2006, Wallowa-Whitman National Forest***

## Glossary

**Abiotic** - non-living parts of the ecosystem such as soil particles, bedrock, fire, air, or water

**Advanced decay** – the later stages of **decay** often characterized by a dry, crumbling or wet, wood structure

**Aecium** (pl. aecia) - specialized **spore**-producing structure formed on trees infected with rust **fungi**

**Aeciospore** - type of spore produced in an **aecium** that typically infects alternate hosts

**Alternate leaves** – arrangement of leaves in which they emerge from the stem one at a time, as contrasted with **opposite leaves** that emerge from the stem in opposing pairs

**Azimuth** – a compass reading in degrees ranging from 0° (north) to 359°

**Bark beetles** – a group of forest insects whose adults and larvae make **galleries** in the cambial region of living or felled trees; a subfamily of the Curculionidae

**Basal wound** - a **wound** at the base of a tree

**Biotic** - pertaining to the living parts of the ecosystem such as animals, plants, **fungi**, or insects

**Bole** - a trunk or main stem of a tree; seedlings and saplings have stems rather than boles

**Boring dust** – a mixture of fecal matter and wood debris resulting from chewing and tunneling by **bark beetles** and wood borers; also called frass

**Branch flagging** – a disease **symptom** where some of the foliage on branches, particularly older foliage, is dead or dying

**Branch stub** - the remnant of a tree branch after it breaks off near the trunk; often an entrance point for decay **fungi** or a site where fungal **conks** form

**Branch whorl** – a circle of branches developed from one node on a tree

**Broom** or **witches' broom** - an abnormal clustering of branches associated with infection by a **dwarf mistletoe**, **rust fungus**, genetic aberration, or other insect or **disease**

**Butt** - the base of a **bole** to a height of 8 feet

**Butt log** - the first log above the stump

**Butt rot - decay** developing in and sometimes confined to the **butt**; originating at **basal wounds** or coming up through roots

**Callus** - tissue produced at **wound** sites in response to injury that may or may not overgrow an injured area

**Cambium** - a layer of living cells between the wood (xylem) and inner bark (phloem) of a tree

**Canker** - a lesion on a stem, branch, or root; typically longer than wide; the **cambium** and cortex of which have been killed

**Canopy** - the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees

**Causal agent** - a **biotic** or **abiotic** entity that causes a deviation from the normal form or function of a tree; can be biotic entities such as fungi or insects or abiotic entities such as wind or fire

**Check** - a longitudinal fissure in wood resulting from stresses that caused wood fibers to separate along the grain

**Chlorosis/Chlorotic** - an abnormal yellowing of foliage

**Compression strength** - a measure of resistance of a body to compressive loading; the force at which failure occurs under a compressive load

**Conk** - a shelf-like reproductive structure of the type formed by many wood-decay **fungi**; also called a **sporophore** or **fruiting body**

**Crook** - an abrupt bend in a tree or log

**Crotch** - that part of the tree where the main stem or larger branches fork

**Crown** - the upper part of any tree carrying the main branches and foliage

**Cubical decay** – decayed wood that breaks into distinct cubes

**Dbh** - the **diameter** of a tree at **breast height**; breast height is defined at 4.5 feet above the ground on the uphill side of any tree.

**Decay** - degradation or decomposition of wood by **fungi** and other microorganisms resulting in the progressive loss of integrity and strength of affected parts; can be **incipient** or **advanced**

**Decay column** – generally a large section of the tree bole that is internally decayed in the shape of a cylinder or column with tapered ends; a product of compartmentalization

**Danger tree** or **hazard tree** - any tree or its parts that will fail because of a damage, defect, or disease and cause injury or death to people or property

**Defect** - any feature, fault, or flaw that lowers the strength, integrity, or utility of an affected part

**Delaminate** - to separate into sheets as with the pages of a book; wood delaminates at the growth rings; characteristic of **decay** caused by *Phellinus sulphurascens* and other **decay fungi**

**Disease** – a prolonged disturbance of the normal form or function of a tree or its parts; usually caused by organisms such as **fungi**, mistletoes, or **abiotic** agents (air pollutants) but not insects

**Disease center** - a group of dead and dying trees that have developed progressively over time; caused by root **pathogens** such as *Armillaria* spp. or *Phellinus sulphurascens*; also called a mortality center or infection center

**Distress- (stress-) cone crop** – abundant, small cones that are often produced on root diseased trees

**Drupe** – a type of fruit consisting of an outer skin, a usually pulpy or succulent layer, and a hard or woody inner shell usually enclosing a single seed.

**Dwarf mistletoe** - a parasitic flowering plant with stems and seeds that develops extensive absorption systems in the **sapwood** of conifers and derives most of its water and nourishment from the host

**Ectotrophic mycelium** - fungal material, usually white to cream-colored, found on the outside of the root bark that is formed by certain root **pathogens** (i.e. *Phellinus sulphurascens* and *Heterobasidion occidentale*)

**Embedded (included) bark** – the inner and outer bark that forms between the expanding cylinder of the branch and the trunk or between two trunks. As the branch and trunk cylinders expand, the intumed bark becomes a wedge between the two cylinders that greatly weakens the fork.

**Exudate** - matter that has oozed out of a stem, branch, or root that may be a symptom of a **defect** or **infection** such as root-collar exudates caused by *Armillaria* spp.

**Failure** - partial or total breakage or collapse of a tree or tree part

**Frost crack** - splitting of the outer bark and **sapwood** that occurs in the trunks of trees subjected to extreme cold; such fissures follow the grain and are usually superficial; they originate from old, mechanical **wounds**; often called bleeding or weeping cracks if copious **exudates** are present

**Fruiting body** - **conk**, **mushroom**, or other fungal, reproductive structure that produces **spores**

**Fungus** (pl. fungi) - a group of organisms lacking chlorophyll (therefore it does not photosynthesize), having cell walls with both cellulose and chitin, having a vegetative body composed of **hyphae**, and reproducing by **spores**

**Gall** - a pronounced swelling or tumor-like body produced on trees parasitized by certain **fungi** or bacteria, or infested by gall-forming insects

**Gallery** - a tunnel formed by the feeding of insect larvae or adults, particularly by **bark beetles**

**GPS** – **Global Positioning System** is a space-based satellite-navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

**Haul route** – a road that is used to transport logs or other forest products

**Hazard** - the recognized potential that a tree or tree part may fail and cause injury or damage by striking a **target**

**Hazard tree** or **danger tree** – any tree or its parts that will fail because of a damage, **defect**, or **disease** and cause injury or death to people or property

**Heart rot - decay** usually restricted to the **heartwood** in living trees

**Heartwood** - the inner, nonliving part of a tree stem that is altered to a protective state as a result of normal, genetically controlled aging processes as cells die; provides mechanical support

**Hypha** (pl. hyphae) - single, microscopic, thread-like filament made up of fungal cells

**Incipient stain/decay** - early stages of **decay** often characterized by discoloration of the wood

**Increment borer** - an auger-like instrument with a hollow bit and an extractor used to remove thin radial cylinders of wood (increment cores) from trees having annual-growth rings to determine tree age or detect the presence of wood **decay** or stain

**Infection** – the act of a **pathogen** establishing itself on or within a host

**Lichen** – a type of organism composed of an alga and a **fungus** that grow in symbiotic association often on tree boles and branches, and can hide **conks**, burls, or cavities.

**Live-crown ratio** - the ratio of live-crown length to total tree height; usually expressed as a percentage

**Mycelial fan** - a mass of **hyphae** that grows under the bark of infected roots and **butts** and has a “fan-like” appearance. Mycelial fans, especially of *Armillaria* spp., are usually thick enough to peel off like latex paint and are white to cream-colored when fresh and turn brown when old.

**Mycelial felt** - a dense and expansive **mycelium** that takes the form of a thick sheet

**Mycelium** (pl. mycelia) - a mass of **hyphae** or fungal filaments

**Mushroom** - the reproductive fruiting body of any fleshy **fungus**, usually produced annually. **Spores** are produced from mushrooms.

**Necrosis** - death of a plant or a plant part; usually referring to localized death of living tissues of a host

**Old-growth (forest)** – usually a late-successional stage of forest development that contains large and old live and dead trees (overmature trees), multiple canopies, and down logs

**Opposite leaves** – leaves that form on the same side of a stem (node), as contrasted with **alternate leaves** that form on different sides of a stem

**Parasite** - an organism that grows part or all of its life on or within another organism of a different species and derives all or part of its food from it

**Pathogen** - a **fungus**, bacterium, virus, or other infective agent capable of causing **disease** in a particular host or range of hosts

**Pitch tubes** or **streams** – a tubular mass of **resin**, **boring dust**, and frass that forms on the surface of the bark at the entrance holes of **bark beetles**

**Pore** - a small hole in the undersurface of a fungal **fruiting body** from which **spores** emanate

**Pulaski** - a chopping and trenching tool that combines a single-bitted-ax blade with a narrow trenching blade resembling an adz hoe; named for the USDA Forest Service ranger who invented the tool for firefighting and saved numerous lives during the 1910 fire in Idaho.

**Punk knot** or **swollen knot** - a protruding and unhealed knot of a tree with **heart rot**, the surface is not encased fully in the bark, and the knot interior contains highly decayed wood that resembles the interior of the **conk** of the causal **fungus**

**Pustules** – very small (<1/2 in. wide) **fruiting bodies** that form on the roots of infected trees, especially *Heterobasidion* spp. on saplings or seedlings

**Qualified person** - a person who has knowledge, training, and experience in identifying danger trees, their potential-failure zones, and the appropriate measures to eliminate the danger

**Resin** - secretions of certain trees, especially conifers, that are oxidation or polymerization products of terpenes, consisting of mixtures of aromatic acids and esters; generally associated with tree resistance to **fungi** and insects; also called pitch

**Resinosis** - the reaction of a tree to invasion by certain **pathogens** and insects or to **abiotic** injuries that results in the copious flow of **resin** over the outer bark in the area of injury, or resin-soaking within the outer bark, or in **resin** accumulation under the bark

**Rhizomorph** - a thread-like or cord-like fungal structure made up of strands of **hyphae** that are covered with a protective rind; rhizomorphs look like roots, but they are an extension of a **fungus** that infects live or dead host parts (usually roots or wood); may occur with infection by several species of **fungi** including *Armillaria* spp.

**Rind** - the shell of solid (undecayed) **sapwood** surrounding a **decay column** in a tree. A rind may be broken and not continuous because of a **wound** or **canker**.

**Risk** - the proximity to actual damage and loss; the real possibility or chance of damage and loss

**Root collar** or **root crown** - where the root system joins the **bole** of the tree

**Root graft** - the growing together of two or more roots in such a way that their **cambium**, xylem, and phloem eventually fuse, and materials, including **fungi**, pass from one root to another

**Rust** or **rust fungus** – term used for a particular group of **diseases** or the **fungi** that cause them; most rusts require at least two host species to complete their life cycles; an example is white pine blister rust on white pine and *Ribes* spp.

**Samara** – an indehiscent, usually one-seeded, winged fruit

**Saprophyte** - an organism that lives on dead, organic matter

**Sap rot** - wood **decay** that is characteristically confined to the **sapwood**

**Sapwood** - the outer layers of a stem, which in a live tree are composed of living cells (xylem) that conduct water up the tree

**Scar** – a **wound** that shows some evidence of **callus** tissue (sealing)

**Setal hypha** (pl. hyphae) - a thick-walled, reddish-brown **hypha** that tapers to a point; it is sub-microscopic and only found in **advanced decay** associated with laminated root rot or cultures of *Porodaedalia pini*

**Shake** - a physical defect of trees caused by exposure to high winds; the **defect** appears in its most advanced stages as deep longitudinal fissures that follow the grain of the **butt log** and are associated with separations of the growth rings deep in the **heartwood**. More commonly, growth-ring separations occur without the external fissures.

**Sign** - the manifestation of disease by the presence of structures of the **causal agent** (**conks, mushrooms, setal hyphae, mycelial fans** or **felts, rhizomorphs**)

**Simple leaves** – one leaf per stem or petiole as opposed to compound leaves which have more than one leaf per petiole

**Skyline logging** – a type of forest harvesting with a cableway stretched tautly between two points, such as a yarder tower and a stump anchor, and used as a track for a block or skyline carriage

**Snag** - a standing, dead tree often classified by different stages of **decay**

**Sound-rind thickness** – width of the shell of solid (undecayed) **sapwood** surrounding a **decay column**; because the width varies in thickness, it is usually measured at three or more points on the trunk and averaged to get a value. It does not include the bark.

**Spore** - a microscopic reproductive propagule of **fungi** (and other cryptogams)

**Sporophore** - **conk, mushroom**, or other fungal reproductive structure that produces **spores**

**Stem** - the main trunk or central stalk of a plant; also called a **bole** in trees

**Structural roots** - major tree roots that significantly add to the support of a standing tree

**Symptom (symptomatic)** - the outward manifestations of **disease** in a host such as **chlorotic** foliage, dead branches or tops, or dead trees

**Target** - person or object within striking distance of a tree or its parts

**Topkill** – death of the upper crown of a tree; usually caused by insects, **pathogens**, animals, or weather

**Undermined roots** - roots that are no longer firmly anchored due to soil removal or loss, beneath and/or around them

**Vascular wilt** – symptom of a lack of water in the plant vascular system whereby foliage loses its turgidity and droops (wilts)

**Wetwood** - a water-soaked area in the **heartwood** of a tree that is a **symptom** of infection by certain **fungi** (particularly yeasts) and bacteria

**Windshake** - a separation along the grain in a tree stem caused by wind stress

**Windthrow** – a tree that has fallen to the ground, usually at the roots or **butt**, due to excessive wind or perhaps without wind because of decayed roots or **butt**

**Wind-shatter** - a tree that has fallen to the ground as a result of a break above the **butt** due to excessive wind or perhaps without wind because of a decayed stem

**Wound** - an injury that usually breaks the bark of branches, stems, or roots of a tree and serves as a possible entry point for many species of **fungi**. Old wounds may become sealed with new bark and eventually become hidden. **Scars** are wounds that have sealed and have **callus** tissue.

**Zone line** - a narrow, dark-brown or black line in decayed wood, generally resulting from the interaction of different strains of **fungi** or the host reaction



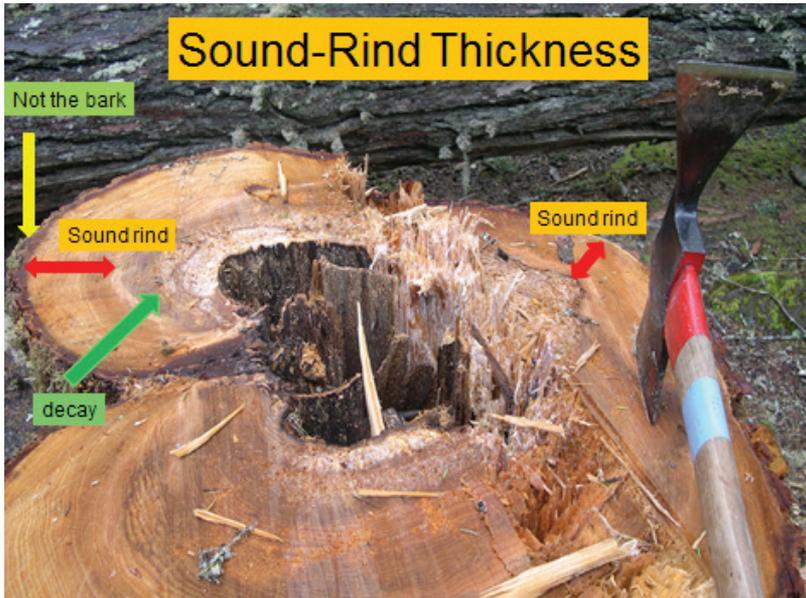
## Appendix

**Table 7. Minimum sound-rind thickness<sup>1</sup> at various diameters inside the bark of conifers measured at the defect for trees without open wounds. Trees with sound-rind thickness below minimum values have imminent-failure potential.**

Tree diam. (in.)	Rind thickness <sup>2</sup> (in.)	Tree diam. (in.)	Rind thickness <sup>2</sup> (in.)
4	0.5	44	6.5
6	1.0	46	7.0
8	1.0	48	7.0
10	1.5	50	7.5
12	2.0	52	8.0
14	2.0	54	8.0
16	2.5	56	8.5
18	2.5	58	8.5
20	3.0	60	9.0
22	3.5	62	9.5
24	3.5	64	9.5
26	4.0	66	10.0
28	4.0	68	10.0
30	4.5	70	10.5
32	5.0	72	11.0
34	5.0	74	11.0
36	5.5	76	11.5
38	5.5	78	12.0
40	6.0	80	12.0
42	6.5	82	12.5

<sup>1</sup> Modified from Wagener (1963) by expanding the range of diameters covered

<sup>2</sup> Minimum sound-rind thickness is  $0.15 \times$  diameter and rounded to the nearest 0.5 in.



**Sound-rind thickness in this decayed hemlock stump does not include the bark.**



**Danger-tree policy-review field trip, 2007, Umatilla NF**

**Table 8. Minimum sound-rind thickness<sup>1</sup> at various diameters inside the bark of conifers measured at the defect for trees with open wounds. Trees with sound-rind thickness below minimum values have imminent-failure potential.**

Tree diam. (in.)	Rind thickness <sup>2</sup> (in.)	Tree diam. (in.)	Rind thickness <sup>2</sup> (in.)
4	0.5	<b>44</b>	8.5
6	1.0	<b>46</b>	8.5
8	1.5	<b>48</b>	9.0
10	2.0	<b>50</b>	9.5
12	2.0	<b>52</b>	10.0
14	2.5	<b>54</b>	10.5
16	3.0	<b>56</b>	10.5
18	3.5	<b>58</b>	11.0
20	4.0	<b>60</b>	11.5
22	4.0	<b>62</b>	12.0
24	4.5	<b>64</b>	12.0
26	5.0	<b>66</b>	12.5
28	5.5	<b>68</b>	13.0
30	6.0	<b>70</b>	13.5
32	6.0	<b>72</b>	13.5
34	6.5	<b>74</b>	14.0
36	7.0	<b>76</b>	14.5
38	7.0	<b>78</b>	15.0
40	7.5	<b>80</b>	15.0
42	8.0	<b>82</b>	15.5

<sup>1</sup> Modified from Smiley and Fraedrich (1992)

<sup>2</sup> Minimum sound-rind thickness is 0.19 x diameter and rounded to the nearest 0.5 in.



***An open canker on this aspen probably indicates a thin, sound rind and imminent-failure potential.***



***Danger-tree workshop, 2006, Deschutes National Forest***

**For assistance on Oregon and Washington federal lands:**

<http://www.fs.fed.us/r6/nr/fid/staffweb/regoff.shtml>

**Pacific Northwest Regional Office  
Forest Health Protection**

USDA Forest Service  
1220 S.W. Third Avenue  
Portland, OR 97204  
503-808-2997

**Blue Mountains Forest Insect and  
Disease Service Center**

USDA Forest Service  
Forest Sciences Laboratory  
1401 Gekeler Lane  
LaGrande, OR 97850  
541-962-6544

**Southwest Oregon Forest Insect  
and Disease Service Center**

USDA Forest Service  
J. Herbert Stone Nursery  
2606 Old Stage Road  
Central Point, OR 97502  
541-858-6126 or 6124

**Wenatchee Forest Insect and  
Disease Service Center**

USDA Forest Service  
Forestry Sciences Laboratory  
1133 N. Western Avenue  
Wenatchee, WA 98801  
509-664-9223 or 9215



**Central Oregon Forest Insect and  
Disease Service Center**

USDA Forest Service  
Deschutes National Forest  
Headquarters  
63095 Deschutes Market Road  
Bend, OR 97701  
541-383-5591 or 5788

**Westside Forest Insect and  
Disease Service Center**

USDA Forest Service  
Mt. Hood National Forest  
Headquarters  
16400 Champion Way  
Sandy, OR 97055  
503-668-1475 or 1474

**For assistance on Oregon and Washington state and private lands:**

**Washington Department of Natural Resources  
Resource Protection Division**

Natural Resources Building, Fourth Floor  
1111 Washington Street, SE  
Olympia, WA 98501  
390-902-1692 or 1309

**Oregon Department of Forestry  
Forest Health Management  
Insects and Diseases**

2600 State Street  
Salem, OR 97310  
503-945-7397  
<http://www.oregon.gov/odf/privateforests/pages/fh.aspx>



*Danger-tree  
workshop,  
2009,  
Fremont-  
Winema  
National  
Forest*



*2006 workshop  
near Lakeview,  
OR*





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