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Department of
Agriculture

Forest Service

**Pacific
Northwest
Region**

United States
Department of
Interior

Bureau of
Land Management

Field Guide for Danger Tree Identification and Response

Oregon
OSHA

Associated Oregon
Loggers, Inc.

Field Guide for Danger Tree Identification and Response

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Introduction

Tree stability is determined by the tree's location and the presence of defects, insects, disease, work activities, and weather conditions. If a tree is unstable, it may fail either partially or totally. If a tree fails, it is a danger to anyone that may be struck by it.

Objectives:

- To provide information to employers that will help keep workers safe from exposure to tree dangers.
- To provide information to qualified people that will enable them to do the following:
    - Recognize tree conditions and determine tree failure potential.
    - Determine a tree's potential failure zone.
    - Understand how a work activity could induce a tree with a failure potential to fall.
    - Determine if a tree presents a danger to workers as a result of
        - Condition and failure potential.
        - The work activity.
        - Exposure.
        - Whether or not the work activity is within the tree's potential failure zone.

Common diseases and defects that cause trees to fail are presented, along with instructions on how to identify them. Potential failure zones are described. Possible activities around trees are grouped into three classifications according to how they may induce the tree to fail. There is a discussion on how to determine if the tree is a danger to employees, including examples. A form is presented to record the tree evaluation. Finally, there is a discussion of what to do if there is a danger.

These guidelines are intended for use with any forest activity, in any location including roads through forested areas, and are based on native tree species. They are not intended to be used for recreation sites, although many of the guidelines were adapted from guidelines for developed recreation sites (1).

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 with employees operating on private or public land.

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 1960.8) requires the 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 that danger.

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

The health and safety of Forest Service 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 addresses the health and safety of employees in BLM Manual 1112-1, Safety and Health Management; and Handbook 1112-2, Safety and Health for Field Operations (7, 8).

Chapter 2 of the BLM Manual 1112-1, Safety and Health Management, describes the risk and management process which provides management with a systematic method for identifying and managing the risks associated with any BLM operation. Chapter 15 further discusses workplace and hazard assessments (7).

BLM handbook 1112-2, 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).

These 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 rules and standards.

This document, titled *Field Guide for Danger Tree Identification and Response*, is designed to implement the applicable rules. It does not replace the rules or standards.

The discussion of danger trees applies to all forest work activities except within developed recreation sites.

Responsibilities

Employer Responsibilities

The employer has the responsibility to identify and mitigate dangers to workers from danger trees.

The Oregon 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 (7), 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 or snags within reach of a work area to determine if they pose a danger to personnel. If they pose a danger they must be felled, or the work must be arranged to minimize danger to workers.

Qualified Person

When an employer is faced with danger trees, there needs to be people with sufficient knowledge, training and experience, to follow a process for dealing with them.

A **qualified person** is defined as a person who has knowledge, training, and experience in identifying danger trees, their potential failure zones, and measures to eliminate the danger.

Process for Tree Evaluation and Action

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

1. Determine the type of work activity.
2. Identify tree defects and determine the tree's potential to fail.
3. Determine the potential failure zones.
4. Determine if the tree poses a danger to workers.
5. Determine what action to take if the tree is a danger to workers.

Step 1 – Determine the type of work activity.

No worker exposure to a danger tree is allowed by state safety laws.

What characteristics of work activities should the qualified person consider when determining if a tree presents a danger to workers?

There are three categories of work activities.

- Traffic on roads.
- Activities that do not impact the tree such as walking or conducting non-motorized activities that do not involve tree contact.

- 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.

Walking by a tree or other non-motorized, non-tree contact activities are not likely to induce the tree to fail. The tree may fail due to its condition or weather influences.

Motorized activities, or non-motorized activities that may contact the tree, include road maintenance activities such as running a grader, culvert work, road construction, logging (all types) including timber falling, site preparation, road construction, trail construction, and helicopter operations, may induce tree failure.

Activity - 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 the roadways must be felled (2).

Washington 296-54-527 Truck roads (3) 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)

The reality is there are many miles of roads that may have danger trees adjacent to them. It is not possible to solve the danger tree problem immediately, so it is necessary to prioritize the danger tree treatment workload. The treatment priority should be highest where workers are most likely to be impacted by danger trees. Consideration of exposure level and traffic frequency provides a way to prioritize the workload.

There are three types of exposure: intermittent, short duration, and long duration. Here are some examples. Intermittent exposure includes traffic driving by a defective tree. Short duration exposure includes people stopping next to a defective tree for a short time. It also includes people stopping at an intersection that is next to a defective tree. Long duration exposure includes people exposed to defective trees while parked at a trailhead, repairing a road, or working on a log landing.

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 workers are exposed to a tree, the more opportunity there is for the failed tree to impact them. If exposure duration and traffic frequency are reduced, the opportunity for the tree to impact the worker is also reduced. The qualified person should consider traffic frequency and exposure duration when prioritizing the treatment workload for danger trees.

If the tree's potential for failure is likely or imminent, and the potential failure zone overlaps the traveled portion of the road, the tree poses a danger to workers if it fails.

For specific direction, refer to agency or company policy about danger trees along roads. When developing the danger treatment priority, consider trees in the following situations:

- Trees with an **imminent** potential to fail along all roads utilized by workers on the project.
- Trees with a **likely** potential to fail along all roads utilized by workers on the project.
- Trees with an **imminent** potential to fail that overlap areas where people congregate such as landings, trailheads, parking areas, places where motorists can pull off to the side of the road, intersections, and areas where workers are repairing or maintaining a road.
- Trees with a **likely** potential to fail that overlap areas where people congregate such as landings, trailheads, parking areas, places where motorists can pull off to the side of the road, intersections, and areas where workers are repairing or maintaining a road.
- Trees with an **imminent** potential to fail that overlap the traveled portions of roads with a high traffic frequency.
- Trees with a **likely** potential to fail that overlap the traveled portions of roads with a high traffic frequency.

- Trees with an **imminent** potential to fail that overlap the traveled portions of roads with a low traffic frequency.

Activity – Non-motorized, non-tree contact

These are activities that involve walking near trees without touching them. They are also non-motorized. The premise behind this activity type is that trees are much less likely to fail if they are not contacted, and workers are more likely to recognize tree dangers if they are not focused on operating vehicles or machinery.

Examples include tree planting, inventory (any type), surveying, walking to a jobsite along a trail, and designating timber.

With this type of activity, it is important to recognize trees that have an imminent failure potential. These trees may fail at any time so they are a danger to workers regardless of the activity type. Because these trees expose employees to dangers, only employees who are trained and experienced to remove the danger tree, and are 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 to workers, the qualified person needs to evaluate the tree condition, activity, and whether or not the worker will be within the potential failure zone. If the qualified person determines that the likely failure potential tree does not represent a danger, employees should work through the potential failure zone quickly so as to minimize exposure time and avoid tree contact. If the tree does represent a danger, it should be treated as a dangerous imminent failure potential tree.

Activity – Motorized, tree contact

Motorized activities, or those activities that may contact the tree, include road construction, logging (all types), timber falling, tree climbing, site preparation, trail construction, and helicopter operations. The premise behind this activity type is that vibration due to machine operation, or air movement in the case of a helicopter, or tree contact by a machine, log, or operating line, may induce tree failure. As a result of noise, or worker focus on the job task, the worker might not recognize the danger, or notice the failure beginning to take place, and miss the opportunity to escape.

With this type of activity, it is important to recognize trees that have an imminent failure potential. Because these trees may fail at any time, they are a danger to workers. Only employees who are trained and experienced to remove the danger tree and are 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 to workers, the qualified person needs to evaluate the tree condition, activity, and whether or not the worker will be within the potential failure zone. If the qualified person determines that the likely failure potential tree does not represent a danger, employees should work through the potential failure zone quickly so as to minimize exposure time, and avoid unnecessary tree contact. If the tree does represent a danger, it should be treated as a dangerous imminent failure potential tree.

Attributes of activities that may induce tree failure:

Table 1. Activities and Hazards

Activity	Hazards
Timber falling, manual	Felled trees may bump adjacent trees and cause them to fail. Trees felled through other trees or onto slash (especially dead, dry material), may cause material to be flung in many directions. Some trees are too dangerous to fall manually. Exposure duration may be long.
Timber falling, mechanical	Trees being felled may fail and fall on the machine. Adjacent trees may fail through contact and fall on the machine. The machine must comply with state code related to protective structures and use. Machines may be used to fall danger trees that are too dangerous to fall manually.
Skyline logging	In partial cutting, many things can contact a tree and cause it to fail; logs being yarded, operating lines, machine operation on landings, guy lines and support lines. Support trees or tail trees may fail. Exposure duration at landings can be long.
Mechanized, tractor, or shovel logging	Machines may contact trees, or trees they fell may contact trees causing them to fail.
Helicopter logging	In partial cuts the rotor wash or contact with lines or logs may cause trees, tops of trees, or hang-ups to fail. This effect may be delayed; the tree may fail when the helicopter is no longer over it.
Machine use in site prep, brush piling, or slash treatment	Machinery or material being moved may contact trees and cause them to fail.
Trail construction or maintenance	Machinery or people may contact trees and cause them to fail. Also the exposure duration may be long.
Road construction	Equipment or moving material may contact trees and cause them to fail. Exposure duration may be long.
Road maintenance	All maintenance activities including slide and debris removal and culvert maintenance. Machine operation may cause tree failure. Exposure duration may be long.

Step 2 – Identify tree defects and determine the tree's potential to fail.

Failure potential is a function of tree condition. There are three types of failure potential: **low, likely, or imminent**. Trees with likely or imminent potential to fail may be classed as danger trees depending on the work activity and whether the work activity is within the tree's potential failure zone.

In order to define the potential failure zones, it is necessary to determine which tree part is likely to fail: entire tree, tree top, branches or bark.

A tree may have a **likely potential to fail** if any of the following conditions exist (1, Pgs. 35-65). Appendix D contains a detailed listing of symptoms and indicators.

- Root diseased but still alive.
- Old lean that has not corrected itself.
- Some undermined or severed roots.
- Some heart, butt, or sap rot.
- Cracks or structural defect associated with some decay.
- Dead tops with some heart or sap rot.
- Dwarf mistletoe bole swellings if they have decay that extends to an area less than **half** the bole diameter.
- Fungus cankers on the bole when the canker width is less than **half** the bole diameter.
- Forked tops and crotches associated with decay, cracks, splits, or callus ridges. Pitch or resin is not always associated with likely failure potential. Pitch is often a sign in a healthy tree when it is defending itself against pathogen or insect attack.
- Dead trees that are still sound.
- Fire damaged or killed trees that are still sound.
- Hardwoods with sap rot approaching half their diameter.

A tree may have an **imminent potential to fail** if it is so defective or rotten that it would take little effort to make it fail during project implementation. Trees with an imminent failure potential are much more likely to fall than those trees rated as likely to fail.

Trees with an imminent potential to fail include those that have the following conditions (1, Pgs. 35-65).

- Root sprung.
- Recent lean.
- Missing bole wood due to fire or damage.
- Significant heart or sap rot.
- Loose bark.
- Dwarf mistletoe bole swellings if they have decay that extends to an area **more than half** the bole diameter.
- Fungus cankers on the bole when the canker width is **more than half** the bole diameter.
- Dead tops with significant sap rot.
- Hung up tops, limbs, or hung up trees.
- Dead trees that are not sound.
- Fire damaged or killed trees that are not sound.
- Trees with multiple defects.

Trees with some of these conditions may have either a likely or an imminent potential to fail. For example, some dead tops, dead trees, and fire damaged or killed trees may be less stable than others. Trees with these conditions require an evaluation to determine which class to place them in.

For additional detail and indicators, refer to Appendix D and to the reference document (1).

Wind or snow loading.

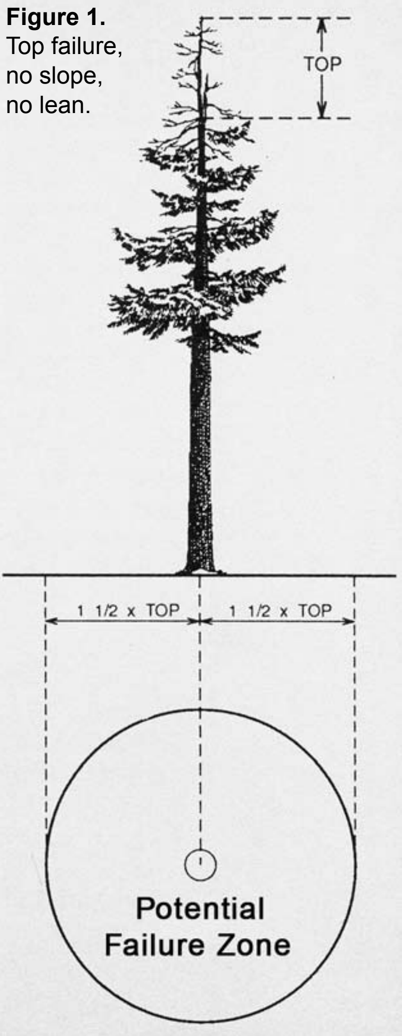
Wind or snow loading may increase the chances that a tree with decay or defect will fail. It is prudent to assume that as wind or snow loading increases, the potential for a tree to fail also increases.

Step 3 - Determine the potential failure zone.

The potential failure zone is the area that could be reached by any part of a failed tree.

When a tree fails, the tree or its parts may strike other trees and cause them to fail as well. The parts may slide or roll. Also, when a tree is being felled, it may strike other trees or debris on the ground and fling material a considerable distance. This is especially true in dead timber. The qualified person needs to be aware of these situations when determining the potential failure zones.

Figure 1. Top failure, no slope, no lean.



Top Failure - Potential Failure Zone

The area on-the-ground that could be reached by a dislodged top, slab, or chunk is called the potential failure zone for a tree top failure.

When determining the zone, evaluate the following conditions:

- Ground slope.
- Amount and direction of lean.
- Length of the top portion that could dislodge.

❖ **Level or sloped ground; no discernable lean. Figure 1.**

Determine the length of the top portion that could dislodge. The failure zone forms a circle around the tree with a radius equal to at least 1 ½ times the length of the dislodged portion. On sloped ground where the dislodged section may slide or roll down hill, the failure zone must be extended on the down-hill side for whatever distance is necessary to protect workers.

❖ **Level or sloped ground; lean in any direction. Figure 2.**

Determine the length of the top portion that could dislodge. Determine the amount of lean (horizontal distance from where the top portion could dislodge relative to the base). The failure zone is the distance determined by adding 1 ½ times the length of the dislodged portion 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.

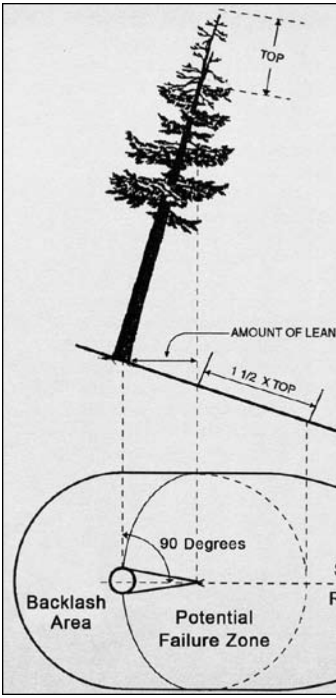


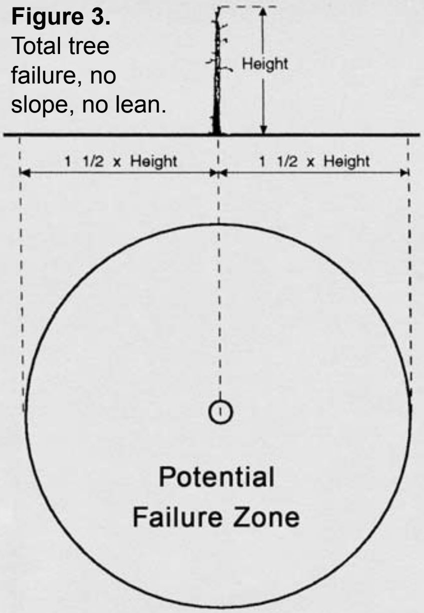
Figure 2. Top failure, slope, lean.

The area behind the lean is not within the failure zone. Be aware, however, that if equipment, lines, moving logs, or falling timber contacts a likely or imminent failure potential tree, the contact could force a backlash opposite to the lean and create an additional danger during the time of impact beyond the potential failure zone. On sloped ground where the dislodged section may slide or roll downhill, the potential failure zone must be extended on the downhill side for whatever distance is necessary to protect workers.

Total Tree Failure - Potential Failure Zone

The failure zone is defined as the area on the ground that could be reached by any portion of the tree that may collapse.

Figure 3. Total tree failure, no slope, no lean.



When determining the failure zone, the following conditions must be evaluated:

- Ground slope.
- Direction of lean.
- Height of the tree.

❖ **Level or sloped ground; no discernible lean. Figure 3.**

The failure zone is a circle around the tree with a radius of at least 1 ½ times the total tree height.

On sloped ground, the failure zone downhill of the tree may have to be extended whatever distance is necessary to protect workers.

❖ **Level or sloped ground; lean in any direction. Figure 4.**

The failure zone is an area at least 1 ½ 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.

The area behind the lean is not within the failure zone. Be aware that if equipment, lines, moving logs, or falling timber contacts a likely or imminent failure potential tree, the contact could force a backlash opposite to the lean and create an additional danger during the time of impact beyond the potential failure zone.

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

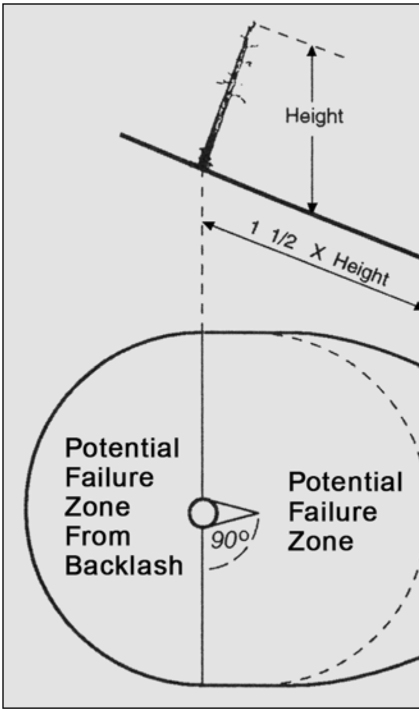


Figure 4. Total tree failure, slope, lean.

Step 4 – Determine if the tree poses a danger to employees.

- Determine if the activity is likely to cause the tree to fail.
- Evaluate the tree. Determine the tree condition and its failure potential.
- Identify the potential failure zone.
- Make a judgment about whether or not the tree is a danger to employees.
- If the tree is a danger, remove the danger by taking the tree down, or arrange work so that employees are not in the potential failure zone.

The following three examples illustrate the process a qualified person should go through when evaluating trees.

Example 1

Part 1. Assume there is a skyline logging operation. You as the qualified person, notice that behind the landing, the standing trees look abnormally faded. There are conks around the base of several of the trees. There is some basal resin and bark staining on them. There has been some wind throw.

You conclude that the trees may have root rot, and have a likely potential for failure. 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 anything 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 to workers and need to be taken down, or the landing moved.

Part 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 abnormally faded. There are conks around the base of several of the trees. There is some basal resin and bark staining on them.

You conclude that the trees may have root rot and have a likely potential to fail. Next, you determine that the planting job site is within the potential failure zone of the root rot trees. The activity is tree planting, and it is not likely that anything will strike the trees and cause them to fail. Your conclusion is that the root rot 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 that you are evaluating trees along a haul route road. You notice two very similar trees in two locations. These trees have one conk on the bole.

You conclude the trees have some heart rot and have a likely 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 think 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 to employees, and they need to be taken down.

Example 3

You are evaluating a tree planting job. The unit being planted has many dead trees and a few large live trees left. You notice that most of the dead trees, even though they have only been dead for two years, have pouch fungus conks (sap rot) on them, and the bark looks loose. One of the green trees has a recent lean, and you suspect it is root sprung. You also notice that there are some dead trees that are hung up in some other trees. On the other side of the unit, there are a few trees standing straight with conks on the bole.

You conclude that the leaning tree, the trees with the hang-ups, and the sap rot trees with the loose bark have an imminent potential to fail. Because these trees have an imminent failure potential, and their potential failure zones include the area to be planted, you conclude that the trees present a danger to employees. The areas cannot be safely planted without removing the danger by taking the trees down.

The straight green trees with heart rot are different. While they have a likely potential for failure, the exposure under them will be short duration, and the activity is not likely to do anything 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 do not linger under the trees.

Record your results

As a qualified person, when you examine trees, it is important to record your work. Appendix B has a tree evaluation form.

Step 5 – Action if tree is a danger to workers.

Employees are not allowed to be exposed to danger trees. If upon considering the tree condition and activity, it is determined that the tree poses a danger to employees, the tree either needs to be taken down or the work arranged so that employees are not exposed to the danger.

Literature Cited

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8. BLM Handbook 1112-2, Safety and Health for Field Operations.

Citation example: (1, Pg 15) means page 15 in Harvey.

Appendix A - Forest Service Road Maintenance Levels

Table 2. Relationship between Forest Service road maintenance levels.

	Maintenance Level				
Parameters	1	2	3	4	5
Traffic type	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		

Appendix B – Tree Evaluation Form

Table 3. Tree evaluation form

Tree, Site, Road Evaluation Form	Location	Date
Name	Species	DBH
Tree #	Comments	
Height		
Failure class (None, Likely, or Imminent). Describe tree condition.	Sketch of potential failure zone.	
Identify the work activity.	Exposure (intermittent, short duration, long duration).	Could the work activity cause the tree to fail? Describe how.
Will the activity put workers in the potential failure zone, or in the case of roads, will the potential failure zone overlap the road travel way? (Y/N) and explanation.		
Danger to employees (Y/N)		
Action		

Appendix C – Quick Reference Cards

Process for Tree Evaluation and Action
These are the steps the qualified person should take when dealing with potential danger trees:

- Determine the type of work activity.
- Identify tree defects and determine the tree's potential to fail.
- Determine the potential failure zones.
- Determine if the tree poses a danger to workers.
- Determine what action to take if tree is a danger to workers.

Determine Work Activity

- Traffic on roads.
- Activities that do not impact the tree such as walking or conducting non motorized activities that do not involve tree contact.
- Motorized activities near the tree or activities that may cause the tree to be contacted.

While developing the danger tree treatment priority along roads, consider trees in the following situations:

- Trees with an imminent potential to fail along all roads utilized by workers on the project.
- Trees with an imminent or likely potential to fail that overlap areas where people congregate such as landings, trailheads, parking areas, places where motorists can pull off to the side of the road, intersections, and areas where workers are repairing or maintaining a road.
- Trees with an imminent or likely potential to fail that overlap the traveled portion of roads with a high traffic frequency.
- Trees with an imminent or likely potential to fail that overlap the traveled way on roads with a low traffic frequency.

Identify tree defects and determine the tree's potential to fail - likely.

A tree may have a **likely potential to fail** if any of the following conditions exist. (1, Pgs. 35-65). Appendix A contains a detailed listing of symptoms and indicators.

- Root diseased but still alive.
- Old lean.
- Undermined or severed roots but not severely.
- Some heart, butt, or sap rot.
- Cracks or structural defect associated with some decay.
- Dead tops with some heart or sap rot.
- Dwarf mistletoe bole swellings if they have decay that extends to an area less than **half** the bole diameter.
- Fungus cankers on the bole when the canker width is less than **half** the bole diameter.
- Forked tops and crotches associated with decay, cracks, splits, or callus ridges. Pitch or resin is not always associated with likely failure potential. Pitch is often a sign in a healthy tree when it is defending itself against pathogen or insect attack.
- Dead trees that are still sound.
- Fire damaged or killed trees that are still sound.
- Hardwoods with sap rot approaching half their diameter.

Identify tree defects and determine the tree's potential to fail - imminent.

A tree may have an **imminent potential to fail,** if it is so defective or rotten, that it would take little effort to make it fail during project implementation. It is much more apt to fail than those trees rated as likely to fail.

Trees with an imminent potential to fail include those that have the following conditions (1, Pgs. 35-65).

- Root sprung.
- Recent lean.
- Missing bole wood due to fire or damage.
- Significant heart or sap rot.
- Loose bark.
- Dwarf mistletoe bole swellings if they have decay that extends to an area **more than half** the bole diameter.
- Fungus cankers on the bole when the canker width is **more than half** the bole diameter.
- Dead tops with significant sap rot.

Potential Failure Zones

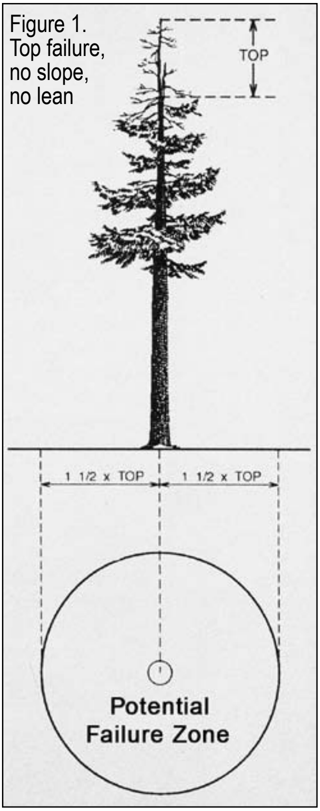

Figure 1. Top failure, no slope, no lean

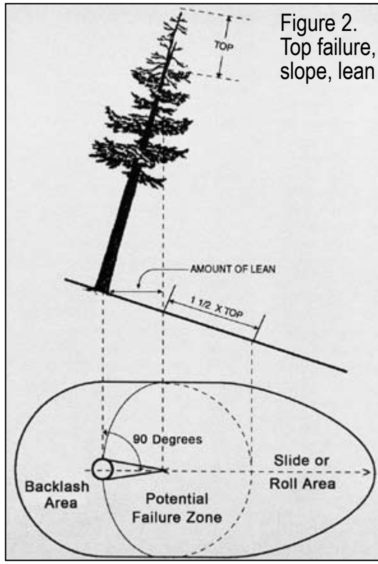

Figure 2. Top failure, slope, lean

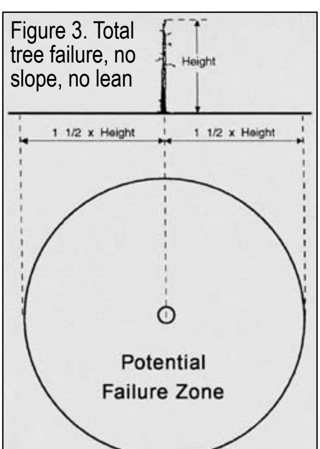

Figure 3. Total tree failure, no slope, no lean

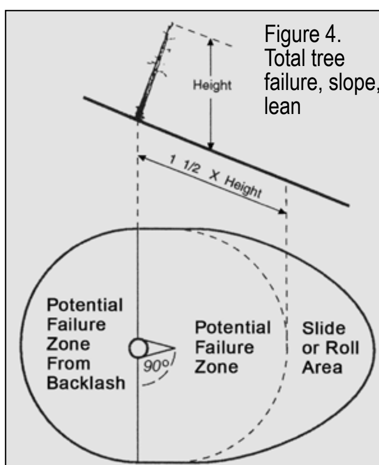

Figure 4. Total tree failure, slope, lean

Motorized, tree contact activity attributes.

Activity	Attributes
Timber falling, manual	Felled trees may bump adjacent trees and cause them to fail. Trees felled through other trees or onto slash (especially dead, dry material) may cause material to be flung in many directions. Some trees are too dangerous to fall manually. Exposure duration may be large.
Timber falling, mechanical.	Trees being felled may fail and fall on machine. Adjacent trees may fail through contact, and fall on machine. Machine must follow State code related to protective structures and use. Machines may be used to fall danger trees that are too dangerous to fall manually.
Skyline logging	In partial cutting, logs being yarded may contact trees and cause them to fail. Lines may contact trees and cause them to fail. Machines on landings may contact trees and cause them to fail. Guy lines and support lines may cause the trees they contact to fail. Support trees or tail trees may fail. Exposure duration at landings can be long.
Mechanized, tractor, or shovel logging	Machines may contact trees, or the trees they fell may contact trees, and cause them to fail.
Helicopter logging	In partial cuts, the rotor wash or contact with lines or logs may cause trees, tops of trees, or hang-ups to fail. This effect may be delayed; the tree may fail when the helicopter is no longer over it.
Machine use in site prep, brush piling, or slash treatment	Machinery or material being moved may contact trees and cause them to fail.
Trail construction or maintenance	Machinery or people may contact trees and cause them to fail. Also the exposure duration may be long.
Road construction, maintenance	Equipment or moving material may contact trees and cause them to fail. Exposure duration may be long. Includes slide and debris removal and culvert maintenance. Maintenance machine operation may cause tree failure.

Determine if the tree poses a danger to employees.

- Determine if the activity is likely to cause the tree to fail.
- Evaluate the tree. Determine the tree condition related to whether or not it will fail and whether it has a likely or imminent potential to fail.
- Identify the potential failure zones.
- After considering all these things, make a judgment about whether or not the tree is a danger to employees.
- If the tree is a danger, take it down it or arrange work so that employees are not in the potential failure zone.

Appendix D – Defect and Disease Identification

It is important to be able to identify tree diseases and defects that affect tree stability. Detailed information about disease and defect identification can be found in Chapter 5 and Appendix C in the publication *Harvey, R. D. Jr., and P. F. Hessburg Sr. 1992. Long-Range Planning for Developed Sites in the Pacific Northwest: The Context of Danger Tree Management. USDA Forest Service. Pacific Northwest Region. FPM-TP039-92. 120p.*

This source discusses common Pacific Northwest conifer diseases and defects. It contains more complete descriptions of diseases and defects than this document. Much of the material and many of the photos were taken directly from this reference.

Tree condition determines failure potential. There are several factors that should be included in that evaluation. Following is a list of significant factors and their indicators. The goal is to identify the disease or defect and assign a tree a failure potential rating of *low, likely,* or *imminent*. Each disease or defect is described, indicators are laid out, and a comment made about failure potential.

Root rots

Root rots or root diseases (1, Pg 15) may cause a tree to fall over if disturbed. Root rots cause total tree failure, so a tree with root rot has a high potential for failure. There are five important root diseases: laminated root rot, Armillaria root disease, annosus root disease, tomentosus root disease, and brown cubical butt rot (Schweinitzii root and butt rot).

- **General symptoms and indicators.** (1, Pg 35).
  - Bark beetle mass attack. Figure 5.
  - General decline of the entire live crown characterized by fading foliage, shedding of older needles, terminal (and eventually lateral shoot) growth reduction. Figure 6.
  - Distress cone crops.

- ◆ Dying branches, thinning crowns, from the extremities inward (old growth) or from the interior crown outward (young growth or second growth).
- ◆ Butt rot, as much as 30-35 feet.
- ◆ Basal resin and bark staining. Figure 7.
- ◆ Wind-throw or wind-shatter of surrounding trees. Root rots commonly affect groups of trees. Figure 8.
- ◆ Standing dead and dying trees. Figure 9.
- ◆ Mushrooms or conks at root collars. Figure 10.

- **Laminated root rot** (1, Pg 37).
  - ◆ Trees adjacent to an infection center may not show signs of infection.
  - ◆ Live infected trees are frequently wind-thrown. Figure 11.
  - ◆ Standing live infected trees have a likely potential for failure except for Douglas-fir, western hemlock, grand fir and mountain hemlock, which have an imminent potential for failure.
  - ◆ Standing dead and infected trees have an imminent potential for failure.

- **Armillaria root disease** (1, Pg 40).
  - ◆ Root decay may be extensive and trees with this root disease should not be considered wind firm whether they are live or dead. Trees adjacent to an infection center may not show signs of infection.
  - ◆ Infected trees may have a large resin flow or resin soaking of the butt. Figure 12. In the fall, honey-colored mushrooms may be found fruiting at the base of infected trees. Figure 10. Unlike laminated root rot, Armillaria root disease-killed trees most often die standing. Figure 13. Dead standing trees and live infected trees have a likely potential for failure.

- **Annosus root disease** (1, Pg 40).
  - ◆ 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. 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 A-horizon. Figure 14. They may appear as small pustules on roots. Figure 15. Butt decay predisposes trees to wind-throw and breakage. Figure 16. Trees identified as being infected should be examined for decay in the roots. Trees with infected roots have a likely potential for failure.

- This root disease is especially dangerous in grand fir and white fir. If the trees are symptomatic, they have an imminent failure potential.

- **Tomentosus root rot** (1, Pg 41).
  - The root rot may be completely hidden on trees with extensive butt rot. Engelmann spruce is the principal host. Figure 17. Fruiting bodies are small, cinnamon colored, leathery mushrooms that appear in the fall on-the-ground near the base of defective trees. Figure 18.
  - When infected trees are mature they are more likely to be severely rotted in the roots and butt. Trees identified with infection in the roots and butts have a likely potential for failure.

- **Brown cubical butt rot** (1, Pg 42).
  - Schweinitzii root and butt rot is very common. On the west side of the Cascade Range, significant butt decay is indicated by a conspicuous fruiting body, referred to as the “cow-pie” fungus, and often by swollen butts. Figures 19 & 20.
  - Elsewhere, the defect may be as common, but it is often present without indicators. As such, it is discovered less often until significant wind events and tree failure have occurred.
  - Tree mortality is unusual, but decay of the butt extending as much as 30 feet up the tree occurs when trees are well past maturity (>150 years of age). Butt swell, which develops over many decades, is apparent on many trees having extensive butt defect.
  - Trees with butt rot often fail under high wind conditions leaving a characteristic barber chair and shattered butt.

- Once trees with fruiting bodies have been identified, those susceptible trees immediately adjacent to them should be evaluated.
- Trees with severe butt defect may have fruiting bodies growing from the butt. Figure 21. This often is indicative of a tree with a likely failure potential. Fresh fruiting bodies are velvety to the touch and have a brightly colored yellow margin. Figure 22. Trees with decay in major lateral roots and the butt have an imminent failure potential.

Undermined or severed roots

Root disturbance including undermined or severed roots (1, Pg 15). A compromised root system makes a tree more likely to fall, resulting in a tree with a likely to imminent potential for failure.

- **General symptoms and indicators.** (1, Pg 44).
    - Undermined roots are often associated with roads or are adjacent to streams or rivers.
    - The result of extreme undermining is tree failure from insufficient anchorage. Loosened, cracked, or broken roots predispose trees to failure in the event of high winds. High winds, saturated soils, and soil disturbances occurring singly or in combination often lead to loosening, cracking, or breaking of roots. Soil saturation is a leading factor in wind-throw of shallow-rooted species or of any species growing in high density or in shallow soil.
    - Trees with newly developed leans may have soil and litter not in contact with the base of the tree on the side away from the lean (there is a conspicuous gap). Figure 23.
    - Cracks, mounds, or ridges of recently heaved soil are adjacent to major lateral roots.

Root sprung trees

Root sprung trees (1, Pg 15) are likely to fall because the roots are compromised by being pulled out of the ground. They have an imminent potential for failure.

Recent lean

Recent lean (1, Pg 15, 63) may indicate rooting problems that may cause the tree to fall. Recently leaned trees have an imminent potential for failure.

- Leaning trees result from root and butt decay or from high winds that cause root wrenching. Figure 24.
- Tree leans are either recent or longstanding. All leaning trees should be examined for evidence of root and butt rot.
- Longstanding leaning trees are those that are leaned over and have subsequently grown a vertical top in the time since the lean occurred. In the intervening years, trees develop tension and compression wood at stress points to aid in their support. They also often develop a reinforced root system, where roots were wrenched, to compensate for prior damages. Unless these roots are disturbed or decay is present, the potential for failure of longstanding leaning trees is low. Figure 25.
- Recently leaned trees are tilted over their entire length. Since there is no evidence of subsequent reinforcement of the root system, trees with recent lean have an imminent potential for failure.
- Newly developed leans can also be recognized by observing the orientation of the top. Tops on trees that have been leaning for many years will have righted themselves and will tend to be vertical. Tops on trees that have developed a recent lean will tend to follow the new lean of the main stem.
- Trees with an older lean have developed additional, often stronger, anchorage in the portion of the root system previously wrenched. These older leaning trees have also been exposed to years of high winds and severe weather following the event that caused their initial lean, and have reestablished their root system. Trees with older leans should not be considered dangerous based upon their degree of lean alone. They should be evaluated based upon:
    - The length of time standing since the last partial failure.
    - The initial cause(s) of failure.
    - The current defect status.
    - Any new evidence of root breakage and leaning.

Heart, butt, and sap rot

Heart, butt, and sap rot (1, Pg 15, 47) may compromise bole integrity causing the tree to break apart. This would result in a likely to imminent potential for failure.

- **Heart rot**
  - Old injuries may have resulted in internal decay. If there is significant rot, the tree has a likely potential for failure.
  - Mass bark beetle attack may be an indicator of root rot. Carpenter ant and termite attack also may be an indicator of rot. If there is significant heart rot, the tree has an imminent potential for failure.
  - Pileated woodpecker activity such as cavity excavation indicates rot. If there is significant rot, the tree has an imminent potential for failure.
  - Heart rots are most abundant in mature and old growth trees, regardless of their size.
  - In most cases, when heart rot is extensive enough within the bole of a tree to be dangerous, it is indicated by conks, punk knots, or other indicators. Figure 26.
  - Heart rots will sometimes be present when there are few or no external indicators. For example, when conks have fallen from a defective tree and they are not observed on-the-ground or in dry habitat types where conks or mushrooms are rarely or not regularly produced.
  - Trees that are large and mature will routinely have the greatest amount of heart rot. Some of the defect will be hidden or inaccessible to the qualified person. Trees with cavities opening to the outside have a much greater potential for failure than trees having equivalent rinds of sound wood but no open cavities.

There are five important heart rots: rust red stringy rot (caused by Echinodontium tinctorium), red ring rot (caused by Phellinus pini), brown trunk rot (caused by Fomitopsis officinalis), red-cedar pencil rot (caused by Oligoporus sericeomollis), and incense-cedar pecky rot (caused by Oligoporus amarus).

- **Rust red stringy rot** (1, Pg 49).
  - Caused by the Indian paint fungus, this is the most damaging heart rot of mature true firs and hemlocks. When this defect is found in trees with the presence of conks and punk knots, the trees have a likely potential for failure. Two or more conks indicate an imminent potential for failure. Trees with no more than a single conk on average have as much as 40 feet of continuous decay in them.
  - When decay is advanced, large, hoof-shaped conks with a spiny lower surface are produced. Figure 27. Conks have a fissured upper surface, and they 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. Figure 28. Conks appear on the bole at the site of old branches. Where conks appear at several old branch whorls, greater defect is indicated.
- **Red ring rot** (1, Pg 50).
  - This is the most common heart rot of Pacific Northwest conifers. The damage associated with this fungus is severe stem decay. Most stands of old-growth Douglas-fir, pines, larch, hemlocks, and true firs exhibit some amount of this defect. Conks are hoof-shaped with cinnamon-brown to tan pore surfaces. Figure 29. Pores are irregular rather than round, and the interior of the conk has the same cinnamon-brown coloration as the pore surface. Punk knots are common on severely decayed trees. Figure 30. They are evidence that a conk is about to form at the site of 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. A true punk knot is observed when the cinnamon brown “punky” fungal material that makes up the context of the conk is clearly visible to the outside with the naked eye or with the aid of binoculars. Conks are formed at branch stubs or over old knots. Several conks in close proximity or numerous conks indicate significant decay.

- Unlike many others, wood decayed by this pathogen maintains some strength against failure. When trees have many large conks, damage to the heartwood is extensive and tree failure is imminent. With few or single conks, affected trees may have adequate strength to withstand high wind forces and tree failure is unlikely.
- Conks are typically higher on trees in older stands. Large conks indicate more decay, smaller conks usually indicate less decay, unless the apparent small conks are remnants of larger conks which have fallen off. On hemlocks especially, but occasionally on other species, conks may be abundant on the undersides of branches ("limb conk" and "butterfly conk"). Individual limb conks may be 12 to 18 inches long with their long axis parallel to the limb conks and may extend 2 or 3 inches out on either side of a limb. Limbs with conks extending up to 2 or 3 feet away from the main stem are common.

- **Brown trunk rot** (1, Pg 52).
    - This heart rot is caused by the quinine conk or the chalky fungus. Damage is severe stem decay occurring either as a top rot when it has entered a broken top or as a heart rot of the main stem, when the site of the old broken top is much lower in the bole and no longer visible. This fungus also enters through basal fire scars.
    - Conks are rare but unmistakable. They are hard, perennial, hoof-shaped to pendulous, and often quite large. Figure 31. Conks have a chalky white to grayish upper surface often with light patches of green (algae). Pores are round and the under surface of the conk is chalky white. The interior of most conks is soft and crumbly. Conks develop at branch stubs, over old wounds, and at the site of old top breaks. Punk knots may be observed at the site of large, older branch stubs that have usually rotted and fallen off. Punk knots are often seen weeping a yellowish brown material that stains the bark below. A single conk indicates severe stem decay.

- **Red-cedar pencil rot** (1, Pg 53).
    - This is a severe stem decay and butt rot of western-red cedar and occasionally true firs. In red-cedar, decay is usually confined to the lower 40 feet of affected trees.
    - This defect is almost never indicated by conks. Trees with significant decay, though, do display a conspicuous bole flattening at the butt called a "dry side" or "dry face." Figure 32.
    - Trees with evidence of a dry side should be sounded with a cruiser's axe and bored to determine the extent of decay and the thickness of the remaining rind of sound wood. Dry sides may extend 40 feet or more up the stem. They are normally covered with bark that hides an area of decayed wood. The perimeter of the dry side is often humped or folded as if in reaction to injury. In severe cases, the callus fold on the perimeter of a dry side may force the heart of the tree to the outside. Dry sides may be confused with irregularities in the butt associated with butt swell or fluting.
- **Incense-cedar pecky rot** (1, Pg 53).
    - This heart rot is very common in mature incense-cedar. Damage is severe stem decay of the heartwood. Decay is not limited to the butt log and it may occur along the entire merchantable length of the bole. In severely damaged trees, most of the heartwood is decayed.
    - Conks occur rarely, but when they do they indicate a cull tree. Conks are annual and fruit at knots in summer or autumn. They are hoof-shaped to half-bell shaped, tan to buff-colored on the upper surface, bright sulfur yellow on the underside (pore surface) with small tubes that exude clear drops of a yellow liquid. Figure 33.
    - As conks age they become tough and cheesy, turning brown and hard. Insects, birds, and squirrels destroy conks, leaving a "shot-hole cup," which is apparent at and below the knot where a conk was attached. Presence of a shot-hole cup also indicates

a cull tree. Large open knots or open branch stubs are also indicative of extensive decay or a cull tree. Woodpeckers also like to work around old punky open knots. Evidence of old woodpecker work indicates old conk locations and cull trees.

- ◆ Dry sides are not typically associated with this pencil rot of incense-cedar. Decay is almost always present in trees greater than 40-inches DBH, and in trees with basal wounds or old dead limbs.

- **Sap rots** (1, Pg 54).
  - ◆ Sap rots are defects unique to the sapwood. Most sap rotting fungi cause rapid decay of dead sapwood only. When these fungi have decayed to the fullest extent of available dead sapwood, they have completed their job. They compete poorly with other fungi that decay heartwood and they are seldom found past the heartwood/sapwood interface. Remember that tree tops are often all sapwood. In living trees, sap rots occur on tissue killed by other agents, most often bark beetles, mechanical damage, and weather damage. On dead trees, especially those killed by root diseases 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 1 to 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 dead sapwood. When this happens, the tree has an imminent failure potential.
  - ◆ When trees are killed with a full complement of foliage, they normally develop sap rot at a rapid rate. Trees killed by crowning fire, or trees with broken or blown tops, exhibit delayed sap rot development. In such trees, the level of sap remains high and it rather quickly ferments, turning sour. Bark beetles will rarely attack such trees and the introduction of sap rotting organisms will be delayed until bark splitting and sun checking or heart checking occurs.
  - ◆ One of the most easily recognized of the sap rotting fungi and the most common, the pouch fungus (Cryptoporus volvatus), is routinely carried by all major species of tree killing bark beetles (Scolytids). Figures 34 & 35.

- Most other sap rotting fungi infect their hosts via airborne spores through openings in the bark. Often when the little white or gray conks appear, the sap wood is fully rotted and the tree has an imminent failure potential.
- Hardwoods are also subject to sap rotting and damage may be significant on live trees. As with conifers, sap rotting of hardwoods occurs in dead portions of living trees. On many Pacific Northwest hardwood species (poplars, maples, alders), sapwood is decayed very rapidly once it is dead, and there may be few obvious external indicators. When external indicators of sap rot are lacking, testing may be required. Sap rot depth can be determined by boring with an increment borer or chopping with an axe. Hardwoods with sap rot approaching half their circumference have a likely failure potential.

Cracks and structural defects including loose bark

Cracks and structural defects including loose bark (1, Pg 15, 55) are parts of the tree that may come apart and fall. If the cracks and defects are associated with significant decay they have a likely potential for failure. Trees with loose bark have a likely or an imminent potential for failure due to bark coming off the tree.

- Cracks and splits in the main stem frequently occur. Cracks and splits are produced in a number of different ways; four of the most common are:
  - Tension and compression failure (often associated with older injuries and significant internal decay).
  - Lightning strike. Figure 36.
  - Wind shake. Figure 37.
  - Frost action. Figures 38 & 39.
- 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 somewhere in the bole between the ground and the place where the heart rot is greatest.
- Cracks are often formed by lightning strikes. Damage to trees 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. Often huge chunks of wood may be blown out of the furrow contributing to its depth and impact on subsequent tree vigor and wind firmness. Occasionally, entire trees or portions will be shattered, severely cracked, or split. The failure potential of lightning damaged trees increases with the length, width, and depth of cracks as well as with the extent of subsequent decay.

- Under the influence of frequent high winds, trees often develop shake in the lowest section of the butt. The twisting action of the wind first causes separations to develop along the growth rings. Later, these develop "legs" which extend outward toward the bark. In time, this radial shake defect breaches the bark and can be observed from the outside. Shake cracks may occur on any side of the bole and "legs" may extend from a few feet to 20 or 30 feet above the ground. Extensive wind shake defect indicates partial failure and may be associated with increasing butt rot.
- Frost cracks are formed by the action of extreme cold. Frost cracks, common at higher elevations, appear on bark as raised nearly vertical callus lines which extend to the ground where frosty air is coldest. This can be contrasted with wind shake cracks which need not be vertical, often do not contact the ground, and may gradually spiral up the side of an affected tree. Frost cracks develop under the influence of freezing temperatures when the outer sapwood growth rings become dehydrated by ice formation producing a contraction on the circumference of the bole with no radial contraction. These cracks begin at the tree base and seldom go higher than 15 feet up the bole. Defect is not commonly associated with true frost cracks and they are seldom associated with high failure potential. Older frost cracks develop a series of raised vertical ridges parallel to the frost crack known as "frost ribs."
- Cracked trees fail due to decay after being cracked.

- Dead tops (1, Pg 15, 62) with evidence of decay (heart rot and sap rot) may break apart and fall if disturbed; these indicate likely to imminent potential for failure. Figure 40.
    - Dead tops on live trees eventually break and fall to the ground. Before tops break, they often rot in place and are held by little or no sound wood. A gentle bumping or jarring of a top killed tree may send the top falling to the ground.
    - The failure potential of dead tops in incense-cedar, western red-cedar, ponderosa pines, and western larch is normally low.
    - Dead tops in true firs, Douglas-fir, spruces, hemlocks, and hardwoods are highly susceptible to attack by decay fungi, and their failure potential is normally higher than that of other conifer species on the same sites.
    - Large, heavy pieces of loose bark on dead tops also present an imminent potential for failure.
    - Generally, dead conifer tops without bark are less likely to fail than newly killed tops. They normally lack the added weight of branches, they have been exposed to a number of severe storms and are still vertical, and they may be resin impregnated depending on the type or original damaging agent.
    - Recently killed tops have a full complement of branches, a top largely comprised of sapwood with extensive sap rotting imminent, and no other evidence to verify their strength or durability. Tops that have been recently killed and have sap rot have a likely potential for failure.

Broken tops, hung-up tops, limbs, trees, dwarf mistletoe bole swellings, fungus cankers, crotches

Hung-up tops or limbs, or hung-up trees, dwarf mistletoe bole swellings, fungus cankers, and crotches are defects that may cause tree failure (1, Pg 15, 57, 59, 63). The hung-up tops or limbs may fall out of the tree if disturbed, or the hung-up tree may fall; these indicate imminent potential for failure.

- **Broken top**
    - Broken-top trees may have rot present below the break. This is especially true of non-resinous coniferous species. If the upper branches in the remaining top are thrifty and vigorous in their appearance, additional top failure is unlikely in the near future. The potential that new tops arising from upturned lateral branches will fail is also low unless indications of internal defect are evident. Figure 41.

- **Defective Limbs**
    - While failure probability is low for attached defective limbs, free-hanging limbs present an imminent potential for failure.
    - Hardwoods, especially poplars, maples, and alders, are more susceptible to limb failure than most conifers because their crotches are structurally weaker, and their long branches are heavily weighted at the extremities with green foliage and fruit. Additionally, heart rots of hardwoods often extend into major limbs creating likely potential for failure.
    - Dead limbs on resinous coniferous species remain attached longer than on non-resinous species, and limbs of hardwoods fail sooner than those of most conifers.
    - Hung up trees have an imminent potential to fail.

- **Dwarf mistletoe bole swellings**
    - Dwarf mistletoe bole swellings are caused by dwarf mistletoe infection of the bole. Figure 42. They are especially common on grand and white fir, western hemlock, and occasionally western larch. While bark and cambium tissues are still alive in the area of the swelling, boles are not often significantly weakened and failure potential is not a serious issue. Eventually the cambium and overlying bark tissues in the oldest part of the swelling die, and decay weakens the tree. Any of the fungi that function as wound parasites can be found decaying mistletoe induced bole swellings. By the time that decay has extended to an area equal to half the circumference of the stem,

breakage is likely and the tree has a likely failure potential. More than half indicates imminent failure.

- **Fungus cankers**
  - Fungus cankers frequently occur on the boles of pine species, especially lodgepole pine. Figure 43.
  - 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 from what would have been the normal circumference at that point. When the width of cankers approaches half the circumference of the stem, and the depressions are deep, the tree has a likely failure potential. More than half indicates imminent failure potential. Cankers caused by other fungal species are occasionally found on conifers and should be bored to determine if decayed wood is present. Cankers also occur on hardwoods and are frequently associated with internal decay. These should also be bored to determine their depth of sound rind.
- **Crotches**
  - Crotches that are tightly V-shaped can split and break from the green weight of foliage, heavy snow loads, or internal decay. This also occurs in hardwoods with large, spreading crowns. Tree crotches should be examined for cracks, splits, and callus ridges that suggest weakening and predisposition to failure or infection by decay fungi. Mushrooms and/or conks associated with crotches indicate internal decay. Pitch streaming below crotches may indicate partial failure.

Multiple defects

Multiple defects (1, Pg 15, 64). The potential for tree failure increases dramatically with the combined effects of multiple defects such as heart rot and cankers or stem injury, root rot and lean, split crotches and heart rot, and wind shake and butt rot. Trees with these conditions have an imminent potential for failure.

Dead trees

Dead trees (1, Pg 15, 65) may have root rot, butt decay, sap rot, loose bark, and have inadequate heart wood or sap wood to be structurally sound. Figure 44. If these situations exist, the tree has either a likely or an imminent potential for failure.

- Dead trees are among those most likely to fail. While some dead trees remain standing for decades, it is virtually impossible to distinguish these from trees that will fail at any time. As a general rule, recently killed trees are more likely to remain standing longer than older kills, unless they have root disease. Dead trees may fail for many reasons including rot or butt decay, heart rot, sap rot, top failure, and bark failure. Unless the qualified person excavates part of the root system and finds root or butt decay, and thoroughly evaluates the level of heart rot and sap rot, and finds them to be significant, the dead tree should be considered to have a likely potential for failure.

Fire damage

For fire damage (1, Pg 15), if the following situations exist, the tree has either a likely or an imminent potential for failure.

- The root system may be damaged by fire; the entire tree may fall.
- The bole may be burned to the extent that portions of it are missing which may cause the bole to break and parts of the tree to fall.
- The limbs may be severely burned making them likely to fall out of the tree.
- Before burning, the tree may have had many conks that indicate severe decay. They may have burned off, eliminating the indicators of root disease or heart rot. The result is that the tree may be more unstable than the visible indicators suggest.

Figure 5 Bark beetle mass attack

Figure 6 Crown decline

Figure 7 Basal resinosis

Figure 8 Wind throw & wind shatter

Figure 9 Standing dead & dying trees

Figure 10 Armillaria root disease mushrooms

Figure 11 Wind throw of live infected trees, laminated root rot

Figure 12 Armillaria root disease butt resin soaking

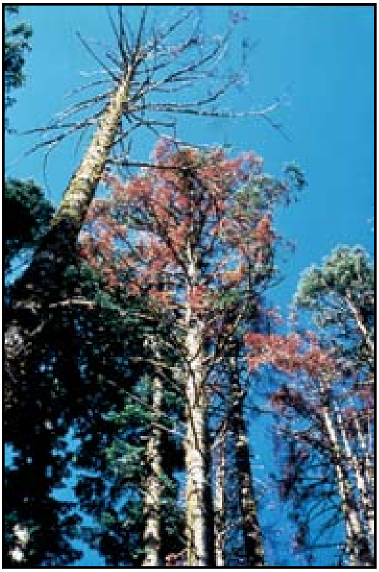

Figure 13 Trees die standing, armillaria root disease

Figure 14 Annosus root disease conks

Figure 15 Annosus root disease pustules

Figure 16 Annosus root disease wind throw

Figure 17 Tomentosus root rot engelmann spruce wind throw

Figure 18 Tomentosus root rot mushrooms

Figure 19 Brown cubical butt rot conk

Figure 20 Brown cubical butt rot butt swelling

Figure 21 Brown cubical butt rot conks

Figure 22 Brown cubical butt rot fresh conk

Figure 23 New lean soil cracking

Figure 24 Recent lean

Figure 25 Old lean

Figure 26 Heart rot indicators

Figure 27 Red rust stringy rot (Iindian Paint Fungus) conks

Figure 28 Red rust stringy rot conk color

Figure 29 Red ring rot conk

Figure 30 Red ring rot punk knot

Figure 31 Brown trunk rot, quinine conk

Figure 32 Red cedar pencil rot dry side

Figure 33 Incense cedar pecky rot conk

Figure 34 Sap rot conk

Figure 35 Sap rot conk

Figure 36 Lightning strike

Figure 37 Wind shake

Figure 38 Frost crack

Figure 39 Frost crack

Figure 40 Dead top

Figure 41 Broken top


Figure 42 Dwarf mistletoe bole swelling


Figure 43 Fungus canker


Figure 44 Dead trees