**City of Brookings**

# Special WORKSHOP Agenda

## CITY COUNCIL

**Monday, September 18, 2017, 7:00pm**
City Hall Council Chambers, 898 Elk Drive, Brookings, OR 97415

**A. Call to Order**
**B. Roll Call**
**C. Topics**
1. Azalea Park Tree Removal [Parks, Pg. 2]
    a. Arborist Report [Pg. 4]
    b. Cost Estimate [Pg. 14]
    c. Forestry Article [Pg. 16]
    d. Press Release [Pg. 17]
2. Submitted Materials
    a. 2014 Field Guide for Hazard Trees [Pg. 19]
    b. Long Range Planning for Developed Sites [Pg. 141]
    c. Email from Dennis Triglia [Pg. 273]
    d. Arboriculture and Wildlife: Approaches to Urban Wildlife Tree Retention [Pg. 274]
    e. Letter from Darlene Ashdown [Pg. 284]

**D. Adjournment**

All public City meetings are held in accessible locations. Auxiliary aids will be provided upon request with at least 72 hours advance notification. Please contact 469-1102 if you have any questions regarding this notice.

# CITY OF BROOKINGS

# COUNCIL WORKSHOP REPORT

Meeting Date: September 18, 2017

Signature ~~(submitted~~ by)

Originating Dept: Parks

City Manager Approval

Subject: Azalea Park Tree Removal

Background/Discussion:

Throughout the history of Azalea Park, from the time it was owned by the State through the transfer to the City, many trees have been removed for various reasons that include development, hazard and Sudden Oak Death mitigation. The Sudden Oak Death mitigated area was replanted shortly after 150 trees were removed and is now recovering with 12-15ft tall Redwood and Cedar trees emerging throughout the area.

In December 2014 during a storm a tree uprooted and fell into the adjacent trees near the intersection of Old County Road and Lundeen Road. The incident prompted a closer look at the condition of the remaining trees. This removal was initiated by Coos Curry Electric Cooperative due to concerns the trees would fall onto high transmission lines disrupting electric power service in the community. The City Council authorized the removal of 38 trees citing concern for public safety.

The tree removal along Lundeen Road prompted a closer look at all trees in high traffic areas of Azalea Park, and to assess their condition and potential risk to park visitors. The process included Oregon State Forester (Urban Forester) Kristin Ramstad who gave a presentation followed by a walking tour of Azalea Park. Ramstad also presented literature published by the International Society of Arboriculture (ISA) titled "How To Recognize and Prevent Tree Hazards". Based on this document, coupled with the experience with the Lundeen Road trees, staff consulted with experts Noah Mitchell (Western Pacific Tree Removal Service) and Rusty Strain (Leatherneck Logging) in identifying trees in Azalea Park that fall under the criterion of "hazard trees". In addition to hazard trees, the work plan map identifies trees that shade native azaleas and tend to fall on the lower end of aesthetics. A tree removal work plan identifying the area of tree removal and preservation areas (see attached tree removal work plan map) was developed and adopted by City Council in December 2016.

The tree removal work plan identifies hazard trees to be removed in specified areas but also identifies areas for preservation and maintenance. The majority of the 60 trees identified in this project for removal exhibit one or more of the following problems; have "conk", split trunk, deadwood or broken tops, one sided foliage and leaning or dying. Other factors include hazard trees in high traffic areas, areas of dense congregation of people and potential property damage.

The recent contract with Western Pacific Tree Service to remove 60 trees is a zero sum contract. The City will receive no money for the trees harvested in this contract. The value placed on the trees identified in this contract is $21,000 (relatively low due to defect) which will be surrendered to the contractor in exchange for the work to remove the trees. The City did receive funds from the trees removed along Lundeen Road and is using those funds to replant the area in the Fall of 2017. The remaining funds from that project will also fund the replanting of designated areas within the 60 tree removal contract.

The project was delayed when a petition surfaced calling for the City to reconsider the tree removal project. Staff was instructed to gather more information.

The City contracted with Licensed Arborist Brian French, owner of Arboricultural International out of Portland Oregon, in the amount of $1972. French is considered one of the leading urban forestry consultants in the state and came highly recommended by Oregon State Forester (Urban Forester) Kristen Ramstad. Staff worked with French to collect data on the trees proposed to be removed and created a map. The data and map were then used to generate a report by French that lists conditions and recommendations moving forward. The report is 146 pages long and available for viewing on the City webpage.

Staff has obtained a proposal from Western Pacific Tree Service to undertake the work as outlined in the French report. The cost proposal is $23,860. There would be no recovery from tree sales. There is no funding in 2017-18 for this work.

Staff issued two press releases announcing the special workshop. The information was published in the Curry Coastal Pilot, announced on Curry and KCIW radio, and posted on the City website. the press release called upon anyone who wished to present information on the proposed tree removal to do so in writing by September 11, 2017. No written materials were received.

French will attend the September 18 workshop and make a presentation on becoming a Tree City USA as well as answer questions regarding the Arborist Report.

Attachments:

a. Arboriculture International - pages 1-10 excerpt from Arborist Report
b. Western Pacific Tree Service Inc. - Estimate based on Arborist Report
c. Oregon Department of Forestry Article - Managing Phellinus Pini (Conk) in City Parks
d. City Press Releases

# ABORICULTURE INTERNATIONAL

# Arborist Report

## Tree Inventory, Condition Report and Recommendations

### PREFACE

This report was prepared at the request of the City of Brookings for inventory and condition ratings of 62 trees located near center of Azalea Park, Brookings, Oregon. Recommendations to remove or retain trees were given after reviewing visual risk assessments.

Tony Baron
Parks and Planning Manager, City of Brookings
(541) 469-1159
abaron@brookings.or.us

Report by Brian French, principal of Arboriculture International, ISA Certified Arborist PN-2786AT and Tree Risk Assessor #CTRA 670 prepared this evaluation.

Unless expressed otherwise, the information contained in this report covers only those items that were examined and reflects the condition of those items at the time of inspection. The inspection is limited to visual examination of accessible items without dissection, excavation, probing, or coring. There is no warranty or guarantee, expressed or implied, that problems or deficiencies of the trees in questions may not arise in the future.

**RE: Tree inventory, condition report and recommendations for trees located at Azalea.**

Date: 6/13/2017
Attn: Tony Baron
Site Address: Azalea Park, Brookings, OR

April 3rd 2017, I was referred to Tony Baron by Kristen Ramstad from the Oregon Department of Forestry to assist with tree risk assessment and recommendations as a certified and consulting arborist. Tony and I made plans to meet, inventory and make recommendations for trees located at Azalea Park. The following report is based on this inventory.

**Table of Contents**

## Summary of Site and Tree Conditions

This park is dominated by stands of mature Douglas-fir trees that offer shade, vertical space, structural diversity and decaying woody debris that supports a diverse understory of plants and wildlife. Overall, the stand appears healthy and vigorous. However, there are individual trees that, in their condition, may pose threats to public safety and property. Although some of the trees are not identified as 'likely to fail', trees are living organisms and will require future monitoring as health and structure will change over time.

## Assignment

Tree Inventory

The purpose of this tree inventory and VTA is to:

- Assess the health and structural condition of significant trees growing within sections as identified.
- Assess the probability of failure of full tree and/or part of tree i.e. deadwood, branch, stem and list likelihood.
- Provide recommendations to prune, remove or retain trees within subject areas.

The tree inventory includes a number to identify each tree. Each tree with an assigned number in the report is photographed. 62 trees are evaluated as part of this report and all are located within the park limits. Trees smaller than 6 inches DBH were not included in this report. The individual tree data is provided on the attached Tree Evaluation spreadsheet (Appendix A).

## Methods

I used a Visual Tree Assessment (VTA) method to evaluate tree health and structure. VTA is based on the outward indications of tree stress and growth, as indicated by the formation of new tree parts, the shape of the new wood and the amount of live tissue. Trees adapt to current and past stress by growing wood to support themselves in an upright condition. This type of assessment is facilitated by my personal knowledge of tree growth as it relates to structural integrity. I used a diameter tape marked in inches on one side and with diameter calculations on the opposite for measuring tree diameter.

Inventory Methodology

The evaluated trees within the park areas were assessed for the following information:

Assigned tree number
Tree species
Trunk diameter (4.5' above grade)
Height
Crown Class
Condition note
Recommendation
Photo

The following are crown class types and their definitions:

Dominant – Typically open grown and free from competition
Co-Dominant – Growing together as a group
Sub-dominant – Growth restricted by other trees nearby
Suppressed – Growth severely restricted by competing trees

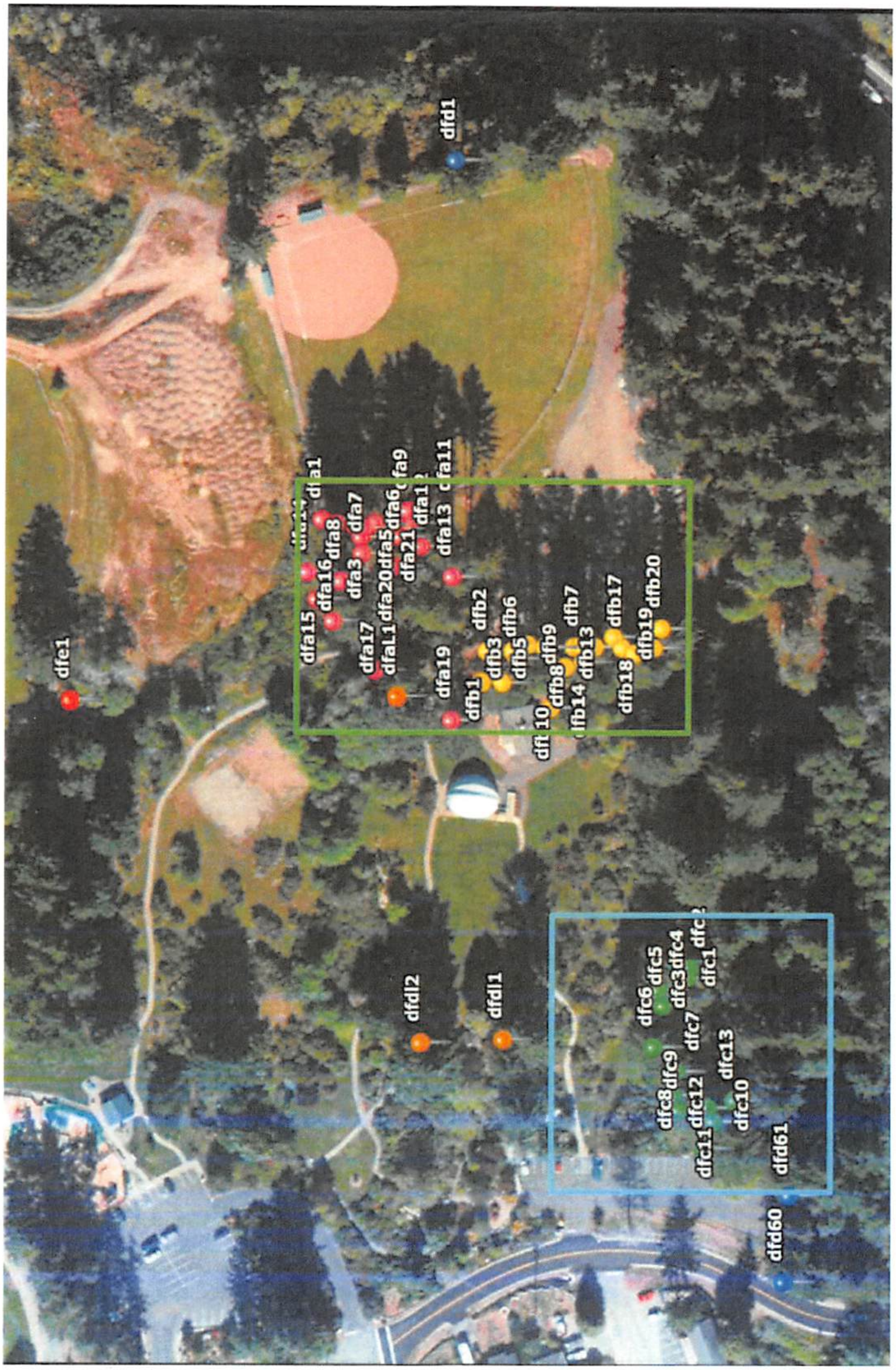
Condition notes offer additional information about trees with defects or structure that may lead to a 'likely' failure. This evaluation is of above ground structures only, and additional defects may exist at root collars or within the root systems. Furthermore, this inventory and evaluation does not consider pests, disease or any other factors that may affect the trees' health at this time.

**Limits of Assignment**
Unless stated otherwise: 1) Information contained in this report covers only those trees that were examined and reflects the condition of those trees at the time of inspection; and 2) The inspection is limited to visual examination of the subject trees without dissection, excavation, probing, climbing, or coring unless explicitly specified. There is no warranty or guarantee, expressed or implied, that problems or deficiencies of the subject trees may not arise in the future. Additional Assumptions and Limiting Conditions can be found in Appendix C.

## Appendix A – Maps, Tree Inventory & Photographs

**Map:** This map provides satellite view of the park's tree canopy density and pinpoints of trees inventoried in this report. The colored pins indicate sections inventoried. The colors and ID numbers correlate with the inventory table on page 7.

Arboriculture International LLC :: Phone: 503 709 0439 :: ai.brianfrench@gmail.com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dfc1
dfc5
dfc6
dfc7
dfc9
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dfd61

## Tree Inventory

| Section | Tree ID # | *Species* | Height | DBH | Crown Class | Condition Notes | Recommendation | Photos |
|---|---|---|---|---|---|---|---|---|
| A | T1 | *D-fir* | 126 | 41 | Co-Dominant | co-dominant 4 stems, sparse, decline | | P 11,12 |
| A | T2 | *D-fir* | 119 | 41 | Co-Dominant | co-dominant 3 stems, conks | | P 13-15 |
| A | T3 | *D-fir* | 131 | 28 | Co-Dominant | 3 degrees lean | | P 16 |
| A | T4 | *D-fir* | 131 | 33 | Co-Dominant | 10 degrees lean, conks | | P 17,18 |
| A | T5 | *D-fir* | 137 | 25 | Co-Dominant | | | P 19,20 |
| A | T6 | *D-fir* | 98 | 18 | Suppressed | Co-dominant stems, included bark, canker | | P 21-23 |
| A | T7 | *D-fir* | 111 | 24 | Dominant | 15 degrees lean, buttress planning on tension side | Removal | P 24-26 |
| A | T8 | *D-fir* | 124 | 46 | Co-Dominant | Co-dominant 3 stems, included bark on upper stems, conks | | P 27,28 |
| A | T9 | *D-fir* | 137 | 28 | Dominant | Buttress planning, appears stable | | P 29,30 |
| A | T10 | *D-fir* | 137 | 26 | Dominant | Low crown ratio | | P 31,32 |
| A | T11 | *D-fir* | 70 | (S1)18, (S2)41 | | Co-dominant stems: (stem1: low crown ratio, poor diameter to height ratio, co-dominant and broken top) (stem 2: epicormics, broken top with slight lean | | P 33,34 |
| A | T12 | *D-fir* | 134 | 24 | Dominant | | | P 35 |
| A | T13 | *D-fir* | 72 | 24 | Sub-Dominant | Asymmetrical crown, low crown ratio | | P 36,37 |
| A | T14 | *D-fir* | 137 | 34 | Dominant | Sparse crown, dead branches and hangers | Pruning | P 38,39 |
| A | T15 | *D-fir* | 111 | 38 | Dominant | Bulbous concave at 50' | | P 40,41 |
| A | T16 | *D-fir* | 131 | 32 | Co-Dominant | | | P 42,43 |
| A | T17 | *D-fir* | 55 | 16 | Dominant | Long arched branch over sidewalk, recommend weight reduction | Pruning | P 44-46 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | T19 | *D-fir* | 134 | " | Dominant | Co-dominant stems, broken branches, deadwood | Reduction long branch, deadwood prune | P 47-49 |
| A | T20 | *D-fir* | 128 | 58 | Dominant | Co-dominant top, concave in stem at 60ft | | P 50,51 |
| A | T21 | *D-fir* | 134 | 30 | Dominant | | | P 52,53 |
| A | T22 | *D-fir* | 150 | 41 | Dominant | | | P 54,55 |
| A | L1 | *D-fir* | 134 | 68 | Dominant | Co-dominant stems, long heave lateral branches, high crown complexity | Weight reduction pruning on heavy branches, Level 2 assessment | P 56-58 |
| B | T1 | *D-fir* | 141 | 37 | Co-Dominant | Co-dominant stems, included bark, conks | Height reduction on smaller stem by 30% | P 59-61 |
| B | T2 | *D-fir* | 131 | 33 | Co-Dominant | Conks | | P 62,63 |
| B | T3 | *D-fir* | 131 | 37 | Co-Dominant | Emergent above other trees | | P 64,65 |
| B | T4 | *D-fir* | 134 | 34 | Dominant | Swelling at base, conk at base | Level 2 assessment | P 66-70 |
| B | T5 | *D-fir* | 101 | 24 | Co-Dominant | 6 degree lean towards parking area | | P 71,72 |
| B | T6 | *D-fir* | " | 34 | Co-Dominant | Co-dominant stem | | P 73-75 |
| B | T7 | *D-fir* | 134 | 43 | Dominant | Major co-dominant stems | Mitigation work, possible removal | P 76,77 |
| B | T8 | *D-fir* | 104 | 26 | Co-Dominant | | | P 78,79 |
| B | T9 | *D-fir* | 91 | 42 | Co-Dominant | Suppressed crown, broken top with 4 secondary tops | Prune out hazardous deadwood | P 80,81 |
| B | T10 | *D-fir* | 141 | 41 | Co-Dominant | 10 degree lean, self-corrected, emergent top | Prune dead branches | P 82,83 |
| B | T11 | *D-fir* | 124 | 30 | Co-Dominant | Emergent top, severe conks | Removal | P 84,85 |
| B | T12 | *D-fir* | 85 | 20 | Co-Dominant | Conks in lower crown | Level 2 assessment | P 86,87 |
| B | T13 | *D-fir* | 121 | 38 | Co-Dominant | Grafted co-dominant stems | Prune dead branches | P 88,89 |
| B | T14 | *D-fir* | 127 | 48 | Co-Dominant | Emergent top, vigorous epicormic growth | Prune dead branches | P 90,91 |
| B | T16 | *D-fir* | 85 | 18 | Suppressed | | | P 92,93 |
| B | T17 | *D-fir* | 124 | 31 | Co-Dominant | | Reduction pruning on long branches over | P 94,95 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | sidewalk | |
| B | T18 | *D-fir* | 121 | 40 | Co-Dominant | Conk | Reduction pruning on long branches over sidewalk | P 96,97 |
| B | T19 | *D-fir* | 114 | 34 | Co-Dominant | | | P 98-100 |
| B | T20 | *D-fir* | 121 | 36 | Co-Dominant | Sparse crown with epicormics, crown dieback | Monitor health | P 101-103 |
| C | T1 | *D-fir* | 141 | 48 | Dominant | Hangers, large dead branches | Prune dead branches, crown raise 2 whorls | P 104,105 |
| C | T2 | *D-fir* | 131 | 27 | Co-Dominant | 6 degree lean, deadwood and hangers | Prune dead branches | P 106,107 |
| C | T3 | *D-fir* | 131 | 38 | Co-Dominant | 7 degree lean, deadwood | | P 108,109 |
| C | T4 | *D-fir* | 134 | 33 | Dominant | Co-dominant stems, dead and broken branches | Reduce co-dominant leader for light on azaleas, possible removal | P 110,111 |
| C | T5 | *D-fir* | 124 | 28 | Dominant | Deadwood and hangers, co-dominant stems | Reduce co-dominant stem, possible removal | P 112,113 |
| C | T6 | *D-fir* | 72 | 33 | Co-Dominant | Long heavy lateral branches, broken top with reiterations, hangers and deadwood | Removal | P 114,115 |
| C | T7 | *D-fir* | 118 | 10 | Co-Dominant | 5 degree lean some deadwood | | P 116,117 |
| C | T8 | *D-fir* | 118 | 28 | Co-Dominant | Co-dominant stems, included bark, conk | | P 118,119 |
| C | T9 | *D-fir* | 127 | 27,16 | Co-Dominant | Co-dominant trunks, dead branches | Prune dead branches, crown raise | P 120,121 |
| C | T10 | *D-fir* | 137 | 38 | Dominant | Co-dominant tops, possible included bark, history of limb failure, dead branches, hangers | Prune to remove hazard branches, inspect top, possible crown reduction | P 122,123 |
| C | T11 | *D-fir* | 141 | 36 | Co-Dominant | Dead branches | | P 124,125 |
| C | T12 | *D-fir* | 127 | 48 | Co-Dominant | Emergent top, asymmetrical crown, large deadwood at park entrance | Prune dead branches | P 126,127 |
| C | T13 | *D-fir* | 147 | 68 | Dominant | Co-dominant stems near trunk, included bark, history of limb failures | Crown reduction or possible removal | P 128,129 |
| D | L1 | *D-fir* | 111 | 72 | Dominant | Co-dominant leaders, high crown complexity, dead branches, broken branches, large hangers, conks, | Weight reduction on reiterations, remove deadwood | P 130,131 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | included bark on middle reiteration | | |
| D | L2 | *D-fir* | 98 | 54 | Dominant | Co-dominant stem, conks | Deadwood removal, climb to inspect crown | P 132,133 |
| D | T1 | *D-fir* | | | Dominant | Crown dieback | Removal | P 134 |
| D | T50 | *D-fir* | | | | Co-dominant stems, included bark, 20 degree lean | Removal | P 135 |
| D | T60 | *D-fir* | | | Co-Dominant | Crown decline | Removal | P 136 |
| D | T61 | *D-fir* | | | Co-Dominant | Suppressed crown, low crown ratio | Removal | P 137 |
| E | T1 | *D-fir* | | | Dominant | 48" of backfill on trunk within the critical root zone (CRZ) | Removal | P 138 |

**Guide to abbreviations:**

*D-fir – Pseudotsuga menziezii*, Douglas-fir

# Western Pacific Tree Service, Inc.

Estimate

P.O. Box 998
Brookings, OR 97415

Phone: 541-469-7450
Fax: 541-813-1256

| Date | Estimate # |
|---|---|
| 9/4/2017 | 2017 |

| Name / Address |
|---|
| City of Brookings<br>Attn: Tony Baron<br>898 Elk Dr.<br>Brookings, OR 97415 |

| Description | Qty | Rate | Total |
|---|---|---|---|
| Estimates regarding arborist report dated 6/13/2017<br>Each bid includes fulfilling arborist recommendation with complete clean up of all debris. All Pruning will be from either an Aerial Lift or climbed using SRT for low impact to crown of trees. | | 0.00 | 0.00 |
| AT7 Doug Fir | | 975.00 | 975.00 |
| AT14 | | 275.00 | 275.00 |
| AT17 | | 200.00 | 200.00 |
| AT19 | | 575.00 | 575.00 |
| AL1 | | 1,850.00 | 1,850.00 |
| BT7 | | 2,200.00 | 2,200.00 |
| BT1 | | 425.00 | 425.00 |
| BT9 | | 325.00 | 325.00 |
| BT10 | | 325.00 | 325.00 |
| BT11 | | 725.00 | 725.00 |
| BT13 | | 325.00 | 325.00 |
| BT14 | | 325.00 | 325.00 |
| BT17 | | 225.00 | 225.00 |
| BT18 | | 225.00 | 225.00 |
| CT1 | | 650.00 | 650.00 |
| CT2 | | 325.00 | 325.00 |
| CT3 | | 350.00 | 350.00 |
| CT4 | | 1,900.00 | 1,900.00 |
| CT5 | | 750.00 | 750.00 |

| Total | |
|---|---|

# Western Pacific Tree Service, Inc.

Estimate

P.O. Box 998
Brookings, OR 97415

Phone: 541-469-7450
Fax: 541-813-1256

| Date | Estimate # |
|---|---|
| 9/4/2017 | 2017 |

| Name / Address |
|---|
| City of Brookings<br>Attn: Tony Baron<br>898 Elk Dr.<br>Brookings, OR 97415 |

| Description | Qty | Rate | Total |
|---|---|---|---|
| CT6 | | 875.00 | 875.00 |
| CT7 | | 325.00 | 325.00 |
| CT9 | | 475.00 | 475.00 |
| CT10 | | 1,100.00 | 1,100.00 |
| CT11 | | 325.00 | 325.00 |
| CT12 | | 325.00 | 325.00 |
| CT13 | | 650.00 | 650.00 |
| DL1 | | 1,700.00 | 1,700.00 |
| DL2 | | 760.00 | 760.00 |
| DT1 | | 825.00 | 825.00 |
| DT50 | | 600.00 | 600.00 |
| DT60 | | 2,100.00 | 2,100.00 |
| DT61 | | 625.00 | 625.00 |
| ET1 | | 225.00 | 225.00 |

**Total** **$23,860.00**

# Managing *Phellinus pini* in City Parks

*Phellinus pini*, also called red ring rot, or white-speck, is a fungal disease that causes heart rot of several species of coniferous trees. It can attack second growth trees, as well as old growth. Red ring rot enters into the heartwood of the tree via living or dead branches and stubs, not through trunk wounds. One of the visible signs of the disease on standing trees is the presence of conks (fungal bodies) growing on the bark of the tree, often out of old branch wounds. These conks can range in size from just a few inches across up to about nine inches wide. On the lower side of a conk is a flat, light brown surface is composed of tiny tubes; on the upper side, the conk sometimes looks like a small lumpy horse's hoof, but it can take other forms as well. In cross section, infected wood contains small white pockets that are sometimes distributed along the growth rings of a tree, hence the name white-speck. While many people imagine "rot" to appear wet and spongy, this disease causes the heartwood of infected trees to become brittle and dry. The presence of red ring rot quickly degrades the strength and quality of the timber in a stand of trees.

In Oregon parks with native remnant Douglas-fir stands, it is common to find one to several trees with red ring rot conks. Because *Phellinus pini* degrades a tree's heartwood, and usually leaves the outer ring of conductive sapwood intact, the tree can remain relatively stable for a several years even though it has this disease. As long as the sound wood (undecayed) ring is wide enough to support the tree, the incidence of failure will be relatively low. From a park management perspective, trees with *Phellinus pini* conks should be annually inspected by an experienced forester or arborist to determine the quantity and quality of sound wood.

If tree removal is necessary, it should be done with the complete awareness of how the removal may affect the dynamics of the entire stand. For example, large trees growing on the windward side of a stand have the strength to withstand wind gusts, and by their location can contribute to the stability of the trees on the interior of a stand. However, stand stability is not merely a question of keeping the wind-firm edge trees intact. Removal of too many trees inside of a stand -- or even just a few of the larger dominant trees in the interior of the stand – can also adversely affect stand stability. It may be better to remove the infected trees – prioritizing the removal of the most hazardous ones – over a period of years. Generally speaking, it may also be prudent for cities to restrict public entry into parks of native remnant trees during windstorms and severe weather, especially when *Phellinus pini* or other defects are present.

**Managing *P. pini* in City Parks**
By K. Ramstad, Community Assistance Forester
OR Dept Forestry. April 2011. Page 1 of 1

**CITY OF BROOKINGS**
**Press Release: For immediate release**
September 6, 2017

# Written Submittals for Azalea Park Trees Workshop Due September 11

The Brookings City Council is encouraging public comment on an arborist report concerning the condition of trees at Azalea Park and the recommended removal of nine trees.

The report by certified arborist Brian French is available for review on the City's website at http://or-brookings.civicplus.com/Archive.aspx?ADID=554. Public review copies are also available at the City Recorder's Office at City Hall and the Chetco Public Library.

The 146-page document inventories and provides condition ratings for 62 trees located in Azalea Park.

"The City Council requests written comments that will be considered during a City Council workshop concerning this matter on September 18," said Mayor Jake Pieper. "Written comments and related documents should be provided to the Recorder's Office at City Hall no later than September 11 to allow for the Council to review the materials prior to the meeting."

"We are looking for information supported by documentation that will assist the City Council with making decisions concerning the future of trees that had earlier been identified as potential hazard trees at Azalea Park," Mayor Pieper said. "While we will take public comment at the workshop, citizens can make a more meaningful contribution by providing information in writing."

The workshop will be held in the Council Chambers beginning at 7:00 p.m. French will attend to provide background.

Plans to remove as many as 60 trees were placed on hold in May after a number of citizens expressed concern. French recommends the removal of nine trees and that another six be further evaluated by climbing and taking core samples. He also recommends that a number of other trees receive substantial pruning and close monitoring…and could become candidates for removal.

"Staff will be obtaining cost estimates for the removal and pruning work and will have this information available at the workshop," said City Manager Gary Milliman.

French is founder of the Portland based tree care company Arboriculture International. He has been a climbing certified arborist since 2002 and is an International Society of Arboriculture qualified tree risk assessor. Serving as coordinator for the Oregon Champion Tree Registry and Portland Heritage Tree Program Chair, his work focuses primarily on the preservation of significant, old trees and associated flora and fauna. He served as the

Municipal Arborist in Beaverton and has performed extensive volunteer work for organizations like the Audubon Society of Portland.

No decisions will be made at the workshop. “This is an information exchange opportunity,” Pieper said.

**NEWS MEDIA CONTACT INFO:** For further information regarding this press release, please call 541-469-1102.

for the greatest good

# Field Guide for Hazard-Tree Identification and Mitigation on Developed Sites in Oregon and Washington Forests

2014

**Non-Discrimination Policy**

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religión, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases will apply to all programs and/or employment activities.)

**To File an Employment Complaint**

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (click the hyperlink for list of EEO counselors) within 45 days of the date of the alleged discriminatory act, event, or in the case of a personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

**To File a Program Complaint**

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html, or at any USDA office, or call (866) 632-9992 to request the form. Send your completed complaint form or letter to us by mail at U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, by fax (202) 690-7442 or email at program.intake@usda.gov.

**Persons with Disabilities**

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***Front cover photo:*** This Douglas-fir was felled because of high-failure potential due to laminated root rot.

# Field Guide for Hazard-Tree Identification and Mitigation on Developed Sites in Oregon and Washington Forests

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***Suttle Lake, Deschutes National Forest***

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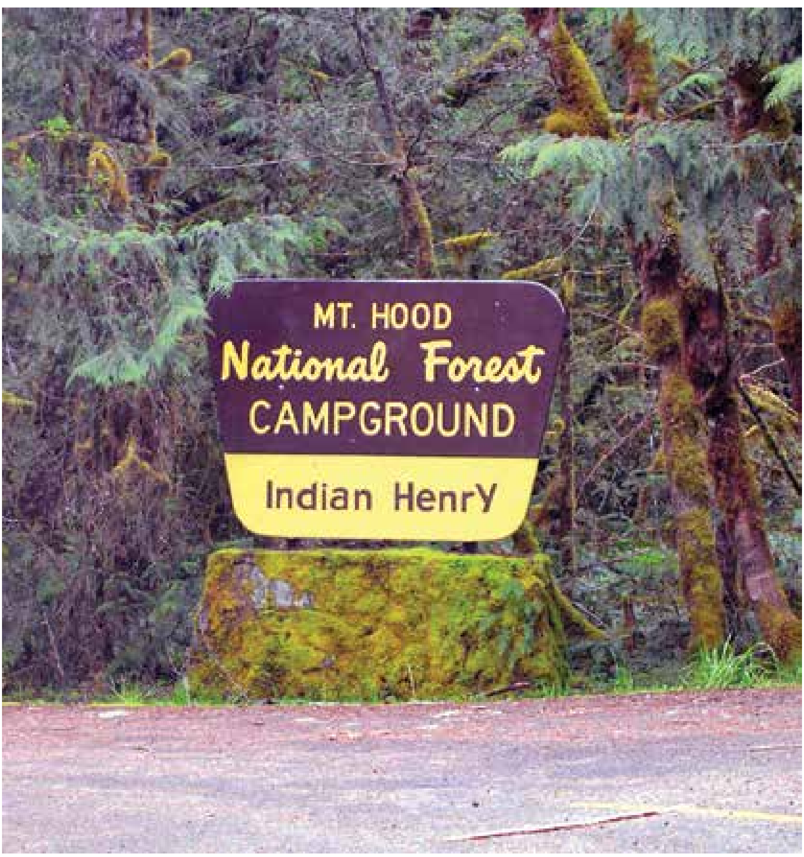
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# Introduction

Hazard-tree management requires unique skills that combine science and intuition. It requires observation, knowledge of the site, experience with tree defects and decays, thorough investigation, and adequate documentation. This guide is intended to aid users in hazard-tree identification, evaluation, and mitigation with an emphasis on native forest trees of the Pacific Northwest.

This guide is for forest-resource managers, recreation staff, pest-management specialists, concessionaires, consultants, and arborists who deal with developed sites in forested areas and need to identify, monitor, and mitigate hazard trees. It is a revision of a similar guide: "Long-range planning for developed sites in the Pacific Northwest: the context of hazard tree management" (Harvey and Hessburg 1992). We recommend that this guidebook be used for identifying and mitigating hazard trees in and around developed sites such as campgrounds, picnic areas, ski areas, boat launches, parking lots, trailhead parking areas, buildings, and administrative complexes. These sites should have a thorough, systematic survey by knowledgeable inspectors due to the long-term exposure and high target values. Such sites should be frequently visited and trees of concern documented, treated or retained, and periodically monitored.

Forest trees, especially large ones, greatly add to the beauty and enjoyment of developed sites. Pathogens, insects, and weather events, however, can cause substantial damage to forest trees in the Pacific Northwest. Reducing this damage is an objective of managers for most forest sites. On developed sites, tree damage may pose a hazard to the safety of people or their property. Developed sites are places where people often congregate and are exposed for longer than intermittent time periods to potentially failing trees. Camp sites and buildings, where breakage from or failure of defective trees could result in damage to people or their property, are examples of valuable targets that need to be protected. Targets that are exposed during the winter, when storms often cause trees or their parts to fail, are particularly vulnerable to tree failure and subsequent damage. The longer the exposure to tree hazards, the greater the potential for property damage or personal injury.

Tree and stand decadence increase with disturbance, advancing age, and forest community succession. With increased decadence comes an increased presence of defective trees prone to failure. In most plant-community types, the result of developed-site use and tree-hazard mitigation has been accelerated succession and increased stand decadence over time. Although trees are a renewable resource, there has been resistance to removing large, old, defective trees from developed sites simply because it takes centuries for them to develop.

Removal or mortality of early seral species increases the proportion of shade-tolerant species such as grand/white fir or hemlock. In community types with these species, repeated hazard-tree removals have promoted shifts in vegetation toward climax conditions and the associated higher susceptibility to insect- and disease-caused damage that typify many developed sites today. Other sites, such as those in dry ponderosa pine communities, tend to remain in pine dominance, even with removals. Trees on these sites are generally more resilient to insects and diseases and usually have a relatively low incidence of damaging agents that could predispose them to failure.

This guide will assist you in appropriately inventorying, documenting, and treating hazard trees. The objectives of this guide are to present:

1) The need to develop long-term management plans for developed sites
2) A standard for evaluating tree hazards in developed sites
3) An up-to-date field aid for accurate identification of diseases, defects, and resulting tree-failure potential
4) A standard for recording developed-site evaluations

*Mt. Baker, Mt. Baker-Snoqualmie National Forest*

# Chapter 1 - Vegetation-Management Planning and Mitigating Tree Hazards

To maintain a balance of benefits in the long term, managers of developed sites must contend with several forest-disturbance agents. The most obvious effects that these agents have on developed sites occur through their influence on forest health and succession. Insects, diseases, and abiotic factors such as wind, drought, and snow cause the deterioration and demise of trees. When removing hazard trees, we may need to consider and plan for replacement vegetation to achieve the desired future condition of the site and the associated vegetation. This, of course, needs to be tailored to the plant community of the site and the silvics of the desired tree species. This constitutes the heart of a vegetation-management plan, which is advisable for documenting both a site-specific and administrative-unit management strategy.

## Hazard-Tree Mitigation as a Part of Vegetation Management

Hazard-tree mitigation is one of many management actions prescribed in a vegetation-management plan. Appropriate hazard-tree management complements other management actions to achieve a common set of goals. The primary objective of vegetation-management planning is to develop a description of the desired future condition of the vegetation and the strategy to achieve that goal. Input by various resource specialists should be included.

Older stands with multiple canopy layers generally make highly attractive and aesthetically desirable recreation areas. It may take two or more centuries to develop stand structures that contribute to the most desirable recreation sites. Development and maintenance of desirable older stand structures needs to be a planned objective, and achieving that goal requires management actions that are dependent on the type of plant community and the existing biotic and abiotic disturbance agents. In some situations, it may be difficult or impossible to maintain old-growth structure and keep the area safe. Thus, for future recreation sites it might be more desirable to place them in younger stands because they are often hazard free and more easily managed.

Hazard-tree evaluations, as part of a vegetation-management plan, should involve a systematic, peer-accepted evaluation process that identifies and mitigates hazards and reduces them to acceptable levels. The process needs to be repeatable with continuity over time as personnel change. Record keeping is important, especially documenting trees to be monitored and assuring that hazard trees deemed unacceptably dangerous are mitigated.

Many federally owned developed-recreation sites are being managed by private concessionaires, who may be tasked with the identification and mitigation of hazard trees on those sites. It therefore becomes important that recreation managers work closely with concessionaires on hazard-tree documentation, monitoring, and integration with vegetation-management plans.

## What Constitutes a Hazard?

In recreation-resource management, hazard is the exposure to the possibility of loss or harm. With reference to trees, it is the recognized potential that a tree or tree part may fail and cause injury or damage by striking a target. All standing trees within areas occupied by people, property, and structures present some level of hazard. Failure potential by itself does not constitute a hazard. Hazard exists when a tree of sufficient size and mass to cause injury or damage is within striking distance of people, property, or structures (targets). Hazard increases with increasing tree defect, failure potential, potential for damage, and target value. Management actions are taken when the line officer or land manager decides to mitigate the hazard when risks (the product of damage potential and consequences of damage) are unacceptable.

Hazard is defined as acceptable (we will not mitigate) when:

1) All components of hazard have been fully evaluated, and

2) Failure and/or damage probability is estimated to be low

Hazard is unacceptable (we will mitigate) when:

1) The amount of defect indicates failure is likely,

2) The failure potential and relationship to targets indicates damage is likely, and

3) Targets include people, property, or structures

Hazard evaluations assess both failure potential and damage potential.

## Hazardous Trees and Associated Liabilities

In this guide, a *hazard tree* is any tree that is within striking distance of a permanent or transitory target of value. Any tree or tree part has some level of failure potential. Biotic and abiotic agents can interact to increase the likelihood of failure. If visitors wish to recreate in forests, they must accept a certain amount of hazard. Land managers and evaluators must learn to recognize the signs of increasing hazard so it can be minimized.

Visitors can be grouped into three distinct classes: invited, licensed, and trespassing. For lands maintained open to the public, visitors are considered invited, and public-land managers are liable to an extent for their safety. The USDA Forest Service Manual (FSM 2309, 2330, 6703, 6730) outlines specific objectives, policies, and responsibilities for managers of recreation sites. These include documented hazard-tree evaluations by "qualified" people and may include corrective actions or treatments. Some liability for injury or loss lies with the landowner or agent for the land. In most states, a Recreational Use Statute or similar legislation provides protection to landowners by holding them free of liability resulting from accidents or deaths occurring on their lands held open for public use. This protection does not extend to landowners when a fee is levied. In this situation, and when gross negligence, intentional wrongdoing, or wanton misconduct is a factor, Federal Tort Claims rules apply. Land managers should carefully consider the benefits of protection afforded by Recreational Use Statutes before applying a user fee.

Informing the public that dangerous conditions exist does not eliminate liability. It is the responsibility of land managers or their agents to discover and correct unreasonably dangerous conditions to minimize the potential for injury to invited users or damage to personal property. Responsibility to actively minimize hazard is roughly proportional to the degree of development of an area. Highly developed sites infer a greater degree of responsibility than undeveloped areas. It is imperative that site managers conduct high-quality, hazard-tree evaluations and, as required, treatments that respond specifically to each unacceptable hazard. If no fee is levied for recreation-site use, posting signs to expose tree hazards and associated risks may reduce liability of the landowner or manager.

The goal in developing recreation sites is to provide facilities that visitors will use. Often, large, old-growth trees are the prime attractions, and those are the very trees that often present the greatest threat to public safety. The goal in managing these sites is to maintain the old-growth appearance while eliminating unacceptable risk to visitors. Similarly, the goal in managing any developed-recreation site is to maintain or improve the characteristics of the site that attracted visitors initially and that promoted formal development, while eliminating unacceptable risk to visitors.

## Goal of Hazard-Tree Management

Hazard-tree management historically has been used as a short-term fix to reduce hazard, but this usually does not, by itself, enhance the long-term health or aesthetics of the vegetation in developed sites. Vegetation-management plans should contain strategies to meet long-term goals or desired future condition of the vegetation. Hazard-tree management should be addressed in these plans, and most importantly, so should the strategy for developing or maintaining healthy, resilient, low-hazard trees. The goal of hazard-tree management is to strike a balance between providing healthy trees with low-failure potential and forest vegetation that provides an aesthetically pleasing and natural environment. Hazard-tree management, although based on valid science, is not an exact practice, and mistakes in identifying defects and tree-failure potential unfortunately are made. We provide this guide as a means to minimize these errors.

*South Shore Campground, Deschutes National Forest*

# Chapter 2 - Components of Hazard-Tree Analysis

Hazard-tree analysis involves inspecting and rating trees for their potential to fail and strike targets during the time between examinations. Since it is not reasonable to eliminate all hazards (i.e. all trees) from a developed site, the manager or responsible official must decide what constitutes an acceptable level of risk. Trees near targets and potential targets should be thoroughly inspected. Hazard-tree analysis also involves documentation and record-keeping of trees that have some level of defect but will be retained for the short term and periodically re-evaluated at some scheduled interval.

## A Process for Hazard-Tree Evaluation and Action

There are four steps that the evaluator should take when dealing with potential hazard trees in developed sites:

1) Identify tree defects, determine the tree's potential to fail, and assign a numerical score for failure potential.
2) Determine the potential-failure zone and damage potential, and assign a numerical score for damage potential.
3) Document the assessment and recommend treatment options to the manager or supervisor.
4) Document the completed action and the date it occurred.

The degree to which a tree is hazardous depends on two main factors: (1) Potential for failure and (2) potential that property damage, injury, or death will result from tree failure. Low numerical value for either factor implies minimal risk.

## What is Failure Potential?

Estimating the potential for tree failure may be difficult because of the many interacting variables: tree size, age, form, species, condition, and location; stand structure; site conditions; and presence and extent of tree defects (Table 1). Failure potential is estimated by examining a tree, determining the factors and conditions that could contribute to failure or weakening, and estimating the likelihood that those factors and conditions will simultaneously occur before the next inspection period. Tree characteristics to be evaluated include:

**Table 1. Failure indicators for high, medium, low, and very low-failure potentials for trees in developed sites in Oregon and Washington**

| | Failure Indicator | High-Failure Potential | Medium-Failure Potential | Low-Failure Potential | Very Low-Failure Potential |
|---|---|---|---|---|---|
| | | *Score = 4* | *Score = 3* | *Score = 2* | *Score = 1* |
| | **Dead trees** | **All** | **None** | **None** | **None** |
| **Roots** | **Live trees in laminated root rot centers** ***Phellinus weirii*** | Trees **with** signs or symptoms (ectotrophic mycelium or laminated decay; foliage thinning or yellowing) | **Douglas-fir, mountain hemlock, or true firs** ***without*** signs or symptoms and **≤25ft**. from an infected tree or stump (check for butt rot) | **Douglas-fir, mountain hemlock, or true firs**, ***without*** signs or symptoms and **>25ft.** from an infected tree or stump; **Larch, Engelmann spruce, or western hemlock** ***without*** signs or symptoms (check for butt rot) | **Pine, Sitka spruce, cedar, or hardwoods** ***without*** signs or symptoms |
| **Roots** | **Live trees in Armillaria or annosus root disease centers** ***Armillaria*** **spp.** ***Heterobasidion*** **spp.** | Trees **with** signs or symptoms (mycelial fans, resinosis, staining, conks, or wounds with decay; foliage thinning or yellowing) **and** adjacent (≤50 ft.) to windthrown trees with root disease | Trees **with** signs or symptoms but **not** adjacent to windthrown trees with root disease (check for butt rot) | Susceptible tree species **without** signs or symptoms (Table 6) (check for butt rot) | Resistant tree species **without** signs or symptoms (Table 6) |
| **Roots** | **Live trees in black stain or Port-Orford-cedar root disease centers** ***Leptographium wageneri; Phytophthora lateralis*** | None | None | Trees **with** signs or symptoms (foliage thinning or yellowing; stained inner bark or sapwood) | Trees **without** signs or symptoms |
| **Roots** | **Undermined or severed roots** | Trees with **<50%** of the structural roots remaining in the ground | Trees with **50 to 75%** of the structural roots remaining in the ground | Trees with **>75%** of the structural roots remaining in the ground | None |

| | Failure Indicator | High-Failure Potential | Medium-Failure Potential | Low-Failure Potential | Very Low-Failure Potential |
|---|---|---|---|---|---|
| | | *Score = 4* | *Score = 3* | *Score = 2* | *Score = 1* |
| | **Dead trees** | **All** | **None** | **None** | **None** |
| **Butt** | **Butt rot: *Tomentosus, Schweinitzii, Ganoderma*, or *P. subacida*** | Tree with extensive decay: sound-rind thickness **<15%** of stem diameter[1] (Table 3A) or decay in **>50%** of the structural roots | Tree butts with moderate decay: sound-rind thickness **15 to 25%** of stem diameter or decay in **<50%** of the structural roots | Trees with little or no decay: sound-rind thickness is **>25%** of stem diameter and **no** decay in structural roots | None |
| **Butt** | **Fire-damaged trees for recent (<5yr) fire damage; use bole wounds for old fire damage** | Trees with **<50%** cross-section of bole with sound wood, or **more than one** quadrant of damaged structural roots | Trees with **50 to 75%** cross-section of bole with sound wood, or **one** quadrant of damaged structural roots except for cedar, ponderosa pine, sugar pine, and larch | **Cedar, ponderosa pine, sugar pine, and larch** with **>50%** cross-section of bole with sound wood; **Other species** with **>75%** cross-section of bole with sound wood | Trees with **100%** cross-section of bole with sound wood, and **no** damaged structural roots |
| **Bole** | **Bole wounds** | Trees with sound-rind thickness of **<20%** of stem diameter[1] (Table 3B) | Trees with sound-rind thickness of **20 to 30%** of stem diameter | Trees with sound-rind thickness of **>30%** of stem diameter | None |
| **Bole** | **Mistletoe cankers, fungal cankers** | Trees with **<50%** cross-section of bole with sound wood | Trees with **50 to 75%** cross-section of bole with sound wood | Trees with **>75%** cross-section of bole with sound wood | None |
| **Bole** | **Frost cracks** | Trees with **weeping** cracks and sound-rind thickness is **<20%** of stem diameter[1] (Table 3B) | Trees with **weeping** cracks and sound-rind thickness is **20 to 30%** of stem diameter | Trees with cracks with **no weeping** and sound-rind thickness is **>30%** of stem diameter | None |
| **Bole** | **Bole cracks** | Trees with splits or cracks **with** independent movement, or if decayed, sound-rind thickness is **<20%** of stem diameter[1] (Table 3B) | Trees with splits or cracks **without** movement, and sound-rind thickness is **20 to 30%** of stem diameter | Trees with splits or cracks **without** movement, and sound-rind thickness is **>30%** of stem diameter; callus has formed | None |

| | Failure Indicator | High-Failure Potential | Medium-Failure Potential | Low-Failure Potential | Very Low-Failure Potential |
|---|---|---|---|---|---|
| | | *Score = 4* | *Score = 3* | *Score = 2* | *Score = 1* |
| | **Dead trees** | **All** | **None** | **None** | **None** |
| **Conks** | **Quinine conks**<br>*Fomitopsis officinalis* | Trees with ≥1 conks | None | None | None |
| | **Indian paint fungus conks**<br>*Echinodontium tinctorium* | Trees with **multiple large** (≥6 in. wide) conks or **single large** or **multiple small** conks **and** at least one additional indicator of associated defect/decay such as open cracks or exposed rot, or sound-rind thickness at conks **<15%** of stem diameter[1] (Table 3A) | Trees with **single large** (≥6 in. wide) or **multiple small** conks **without** additional indicators of associated defect/decay, or sound-rind thickness at conk is **15 to 25%** of stem diameter | Trees with a **single small** conk, or sound-rind thickness at conk is **>25%** of stem diameter | None |
| | **Red ring rot conks**<br>*Phellinus pini* | Trees with ≥1 conks **and** evidence of extensive advanced decay[2] such as open cracks or exposed rot,<br><br>or sound-rind thickness at conks is **<15%** of stem diameter[1] (Table 3A) | **True fir, hemlock, spruce, or hardwoods** with ≥1 conks without evidence of excessive advanced decay; **Douglas-fir, pine, cedar, or larch** with ≥3 **large conks** (≥6 in. wide) **within** a 3-ft.-long trunk cylinder<br><br>or sound-rind thickness at conks is **15 to 25%** of stem diameter | Douglas-fir, pine, cedar, or larch with ≥3 large conks **not within** a 3-ft.-long trunk cylinder<br><br>or ≤2 large conks **within** a 3-ft.-long trunk cylinder or any number or location of **small conks**.<br><br>or sound-rind thickness at conks is **>25%** of stem diameter | None |
| | **Other heart-rot conks** | Trees with ≥1 conks **and** evidence of extensive decay such as open cracks or exposed rot, or sound-rind thickness at conks is **<15%** of stem diameter[1] (Table 3A) | Trees with ≥1 conks; **without** evidence of excessive decay, or sound-rind thickness at conks is **15 to 25%** of stem diameter | Trees with ≥1 conks, without evidence of excessive decay **and** sound-rind thickness at conks is **>25%** of stem diameter | None |
| | **Sap-rot conks**<br>*C. volvatus*<br>*F. pinicola*<br>*T. abietinum*<br>*C. purpureum* | **Dead trees** with sap-rot conks | **Live trees** with **>2 conks** on one or more stem quadrants usually associated with wounds | **Live trees with only 1 or 2 conks**; check for extent of dead bark and sound wood | None |

| | Failure Indicator | High-Failure Potential | Medium-Failure Potential | Low-Failure Potential | Very Low-Failure Potential |
|---|---|---|---|---|---|
| | | *Score = 4* | *Score = 3* | *Score = 2* | *Score = 1* |
| | **Dead trees** | **All** | **None** | **None** | **None** |
| **Tops and Branches** | **Forked or multiple tops or trunks** | Trees with V-shaped forks with embedded bark **and** open cracks, decay, or conks | Trees with V-shaped forks with embedded bark but **no** cracks, decay, or conks | Trees with U-shaped forks or V-shaped forks with **no** embedded bark, cracks, decay, or conks | None |
| | **Dead tops or branches (≥3 in. diameter)** | True fir, hemlock, spruce, or hardwoods with indicators of **significant** decay such as open cracks, conks, or exposed rot (tops and branches are high FP, not the whole tree) | **True fir, hemlock, spruce, or hardwoods** with **little** decay; **Douglas-fir or pine** with **significant** decay (tops and branches are medium FP, not the whole tree) | Douglas-fir or pine with **little** decay (tops and branches are low FP, not the whole tree) | **Cedar or larch**; **Pine tops** killed slowly by rust fungi that show **resin** impregnation (tops and branches are very low FP, not the whole tree) |
| | **Detached tops, branches, (≥3 in. diameter) or loose bark (≥1ft.$^2$)** | **All detatched parts** (parts are high FP, not the whole tree) | **Live and attached** tops or limbs but cracked or split (parts are medium FP, not the whole tree) | None | None |
| | **Dwarf mistletoe brooms** | Douglas-fir with **large** (≥10ft. in diameter) **dead** brooms (broom is high FP, not the whole tree) | **Douglas-fir** with **small, dead** brooms; **Other tree species** with **large, dead** brooms (broom is medium FP, not the whole tree) | **Douglas-fir** with **large, live** brooms; **Other tree species** with **small, dead** brooms (broom is low FP, not the whole tree) | **Douglas-fir** with **small, live** brooms; **Other tree species** with **live** brooms (broom is very low FP, not the whole tree) |
| | **Black-cottonwood branches** | Trees with large (≥3 in. diam.) live or dead branches with evidence of **decay** and past **breakage** | Trees with large, live branches with evidence of past **breakage** but **no decay** | Trees with large, live branches **without** decay or breakage | None |

| Failure Indicator | | High-Failure Potential | Medium-Failure Potential | Low-Failure Potential | Very Low-Failure Potential |
|---|---|---|---|---|---|
| | | *Score = 4* | *Score = 3* | *Score = 2* | *Score = 1* |
| | **Dead trees** | **All** | **None** | **None** | **None** |
| **Whole tree** | **Broken or uprooted trees supported by other trees** | All | None | None | None |
| | **Leaning and/or root-sprung trees** | Trees with recent (<5yr) lean ≥15 degrees or old uncorrected lean **with** freshly disturbed soil or root damage | Trees with recent lean ≥15 degrees or old uncorrected lean **without** freshly disturbed soil or root damage | Trees with old corrected lean | None |
| | **Height:diameter ratio[3]** | Trees with **>100%** H:D ratio | Trees with **80 to100%** H:D ratio | Trees with **60 to 80%** H:D ratio | Trees with **<60%** H:D ratio |
| | **Multiple indicators** | Two or more **medium-FP** indicators with synergistic effects: one condition (indicator) worsens the other | Two or more **low-FP** indicators with synergistic effects; two or more medium-FP indicators without synergistic effects | Two or more very **low-FP** indicators with synergistic effects; two or more low-FP indicators without synergistic effects | Two or more very low-FP indicators without synergistic effects |

**[1] To calculate sound-rind thickness as a percentage of stem diameter, divide the sound-rind thickness by the stem diameter and multiply by 100.**

**[2]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.  Sound-rind thickness should include decay caused by *P. pini* that is not advanced.**

**[3]To calculate H:D ratio, divide the total tree height in feet by the dbh in feet (p. 93).**

1. Whether the tree is live or dead
2. Presence of dead, broken, or free-hanging branches
3. Presence or a recent weakening of co-dominant stems or dead, forked, or multiple tops
4. Presence of wounds, injuries, exposed or damaged roots, and associated decay or defect
5. Lean of a tree and factors that contributed to the lean
6. Whether a tree has recently been root-sprung (lateral-root anchorage has been compromised)
7. Whether trees that previously leaned have righted (corrected) their tops subsequently and now have acceptable lateral anchorage
8. Presence and extent of lethal or weakening root, stem, or branch disease or insect infestation
9. Presence and extent of damage caused by human activities

**Dead trees** are important to identify and mitigate in developed sites. Tree mortality in Pacific Northwest forests often is a complex process involving several related factors. Tree mortality tends to be more common in high-elevation forests where stress from weather, insects, and disease result in higher rates of mortality and in the drier interior forests where mortality from fire, insects, and disease are common. Tree mortality may be directly due to biotic or abiotic causes and may be affected by previous damage, current condition (vigor), and attack by secondary agents such as bark beetles.

## Rating Failure Potential

Failure potential is rated on a scale of 1 to 4 in order of increasing severity:

### POTENTIAL FOR FAILURE

**1 = VERY LOW-FAILURE POTENTIAL**
**Live trees without visible defects.**

**2 = LOW-FAILURE POTENTIAL**
**Live trees with only minor defects.**

**3 = MEDIUM-FAILURE POTENTIAL**
**Live trees with moderate defects. Decay extent has rendered the tree at or near the acceptable sound-rind thickness (p. 30-31).**

**4 = HIGH-FAILURE POTENTIAL**
**All dead trees; live trees that are highly defective. Decay extent in live trees has rendered the tree below the acceptable sound-rind thickness.**

## Potential for Striking a Target and Damage Potential

The potential that a tree or tree part will strike a target is determined by evaluating where trees or their parts will likely land in the event of a failure, and whether those places of impact will be occupied by targets at the time. This determination is more straightforward for sites with characteristically high and steady occupancy than where intermediate or low occupancy occurs. Variables that are evaluated include:

- Location of tent pads, fire rings, barbecue pits, water pumps, waste-disposal stations, restrooms, picnic tables, historic buildings, information boards, interpretive stations, trailside rest stops, scenic-viewing areas, ski-lift lines, children's play areas, parking areas, and other potential targets
- Seasonal use patterns
- Day use patterns (day use vs. camping)

## Determining the Potential-Failure Zone

The potential-failure zone is the area that could be reached by any part of a failed tree. However, 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, especially on moderate to steep slopes. Also, when a tree fails, it may strike other trees or debris on the ground and fling material a considerable distance. This is especially true among dead trees. Determining if targets such as toilets, tent pads, or parking areas are within the area where a tree or its parts may fall (Potential-Failure Zone) is an important step in determining if the tree or tree part is a hazard. Therefore, a tree with defect and no target is not a hazard tree. A defective tree, however, whose potential-failure zone intersects a target such as a campfire ring is a hazard, and recommendations for mitigation should be made.

### ***Total-Tree Failure***

The failure zone is defined as the area on the ground that could be reached by any portion of the tree that may fail. When determining the failure zone, the following conditions must be evaluated:

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

The failure zone is a circle around the tree with a radius that is the same as the total tree height (Fig. 1). For instance, if a tree is 150 ft. tall, then its potential-failure zone has a radius of 150 ft. On sloped ground, the failure zone downhill of the tree may have to be extended whatever distance is necessary to protect people or property if the tree or part slides or bounces (Fig. 2). For trees leaning more than 15 degrees, the failure zone is an area the same radius as the tree height beginning at

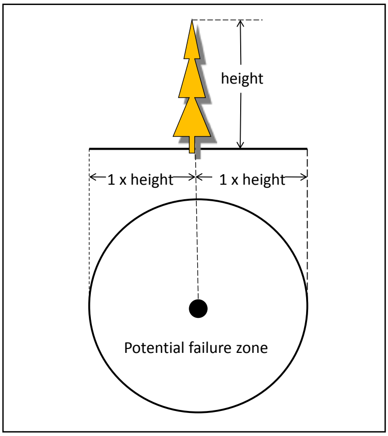


**Fig. 1 –** *Potential-failure zone for total tree failure with no slope or lean ≥15 degrees*

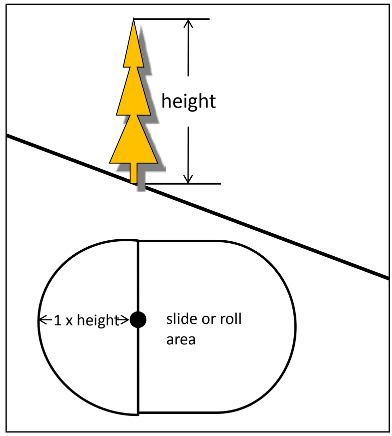


**Fig. 2 –** *Potential-failure zone for total tree failure on sloped ground*

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. 3). The area behind the lean is not within the normal failure zone, but storms with high winds could force a backlash opposite to the lean and create an additional danger.

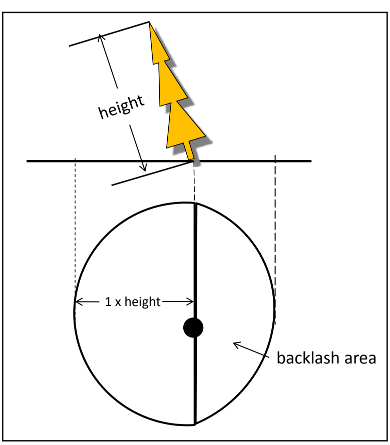


**Fig. 3 –** *Potential-failure zone for total-tree failure with lean ≥15 degrees*

### ***Tree-Part Failure***

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

- Ground slope
- Amount and direction of lean
- Length of the part that could be dislodged

On level or sloped ground where the tree has no discernable lean, determine the length of the part that could be dislodged. The failure zone forms a circle around the tree with a radius equal to the length of the defective part (Fig. 4). For instance, if a dead tree top is 10 ft. long, then the potential-failure zone has a radius of 10 ft. On sloped ground where the dislodged part may slide or roll down hill, the failure zone must be extended on the down-hill side, usually about half the radius of the potential-failure zone (Fig. 5). Dead tops or branches may fail due to high winds that can carry the piece beyond the potential-failure zone.

For tree parts on leaning trees, determine the length of the part that could be dislodged. Determine the amount of lean (horizontal distance from where the part could be dislodged relative to the base). The failure zone is the distance determined by adding the length of the defective 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 90º on either side of the tree from the lean direction (Fig. 6).

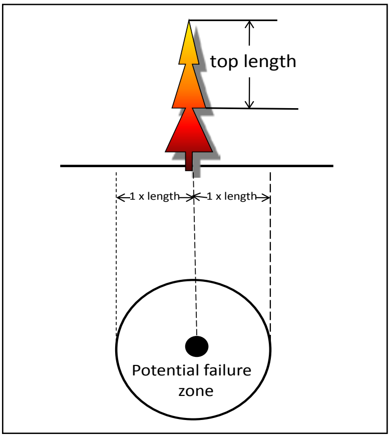


**Fig. 4 –** *Potential-failure zone for top failure with no slope or lean ≥15 degrees*

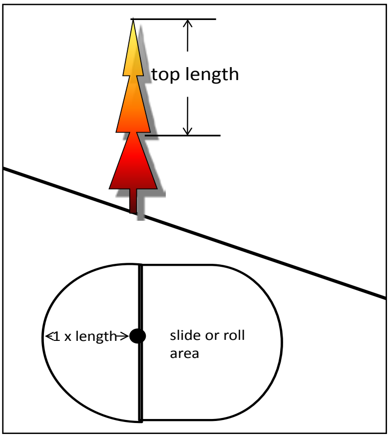


**Fig. 5 –** *Potential-failure zone for top failure on sloped ground*

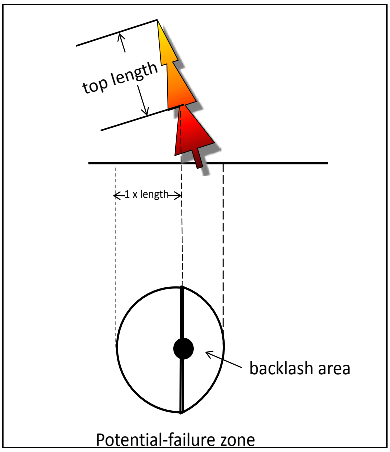


**Fig. 6 –** *Potential-failure zone for top failure with lean ≥15 degrees.*

## Rating Damage Potential

Damage potential is the probability, type, and extent of damage or injury that may result from tree failure. The value of a potential target is estimated by determining the maximum extent of loss in the event that it is struck by a failed tree or tree part. Financial and emotional losses resulting from the death, injury, or dismemberment of a person are far greater than those for the loss of picnic tables, buildings, or vehicles. Values are expressed in relative terms (low, moderate, and high) and are factors considered in evaluating damage potential. For example, if the target is a person or their parked vehicle, then the value would be high. A target of moderate value may be a building or other developed structure or convenience such as a water pump or waste-disposal station. Garbage cans, dumpsters, and information boards may be examples of low-value targets. Roads, trails, and pathways within the developed site should be rated as minor (score=2) or medium (score=3) for damage potential depending on their frequency of use.

Damage potential is rated on a scale of 1 to 4 in order of increasing severity:

### POTENTIAL FOR DAMAGE

**1 = NO DAMAGE**

Target impact will involve only very small tree parts, or there is no chance that failed parts will cause damage when they impact a target.

**2 = MINOR DAMAGE**

Failure of only small tree parts, and impacts in occupied areas are indirect; or failures will likely occur when area is unoccupied; damage when it occurs, is to low-value targets such as garbage cans, campground signs, or fences.

**3 = MEDIUM DAMAGE**

Failure involves small trees or medium tree parts, and impacts will likely occur in areas with targets; impacts will be direct, damage will likely be moderate, target value is moderate, such as for water pumps or waste-disposal stations.

**4 = EXTENSIVE DAMAGE**

Failure involves medium to large tree parts or entire trees, and impacts will be direct in areas with targets; target value is high, and damage to property will likely be severe; or serious personal injury or death is the likely result in areas such as tent sites, parking spurs, or toilets.

## A Standard for Hazard Rating

The standard hazard-rating system suggested here incorporates two important components (USDA 2011). The first component addresses the potential for tree failure within a specified time period. The second component of hazard rating addresses damage potential in the event of a failure. This portion of the rating must incorporate the likelihood that a failed tree or tree part will strike a target, the likelihood of damage, and an estimate of target value. The hazard classification for each individual tree is determined by combining the values from the Failure Potential (1-4) and Damage Potential (1-4) components of the rating system. Seven hazard classes ranging from 2 to 8 are possible (Table 2, Fig. 7).

**Table 2. Treatment priorities by hazard class:**

| *Hazard Class* | *Treatment Priority* |
|---|---|
| 8 | very high |
| 7 | high |
| 6 | moderate |
| 2-5 | low |

**Hazard Tree Rating**

| Damage Potential \ Failure Potential | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 2 | 3 | 4 | 5 | 6 |
| 3 | 4 | 5 | 6 | 7 |
| 4 | 5 | 6 | 7 | 8 |

**Fig. 7 –** *Hazard-tree rating or hazard class is on a scale of 2 to 8.*

As an example, you determine that a tree has low-failure potential with a rating of 2. You rate the damage potential as minor with a rating of 2. The hazard class is therefore 2 + 2 = 4, and the treatment priority is therefore low. Another tree has a high-failure potential with a rating of 4. The damage potential is medium with a rating of 3. The hazard class is therefore 4 + 3 = 7 and the treatment priority is therefore high. For sites administered by public agencies, the deciding official determines what hazard classes are to be treated or monitored.

## How Often Should Hazard Rating be Done?

Timing and frequency of examinations may vary, but all developed sites should be examined for new evidence of hazardous trees at least annually.  For USDA Forest Service sites, at the National Direction FSM 2332.1-Public Safety requires annual public safety inspections of these sites before the managed-use season, and trees are to be examined as part of the annual public safety inspection (Region 6 policy, USDA 2011). Sites should be examined once the severe weather season(s) have passed. This usually occurs in the spring in many parts of the Pacific Northwest, because severe weather is most often associated with winter storms. Winter storms often bring attention to the most severely defective trees or limbs, and the portions of stands with severe root disease or stem decay.

Annual pre-season site reviews should be done systematically, normally consist of a walk-through examination, and should be done before opening developed sites with seasonal closures. The expertise required to do annual inspections is less than for formal hazard-tree evaluations, since annual inspection is primarily for obvious winter and storm damage.

A more thorough and formal hazard-tree examination (baseline survey) should be conducted at least every five years, where each tree and all areas of the developed site are observed for new evidence of hazard or defect. More thorough examinations should be done more frequently than five years if the site is experiencing a recent disturbance such as a bark beetle outbreak, flood, fire, wind event, root disease, or the site is in a forest type with a history of many defective trees (i.e. white fir or cottonwood).

All trees within striking range of a target, either fixed or transitory, should be examined. Evaluations should begin at known or established reference points, and all trees in the vicinity of those points be systematically examined. Ideally, a benchmark or baseline hazard-tree evaluation should already be completed for the site, and notes from the walk-through examination can be used to modify or upgrade that information. If no such baseline evaluation exists for a site, one should be conducted.

The development of a baseline evaluation requires a systematic approach that should be organized in planning sessions before going to the woods. The approach described here is one that has been used and modified over the years. It is divided into four stages:

1) Identify and gather the necessary equipment (see Appendix)

2) Determine the information needs and gather those data

3) Record the information and develop a permanent database

4) Mitigate the unacceptable hazards

## Where and How to Collect Survey Information

***Where to survey***

Walk-through and baseline surveys should begin by obtaining a detailed map of the developed site and reviewing any past survey information. Trees should be evaluated adjacent to the roads entering and exiting the site and all travel loops within the developed portion of the site. All trees of a height that if fallen would reach the road should be examined. The width of the survey area adjacent to roads is equivalent to the height of the tallest trees. Concurrently, all trees adjacent to structures, parking areas, restrooms, waste-disposal stations, water pumps, picnic tables, or ski lifts must be inspected. The width of the survey area around these developments is equal to the height of the tallest trees.

Within developed sites, all trees that could potentially reach tent pads, picnic tables, parking areas, ski-lifts, commonly used streamside or lakeside fishing spots, fire rings, barbecue pits, and all other recognized gathering places or focal points of human activity should be carefully evaluated. If these are not known, consult with knowledgeable site hosts or maintenance workers prior to establishing the baseline evaluation. At all times, examiners should be aware of the tree hazards that have potential to impact human targets. These are most important to identify and mitigate to protect the safety of visitors.

*How to survey*

Begin by evaluating trees 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 examiner to detect dead trees or tops and live crown symptoms of root disease that can include reduced lateral branch and terminal growth, thinning crowns, chlorosis, distress cone crops, and dead tops and branches. Evidence of defoliator activity, dwarf mistletoe infection, stem conks, and bark beetle attack is often initially detected from a distance and involves inspecting multiple trees from different vantage points.

**Tree tagging** Ideally, each tree with elevated failure potential that will be monitored should be tagged with a numbered, aluminum tag fixed to the tree with an aluminum nail. Nails should be driven through the tag leaving 3/4 to 1 in. of the nail exposed to allow for tree radial growth. Tags should be placed near the soil surface of the litter layer, if present, so they are hidden from view yet easily found. Normally, a cardinal compass direction should be selected, and all tags should be placed facing in that direction. This will simplify the process of tag relocation.

**Permanent reference points** are essential for generating maps and for documentation and relocation of individual trees. Locate a large object that is a permanent fixture in the site for a reference point. This may be a fire pit in a numbered campground site, an outhouse along a road, or a lift tower in a ski area. Beginning with the first reference point and continuing in order to the last, trees should be evaluated and observations recorded. Samples of evaluation forms are located in the Appendix.

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 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 that are 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 problems in adjacent, apparently healthy trees.

During tree inspections, examiners should look for signs and symptoms of disease and evidence of insect attack. In the event that signs and symptoms indicate damage and a potential hazard, trees should be examined more thoroughly to determine the extent to which the damage has compromised structural integrity. Some defects such as frost cracks or broken tops may not demand immediate hazard mitigation but suggest the need for periodic re-examination or monitoring during annual surveys.

**Systematic tree examination** begins at the ground around the base of the tree, then proceeds to the butt, bole, limbs, and tree top. All sides of each tree should be examined. 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 will be necessary.

**Table 3A - Minimum sound-rind thickness[1] 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 high-failure potential (score=4).**

| *Tree diam. (in.)* | *Rind thickness[2] (in.)* | *Tree diam. (in.)* | *Rind thickness[2] (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 |

[1] Modified from Wagener (1963) by expanding the range of diameters covered
[2] Minimum sound-rind thickness is 0.15 x diameter and rounded to the nearest 0.5 in.

**Table 3B - Minimum sound-rind thickness[1] 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 high-failure potential (score=4).**

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

[1] Modified from Smiley and Fraedrich (1992)
[2] Minimum sound-rind thickness is 0.19 x diameter and rounded to the nearest 0.5 in.

Lightly tapping suspect trees with an axe or rubber mallet can be used to detect decay columns, hollows, and dead sapwood under the bark. This is only practical for trees with relatively thin bark. Trees that sound suspicious can then be examined in more detail with drills or increment borers. 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, the root collar, butt, and major lateral roots should be inspected for fruiting bodies, ectotrophic mycelium, mycelial fans under the bark, incipient stain or advanced 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 chop into them for examination. At least two major roots should be checked for root

**Fig. 8 –** *Battery-powered drills can be used to check for sound-rind thickness.*

disease if preliminary evidence suggests that it is 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 tree has conks, wounds, or cankers, a cordless electric drill or increment borer can be used to check for presence and extent of decay associated with these indicators (Fig. 8). For soft-wooded species such as cedar, spruce, or alder, coring with an increment borer may be more useful than using an electric drill for detecting incipient decay. The first place to drill is directly into the wound, canker, or flattened area. If decay is found, at least three more drillings should be made to the opposite and adjacent sides, to estimate the extent of decay. Tree species that display buttressing or fluted butts (e.g., western hemlock, western redcedar) may require more sampling since the distal portions of fluted areas are often thicker. The thickness of the remaining rind of sound wood (Fig. 9) should be recorded by averaging all measurements. Refer to Table 3A and 3B for minimum sound-rind thickness. When the thickness of the rind of sound wood is insufficient for a tree's diameter, the failure potential is recorded as high (score=4). The determination of sound-rind thickness with an increment borer should be done only during the baseline survey (p. 27) and then no more than every 5 years to minimuze drill wounds.

For trees with open wounds (Fig. 32) (p. 55), minimum sound-rind thickness is 25% greater than indicated in Table 3A (0.19 x diam.). For example, a suspect tree has a diameter of 32 in. at its base and has a large wound near its base. The minimum sound-rind thickness would be 6.1 in. or 0.19 x diam. (0.19 x 32) because of the wound (Table 3B). After

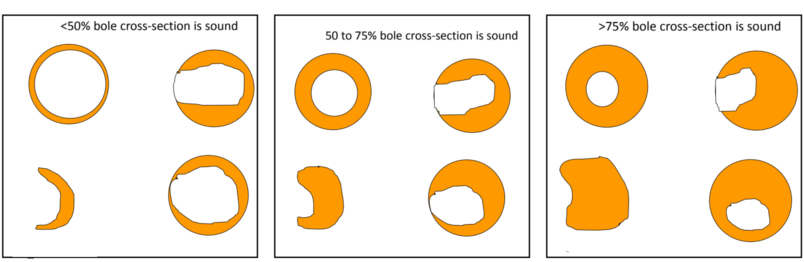


**Fig. 9 –** *Various bole cross-sectional areas showing percentage of sound wood remaining.*

increment boring at three points at the base, you determine that the average sound-rind thickness is only 4 inches; therefore, the tree has a high potential for failure. All of the examples in Fig. 9 where <50% of the bole cross-section is sound are below the minimum sound-rind thickness. The minimum sound-rind thickness applies primarily to conifers but less so to hardwood species for the following reasons: 1) the difference in basic tree form between hardwoods and conifers, 2) the strong and variant influence of leverage on the breakage potential, 3) the high mechanical strength of the wood of many hardwood species such as oak and maples, and 4) the fact that trunk failures, besides those near the groundline, are relatively rare in hardwoods except in weak-wooded species such as cottonwood, alder, and aspen. In hardwoods the condition of the branches and forks often is more important than the condition of the main trunk.

The minimum sound-rind thickness is just one assessment method for living trees with internal decay. The values in Table 3A and 3B are based on single-stemmed conifers with no lean or other bole defects. Also, the guidelines apply to the bole only and not to the roots or root collar. Although the presence of bole wounds can be compensated for as explained above, other visible and hidden defects associated with the decay column should be considered in the assessment (see multiple defects, p. 94). Allowing trees to reach a threshold of the minimum sound-rind thickness should be done only with evaluation of all other defects.

Drilling all trees is not recommended since it is time consuming and usually not warranted, lacking other indicators of internal defect. Trees in areas known to have a high incidence of hidden defect, however, may warrant close evaluation that may include drilling or sounding. Trees with substantial decay usually bear obvious indication of that defect or produce a hollow sound when pounded with a mallet or axe.

Signs of significant woodpecker activity, such as nest-cavity excavation, often indicate the presence of advanced decay. Woodpecker activity for nest sites should not be confused with sapsucker activity. Sapsucker damage often looks alarming but is only superficial. Chopping the bark or drilling into the wood can confirm the presence and extent of this defect. Be discrete with chopping so as not to suggest to visitors that it is an acceptable activity.

The bole above the lower butt is the next logical section to examine. From this point upward, visual examination can be employed 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 often are 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. Record the presence of all signs of potential defect so that if treatment is not immediately warranted, the loss of a conk or misinterpretation of other signs will not lead future examiners to believe the stem is sound.

Tree tops and branches should be examined thoroughly. Free hanging and dead branches should be evaluated and dealt with as needed. Dead tops should be examined for decay and instability indicated by conks, crumbling sapwood, woodpecker activity, or nesting cavities. Binoculars are useful for this assessment.

Recreation site records covering a 10-year period in the Pacific Northwest revealed the frequency of tree failure by position of the defect on the tree (Table 4). Nearly two-thirds of all recorded failures occurred as a result of root or butt defects. Limb failures occurred more frequently in hardwoods than in conifers.

## Documentation

A record that an inspection was done on a site is necessary to provide evidence that a survey was completed. Documenting trees with elevated hazard-rating (e.g. ratings of 6, 7, or 8) can provide evidence that a tree was examined and a decision made to mitigate the hazard or monitor the tree. *A tree record form (see Appendix) should be completed for trees with elevated hazard-tree ratings of 6, 7, or 8*. Healthy-appearing trees will be inspected but may not necessarily have an examination record filled out. Completing a formal report to the responsible official that describes the procedure used, documents the evaluation, and includes a record of trees with elevated hazard and recommended treatment is advisable. Recording results of evaluated trees in developed-site evaluations is necessary for several reasons:

1. The assessment of current hazards and forest health provides a foundation for future vegetation-management activities.
2. It records the predominant defects in each site making the job of future surveys easier.
3. It provides documentation for future hazard management and monitoring efforts.
4. It sets the baseline on which to build other vegetation structures and compositions, and planning and investment horizons.

5. It is the record of performance in the event of litigation.

**Table 4. Distribution of failures by position of defect and tree species in Pacific Northwest recreation sites (Harvey and Hessburg 1992).**

| Tree species | Upper bole (%) | Lower bole (%) | Butt (%) | Branch (%) | Root (%) | Total number |
|---|---|---|---|---|---|---|
| Alder | 23 | 11 | 30 | 1 | 35 | 154 |
| Douglas-fir | 17 | 11 | 15 | 3 | 54 | 404 |
| Engelmann spruce | 0 | 3 | 34 | 0 | 63 | 38 |
| Grand fir | 12 | 18 | 18 | 0 | 53 | 34 |
| Incense-cedar | 14 | 29 | 8 | 4 | 44 | 111 |
| Larch | 8 | 26 | 4 | 4 | 58 | 26 |
| Lodgepole pine | 13 | 8 | 7 | 3 | 69 | 637 |
| Madrone | 10 | 2 | 28 | 42 | 18 | 321 |
| Maple | 13 | 4 | 30 | 9 | 47 | 47 |
| Mountain hemlock | 12 | 77 | 0 | 0 | 12 | 43 |
| Noble fir | 37 | 11 | 0 | 0 | 53 | 19 |
| Pacific silver fir | 5 | 48 | 5 | 0 | 43 | 21 |
| Ponderosa pine | 42 | 6 | 5 | 0 | 47 | 280 |
| Poplar | 15 | 12 | 19 | 31 | 23 | 26 |
| Red fir | 16 | 30 | 13 | 1 | 40 | 87 |
| Sitka spruce | 18 | 27 | 18 | 0 | 36 | 11 |
| Spruce, unidentified | 0 | 53 | 0 | 0 | 47 | 297 |
| Subalpine fir | 55 | 3 | 24 | 0 | 17 | 29 |
| Sugar pine | 14 | 25 | 17 | 8 | 36 | 36 |
| Tanoak | 13 | 24 | 18 | 16 | 28 | 1614 |
| Western hemlock | 4 | 18 | 19 | 1 | 58 | 113 |
| Western redcedar | 0 | 15 | 12 | 10 | 63 | 41 |
| White fir | 6 | 53 | 15 | 0 | 26 | 34 |
| Average | 15 | 22 | 15 | 6 | 42 | 4423 |

A primary benefit of establishing a baseline survey and permanent database is that future site re-inspections and hazard monitoring are simplified. Hazard and monitoring information can be entered into a database and information generated annually, listing the trees indicated in prior inspections that are to be monitored in a given year. Files can provide the locations of specific trees relative to reference points, their species, size, and type of defect, their prior extent of defect, the appropriate monitoring interval, prior hazard and risk ratings, and recommended treatments. Stem maps can be generated using reference points and azimuth/distance information. Maps of virtually any specification can be generated: tree-removal maps for contractors, annual tree-visitation maps for defect monitoring and periodic re-evaluation, and complete developed-site maps for long-range planning and visual-perspective projections. Over time, annual layers of information may be accumulated and available for trend analyses of vegetation, pathogen and insect populations, and management activities.

For trees with disease or defects, a complete tree record should be developed at the time of the baseline survey and updated with each re-evaluation for developed sites where this is warranted. The tree record should contain all the data needed to discover trends for individual trees. When observed in aggregate, stand-level trends will become obvious. The following information should be recorded (see sample forms in Appendix):

1. Site name
2. Date of survey
3. Name of recorder(s)/examiner(s)
4. Tree tag number
5. Tree species
6. Tree dbh
7. Tree height
8. Height to defect(s) or conk(s) (if present)
9. Symptoms and signs of root or butt disease (resinosis, conks, thin crown, cracks)
10. Thickness of remaining sound wood (rind)
11. Cause of root or butt disease *(Phellinus weirii, Armillaria* spp., *Phaeolus schweinitzii*, etc.)

12. Stem defects (conks, decay, mechanical injury, fire damage, frost crack, dead top, etc.)
13. Stem-disease cause (*Phellinus pini, Fomitopsis officinalis,* etc.)
14. Failure-potential score and damage-potential score
15. Recommended treatment
16. Date treatment was accomplished

Decisions on the soundness of individual trees can be a matter of life or death to visitors and public employees. Care should be taken to do a thorough job. Adequate time must be allowed to evaluate all trees that have potential targets. An evaluation crew of two people is most effective and efficient. Ideally, hazard-tree inspections are done when weather and lighting conditions are favorable for seeing defects. Trees in developed-recreation sites may have great aesthetic and wildlife value and are difficult to replace. Removal decisions should be based on careful hazard evaluations and should consider other hazard-mitigation alternatives, such as seasonal closures, moving the location of potential targets, pruning, cabling, bracing, and others (Table 10). Sites that are closed for the winter should be evaluated the next spring for any root-sprung trees or recently cracked tree boles that have developed over the winter when high winds and snow/ice loading may have occurred.

*Western hemlock with annosus rood disease showing advanced decay and the remaining sound wood (rind)*

*Determining defects and failure potential on the Mt. Hood National Forest.*

# Chapter 3 - Identification of Diseases and Defects that Result in Hazardous Trees

This section addresses native tree species and their common defects beginning with the roots and root collar, progressing to the butt and upper bole, and finally the limbs and tops. This is also the progression used in evaluating potentially hazardous trees.

## 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, pines, and larch, because resin (pitch) inhibits fungal growth and insect attack (Table 5). Decay is also slower in cedars which 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.

For recently fire-damaged trees, where green needles may still be present, check the cambium at the root collar to determine if it is alive or dead. For most species, a tree is considered dead when at least three of the four quadrants from around the base of the root collar have cambium, inner bark, or phloem that are discolored and dead. For large ponderosa pines, a dead tree has all four quadrants with dead cambium.

**Table 5. Resinous and non-resinous tree species groups in developed sites in Oregon and Washington**

| *Species Group* | *Resinous (decay resistant)* |
|---|---|
| **True-fir (*Abies* spp.)** | No |
| **Hemlock** | No |
| **Spruce** | Partially |
| **Douglas-fir** | Yes |
| **Larch** | Yes |
| **Pine** | Yes |
| **Cedar** | Non-resinous but decay resistant |
| **Hardwoods** | Non-resinous but some are more decay resistant than others |

Accurate prediction of the failure of dead trees is difficult and uncertain, and targets in developed sites are stationary and of high value. Therefore, it is USDA Forest Service policy that dead trees of any species, size, age, or time since death have a **high-failure potential,** and the hazard should be mitigated in any developed site (Chapter 4 and Table 1). Dead trees may be retained if their damage potential is very low (score 1).

## Wounded Trees

Tree wounds are injuries that break the bark of the stem or branch. Wounds occurring on tree roots and root collars can result in annosus root disease (p. 45), Schweinitzii root and butt rot (p. 55), tomentosus root and butt rot (p. 57), or ganoderma root and butt rot (p. 51). Tree wounds are caused by a variety of factors: vehicles, people, falling trees, weather, fire, animals, or insect attack. A wound is considered open if the sapwood is exposed (Fig. 32) or a hollow interior is visible (Fig. 55). New wounds on living trees can be entry points for stem decay or canker-causing fungi, especially in large and deep wounds. Wounds also can activate dormant spores of decay fungi, such as the Indian paint fungus (p. 74). Wounds on non-resinous tree species (Table 5) 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 tree is wounded, the wood-infecting micro-organisms may be confined to compartments within the tree through a process called compartmentalization. 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 is referred to as the sound rind, and its thickness determines the failure potential of the affected tree (Table 3B). A wounded tree with a sound-rind thickness <20% of the tree's diameter inside bark has high-failure potential (Table 1). 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. Once the decay process starts in a living tree, however, it cannot be mitigated by wound dressings or similar treatments.

**Table 6. Root and butt diseases in Oregon and Washington; frequency of occurrence by host species where 1=common, 2=occasional, 3=infrequent, 4=rare, and blank means non-host or unknown occurrence**

| Host species | Annosus root disease | Armillaria root disease | Black stain root disease | Ganoderma root and butt rot | Laminated root rot | Port-Orford-cedar root disease | Schweinitzii root and butt rot | Tomentosus root and butt rot | Yellow root rot |
|---|---|---|---|---|---|---|---|---|---|
| **Alder** | 4 | 3 | | 3 | | | | | 3 |
| **Aspen** | | 2 | | 3 | | | | | |
| **Ash** | | | | 3 | | | | | |
| **Birch** | | 3 | | 3 | | | | | 3 |
| **Buckthorn** | 3 | | | | | | | | |
| **Cedar** | | | | | | | | | |
| **Alaska** | 3 | 3 | | 3 | 4 | | 3 | | |
| **Incense** | 3 | 3 | | | 4 | | | | |
| **Port-Orford** | 3 | 3 | | | 4 | 1 | | | |
| **Western red** | 2 | 2 | | 3 | 3 | | 3 | | 3 |
| **Cherry** | | 3 | | 3 | | | | | 3 |
| **Chinkapin** | | 3 | | 3 | | | | | |
| **Cottonwood** | 3 | 2 | | 3 | | | | | 3 |
| **Dogwood** | | 3 | | | | | | | |
| **Douglas-fir** | | | | | | | | | |
| **Coast** | 3 | 2 | 1 | 3 | 1 | | 1 | 4 | 3 |
| **Inland** | 3 | 1 | 3 | 3 | 1 | | 1 | 4 | 3 |
| **Hemlock** | | | | | | | | | |
| **Mountain** | 1 | 2 | 3 | 2 | 1 | | 3 | | 3 |
| **Western** | 2 | 2 | 3 | 2 | 2 | | 3 | | 3 |
| **Juniper** | 3 | 3 | | | 4 | | | | |
| **Larch** | 3 | 3 | | | 2 | | 1 | | 3 |
| **Madrone** | 2 | 3 | | | | | | | 3 |
| **Maple** | 4 | 3 | | 3 | | | | | 3 |
| **Myrtle** | | | | 3 | | | | | |
| **Oak** | 4 | 2 | | 3 | | | 3 | | |

**Table 6. Root and butt diseases in Oregon and Washington; frequency of occurrence by host species where 1=common, 2=occasional, 3=infrequent, 4=rare, and blank means non-host or unknown occurrence** *(continued)*

| Host species | Annosus root disease | Armillaria root disease | Black stain root disease | Ganoderma root and butt rot | Laminated root rot | Port-Orford-cedar root disease | Schweinitzii root and butt rot | Tomentosus root and butt rot | Yellow root rot |
|---|---|---|---|---|---|---|---|---|---|
| **Pine** | | | | | | | | | |
| **Jeffrey** | 2 | 2 | 3 | 3 | 3 | | 2 | 3 | |
| **Knobcone** | 3 | 3 | 3 | 3 | 3 | | 2 | 3 | |
| **Lodgepole** | 2 | 3 | 3 | 3 | 3 | | 2 | 3 | 3 |
| **Ponderosa** | 2 | 2 | 2 | 3 | 3 | | 2 | 3 | |
| **Sugar** | 3 | 2 | 3 | 3 | 3 | | 2 | | |
| **Western white** | 3 | 2 | 3 | 3 | 3 | | 2 | | |
| **Whitebark** | 3 | 3 | 4 | 3 | 3 | | 2 | | |
| **Redwood** | 3 | 3 | | | 4 | | 3 | | |
| **Spruce** | | | | | | | | | |
| **Brewer** | 3 | 2 | | 3 | 3 | | 2 | 1 | 3 |
| **Engelmann** | 3 | 2 | | 3 | 2 | | 2 | 1 | 3 |
| **Sitka** | 3 | 2 | | 3 | 3 | | 2 | 2 | 3 |
| **Tanoak** | | 2 | | | | | | | |
| **True Fir** | | | | | | | | | |
| **Grand** | 1 | 1 | | 3 | 1 | | 3 | 3 | 3 |
| **Noble** | 2 | 2 | | 3 | 2 | | 3 | 4 | 3 |
| **Pacific silver** | 1 | 2 | | 3 | 2 | | 3 | 3 | 3 |
| **Shasta red** | 2 | 2 | | 3 | 2 | | 3 | 4 | 3 |
| **Subalpine** | 2 | 2 | | 3 | 2 | | 3 | 4 | 3 |
| **White** | 1 | 1 | | 3 | 1 | | 3 | 3 | 3 |
| **Willow** | | 3 | | 3 | | | | | 3 |
| **Yew** | | 3 | | | 4 | 4 | 3 | | |

## Root and Butt Diseases

Historically, root and butt diseases have been associated with particularly large numbers of tree failures in Pacific Northwest developed sites (Table 4). Some root mortality may be caused by adverse changes to the root-system environment such as can occur from excesive soil compaction or other disturbance (non-specific root decline). Most root diseases, however, are caused by fungi that decay roots and butts causing loss of anchorage of affected trees. Proper diagnosis is important because tree-failure potential can vary considerably depending on which disease is involved. Also, occurrence of each disease differs by host (Table 6) and often by geographic location. Root and butt diseases can severely weaken infected roots and lower stems and cause substantial loss of tree vigor. The most conspicuous impacts of such diseases on their hosts are predisposition to attack by bark beetles, outright tree death, wind breakage, and windthrow.

Unfortunately, root and butt diseases and the defects that they cause are often difficult to detect, and detection efforts are time consuming. Symptoms can be subtle, and many direct indicators of colonization and decay, especially in the early stages of disease, are located either underground where they cannot be seen without substantial excavation or inside of lower stems where drilling is necessary to evaluate them. Because of this, root diseases often go undetected in developed sites until wind storms blow over infected trees that reveal decayed roots and/or hollow butts. Because many root pathogens can survive for decades or centuries in old, infected root residues, it is extremely important to document presence of root diseases in developed sites, since they will likely continue to be significant tree-hazard concerns in those sites far into the future.

Symptoms and signs of root diseases on a host tree include some or all of the following (also see the appendix):

1. General decline of the entire live crown characterized by chlorosis of foliage, premature shedding of older needles, and terminal and, eventually, lateral shoot-growth reduction (Fig. 10)
2. Distress cone or seed crops
3. Dying branches or thinning crowns from the extremities inward in older trees or from the interior crown outward in younger hosts
4. Butt rot, sometimes extending as much as 30 to 35 feet up the stem from the base

5. Basal resinosis (Fig. 11), and/or bark staining (Fig. 12)
6. Windthrow or wind-shatter (Fig. 13)
7. Bark beetle attack (Fig. 56)

**Fig. 10 –** *Crown decline can be a symptom of root disease.*

**Fig. 11 –** *Basal resinosis is often associated with Armillaria root disease.*

**Fig. 12 –** *Bark staining is sometimes associated with Armillaria root disease.*

**Fig. 13 –** *Windthrow can be associated with root disease.*

**Fig. 14 –** *Dead and dying trees often are caused by root disease.*

8. A progression of dead, dying, and declining trees in discrete areas or pockets within the stand (Fig. 14)
9. Mushrooms or conks of root pathogens at root collars (Fig. 15) or in stumps
10. Presence of characteristic mycelia of the fungal pathogens on, in, or under the host bark in the roots and root collar area (Figs. 20, 21, and 23)

**Fig. 15 –** *Armillaria mushrooms are produced in autumn on infected trees.*

Unfortunately, while some trees may exhibit readily visible signs and symptoms, many more may be diseased but not yet showing above-ground indication of infections. Root pathogens typically spread through a stand at a relatively predictable rate; only a portion of their progress at any given time is manifested by above-ground symptoms.

During extended drought periods, root disease diagnosis becomes even more complex. Drought conditions intensify the effect of disease damage on tree vigor and further lower host resistance to infection and decay. More bark beetle infestation and more tree mortality from the combined effects of root diseases and bark beetles acting together result during and just after periods of drought. It also is often more difficult to confirm the type of root disease associated with tree mortality during droughts, since the trees may be attacked by bark beetles earlier in the progress of the disease before signs of the root pathogen are accessible and apparent.

Major root and butt diseases that contribute to tree hazard in developed sites in the Pacific Northwest include the following:

**Annosus root disease** is caused by two species of fungi, *Heterobasidion occidentale* and *H. irregulare*. Formerly, these two species were considered to be different forms of the same species, *H. annosum*. These two fungi look alike, have the same life cycles, and can cause the same kind of disease, but they differ genetically and, most importantly, have different host ranges. In the Pacific Northwest, *H. occidentale* primarily infects true firs, hemlocks, and spruces while *H. irregulare* mainly infects pines and junipers. Though one species may occasionally infect stumps of the other, cross over to live trees is negligible and not practically important from a hazard-evaluation perspective.

Annosus root disease, especially that caused by *H. occidentale*, often is encountered in developed sites and is capable of contributing to very substantial tree hazard. Unfortunately, its occurrence appears to be increasing in Pacific Northwest developed sites. *H. occidentale* is distributed throughout the forested areas of Washington and Oregon. *H. irregulare* is found primarily in dry areas east of the Cascades in the two states.

Both *H. occidentale* and *H. irregulare* are spread over long distances by windborne spores that land on and infect fresh wounds and newly created stumps of host tree species (Table 6). Spread by spores can occur over many miles. Once a stump is colonized, the pathogen grows into the roots, and the stump becomes an inoculum source. Spread to additional host trees occurs when their roots contact these previously colonized root systems, and the fungus grows across. Spread across root systems requires actual contact; fungal mycelia grow within and on the surface of roots but do not grow through soil. Spread across root systems occurs at a rate of about one to two feet per year. Fungal inoculum in infected stumps and trees can remain viable for decades after tree death, being especially long-lived in very large stumps or snags.

Annosus root disease can affect hosts in two ways; it can cause a root and butt rot that becomes more extensive with time and can eventually contribute to windthrow or stem breakage, or it can girdle the host by killing the cambium around all or most of the root collar. True firs are frequently killed by stem girdling but also may develop root and butt decay. Hemlocks and spruces mainly experience root and butt decay. Pines and junipers are killed by girdling.

Annosus root disease is often the most difficult of root diseases to diagnose. Hazard-tree evaluators are well advised to seek assistance from experienced forest pathologists in cases where they suspect annosus root disease. Some host trees infected by *H. occidentale* (especially those true firs that are eventually killed by girdling) and *H. irregulare* (pines and junipers) may exhibit crown symptoms similar to those caused by other root diseases, including foliage fading and thinning, needle chlorosis, growth reduction, and appearance of scattered dead branches in the crown in the years before death (Fig. 14). Others trees show virtually no crown symptoms and appear to die without warning. Some infected trees (especially pines) exhibit basal resin flow (Fig. 11). Hemlocks and spruces that develop butt and lower stem decay rarely show crown symptoms. Decay in these species tends to develop rather slowly. Significant decay that is capable of contributing to tree failure usually does not develop until host trees of these species have reached ages of at least 150 years.

Fruiting bodies of *Heterobasidion* are perennial conks with woody or leathery black to chestnut-brown upper surfaces, white pore-less margins and creamy-white undersurfaces with small, round, irregular pores (Fig. 16). Conks may be found in old stumps, just above ground in root crotches of living, infected trees, and below ground on roots of living or dead hosts. Young conks on roots appear as small, white to buff pustules. Presence of a conk on a tree or stump proves infection, but the opposite is not true; many *Heterobasidion*-infected trees do not produce conks. The presence of a conk on a tree or in a stump indicates that adjacent trees of host species also have a high probability of being infected as well as the tree or stump where the fruiting body is actually found.

Incipient decay of *Heterobasidion* is a light-brown to reddish stain in the outer heartwood (Fig. 17). Advanced decay is white and stringy (Fig. 18) or laminated with elongated pits on only one side of the laminations and no setal hyphae (Fig. 19). Pathologists with laboratory facilities can incubate samples of wood with suspicious stain or early decay and confirm or disprove the presence of *Heterobasidion* based on whether or not diagnostic microscopic fruiting bodies are formed.

Clearly, hidden infection by *Heterobasidion* is common. Individual trees with wounds may be infected while showing only the most subtle of indicators or no apparent indicators at all. Annosus root disease can occur in small infection foci centered on old, infected stumps or wounded trees or in large infection centers where tree-to-tree spread has occurred for many decades. Often, many infected host trees in either kind of situation lack indicators.

When annosus root disease is confirmed in a developed site, live trees in and around disease centers vary in failure potential depending on geographic area, tree species, tree condition and age, and the presence of adjacent windthrown trees with evidence of root disease (Table 1). Host trees that have already been killed or will likely die soon, as well as older host trees with confirmed *Heterobasidion*-induced butt rot, will have the highest failure potential. Because the fungi that cause annosus root disease can spread long distances by spores that infect

**Fig. 16 –** *Conks associated with annosus root disease often form in hollow stumps.*

**Fig. 17 –** *Stain caused by* Heterobasidion occidentale *in grand fir.*

**Fig. 18 –** *White-stringy decay caused by* Heterobasidion occidentale *in a western hemlock stump.*

**Fig. 19 –** *Laminated decay can be caused by* Heterobasidion occidentale.

through wounds and newly cut stumps, it is easy to see why decay occurrence may indeed be increasing in long-established developed sites. Major efforts should be designed to minimize or avoid tree wounding, especially of true firs, hemlocks, and spruces, in developed sites. Treatment of all freshly cut stump surfaces of *Heterobasidion* hosts with registered boron compounds is highly recommended (p. 96).

**Armillaria root disease** on conifer hosts is caused by the fungus *Armillaria ostoyae*. On hardwoods it is caused by either *A. gallica* or *A. mellea*. Though not as damaging as laminated root rot, Armillaria root disease has a history of frequently causing tree mortality in developed sites in the Pacific Northwest. The fungi that cause Armillaria root disease are extremely common and are distributed throughout all forested areas in Oregon and Washington.

The *Armillaria* species that cause root disease can survive as saprophytes in dead host material for at least 50 years. Spread to new hosts involves mycelial growth across root contacts or for very short distances in soil between old, infected roots and the roots of new hosts, or spread to new roots over greater distances through soil via rhizomorphs (shoestring-like structures that may extend two feet or more from an infected root into the soil). The pathogen then spreads to additional new, living hosts by growing across root contacts or through soil between them. The pathogen forms gradually expanding infection centers that enlarge radially at a rate of one to two feet per year. *Armillaria* species form mushrooms (Fig. 15) that can produce viable spores, but the role of spore spread with the disease-causing *Armillaria* species is not believed to be significant.

*Armillaria* can infect the roots of most Pacific Northwest tree species (Table 6). *Armillaria* species may function either as weak pathogens of stressed, low-vigor trees or as aggressive killers of susceptible hosts. *Armillaria* species can be quite variable and affect hosts differentially in different areas. As general rules:

1) Infection of stressed or injured conifers is most likely on high-productivity coastal and Westside sites while aggressive tree killing is more common east of the Cascades in Oregon and Washington and in the Cascades in Southwest Oregon,
2) Infection of hardwoods is frequently associated with stress or wounding throughout the Pacific Northwest,
3) In most cases among conifers, the true firs are the most highly susceptible hosts of Armillaria root disease, interior Douglas-fir is intermediately susceptible, and other conifers are usually somewhat tolerant or resistant,
4) Tree susceptibility to Armillaria root disease can in some cases differ markedly by location in ways that are not yet understood; for example there are areas in southwestern Oregon, south-central Washington, and northeastern Washington where pines can be severely damaged, and Douglas-fir is the most severely damaged host in some localized areas in northeastern Washington,
5) The Armillaria species that cause root diseases often occur in combination with other root disease organisms, especially *Phellinus weirii, Heterobasidion occidentale, Leptographium wageneri,* or *Phaeolus schweinitzii.*

*Armillaria* species generally kill host trees by colonizing the phloem and xylem of the roots and root collar and disrupting movement of water and nutrients in the tree. The cambium around the host's roots and root collar is killed by the fungus, preventing uptake of water and nutrients. Infected trees are frequently predisposed to infestation by bark beetles and wood borers. Trees generally die standing. Though roots may be decayed to a degree, windthrow of trees prior to death is not as common as with other diseases such as laminated root rot and annosus root disease.

Recognizing Armillaria root disease is usually easier than recognizing annosus root disease or laminated root rot. Infected trees show typical root disease crown symptoms, including crown thinning, foliage chlorosis, growth decline, and formation of stress cone crops (Fig. 10). Infected trees also often exhibit resin flow or bark staining at and above the root collar (Fig. 11) and resin-soaked, decayed wood interspersed with straw-colored flecks in the butt and roots. Rhizomorphs may be found under the bark of infected trees, and honey-colored mushrooms are often formed at the bases of infected trees in autumn (Fig. 15). Probably the most certain way to confirm the presence of *Armillaria* is to chop into the root collar of a declining or recently dead tree and observe the white, latex-like mycelial fans that are produced just under the bark (Fig. 20). When these are thick, associated with heavy resin flow, and extend above the ground line, they are considered diagnostic of Armillaria root disease. In the aggressive tree-killing case, dead and dying trees of susceptible host species will be situated in and around disease centers that exhibit evidence of progressive tree mortality over many years (Fig. 14). Infection centers can be very large. In cases where *Armillaria* is affecting low vigor and stressed hosts, infected trees may appear as scattered individuals or small groups of dead and dying trees, often clearly associated with such stress factors as wounding, compacted soils, offsite plantings, drought, infection by other disease organisms, or fires.

**Fig. 20 –** Armillaria ostoyae *often produces mycelial fans under the bark of infected trees.*

As with annosus root disease or laminated root rot, not all *Armillaria*-infected trees can be easily identified. Apparently healthy trees of susceptible species that are growing close to dead or obviously declining trees with identifiable Armillaria root disease also have a high probability of being infected. The actual extent of an *Armillaria* infection center is larger than indicated by obvious indicators.

When Armillaria root disease is diagnosed in a developed site, trees in and around root disease centers vary in failure potential depending on tree species and condition and the presence or absence of adjacent windthrown trees with root disease (Table 1). Since Armillaria root diseased trees are usually killed standing, such dead trees should be considered to have the same **high-failure potential** as any other dead trees. Live infected and symptomatic trees that occur on sites where trees infected by *Armillaria* have previously been windthrown may also be considered to have **high-failure potential** in the few cases where such a scenario occurs (Table 1).

**Black stain root disease** is caused by *Leptographium wageneri*. The disease is a vascular wilt that causes tree mortality but not root decay. A characteristic sign is a brown to purplish-black stain in older sapwood that fades with time in dead trees. The disease is spread from tree-to-tree across root grafts and contacts by mycelial growth, and mycelia also grow very short distances in soil. Long-distance spread is via root-feeding bark beetles and weevils that are attracted to stressed trees. Black stain root disease kills all ages of ponderosa pines at some locations east of the Cascade Crest and young Douglas-fir on the westside. Other species besides the pines and Douglas-fir are rarely affected (Table 6). Black stain root disease often is associated with soil disturbance along roads with soil compaction or large numbers of injured host trees. Black stain root disease has been found in a few developed sites in the Pacific Northwest but is not nearly as common as laminated root rot, Armillaria root disease, or annosus root disease. Because black stain root disease does not cause root decay, affected trees die standing and then have **high-failure potential**. Live trees with disease signs and symptoms have **low-failure potential** (Table 1).

**Ganoderma root and butt rot** or **white mottled rot** affects many conifer and hardwood species (Table 6). It occurs in wounded, live trees and dead or broken trees. The decay is caused by two species of fungi: *Ganoderma tsugae* and *G. applanatum. Ganoderma tsugae* occurs only on conifers and forms a distinctive conk that is annual, stalked, eggshell-like, reddish-brown, and shiny as if lacquered or varnished; hence, the common name, "lacquer fungus" or "varnish conk." *Ganoderma applanatum* occurs on dead or partially dead conifers and on live or dead hardwoods. It produces conks that are perennial, leathery to woody, and may or may not be stalked. The conk undersurface is white to creamy and is easily bruised; hence, the common name "artist's conk." Decay associated with both species is a white spongy rot with black specks. When Ganoderma root and butt rot is diagnosed in developed sites, host trees can have **high or medium-failure potential** depending on the extent of butt decay (Table 1).

**Laminated root rot** is caused by the fungus *Phellinus weirii*. A proposed new name is *Phellinus sulphurascens*. It is the most damaging root disease of forest trees in Oregon and Washington and one of the most hazardous to people and property in developed sites. It is widely distributed and common in the forests of Washington, western Oregon, and eastern Oregon north of the Crooked River.

The fungus that causes laminated root rot can remain viable and infective for more than 50 years after a colonized host has died. The roots of old stumps and standing, dead trees function as virulent inoculum sources for decades after the trees have been killed or cut. The fungus spreads to new hosts via an ectotrophic mycelium (Fig. 21) that grows onto new host roots when they make direct contact with old, infected, residual roots. Subsequently, the pathogen spreads to additional living hosts by growing across root contacts and grafts between them. Thus the pathogen forms gradually expanding infection centers in stands with major host components. The fungus grows across roots at a rate of about one to two feet per year. Long-distance spread involving spores probably occurs occasionally with *P. weirii*, but appears to be so infrequent that it is not of practical importance.

*Phellinus weirii* can infect the roots of all Pacific Northwest conifers (Table 6). Highly susceptible hosts are true firs, Douglas-fir, and mountain hemlock. These tree species are readily infected and their roots are extensively decayed by the pathogen. Other conifers can tolerate or resist infection and/or damage to various degrees (Table 6). Though their roots are not as severely decayed as are those of highly susceptible host trees and they are much more tolerant of the disease, larches, spruces, and western hemlock infected by *P. weirii* may develop substantial butt rot over time. Pines and cedars are rarely infected and almost never killed by *P. weirii*; however, even with these species,

**Fig. 21 –** *Ectotrophic mycelium of* Phellinus weirii *is produced on infected roots of Douglas-fir.*

some root colonization can occur, and the pathogen may maintain itself on the site. All hardwoods are immune to *P. weirii*.

The roots of highly susceptible hosts are extensively decayed by *P. weirii* leading to tree death (often as a result of predisposition to bark beetle infestation) or windthrow. Windthrow frequently occurs among highly susceptible hosts with still-green crowns including some that exhibited little if any evidence of crown symptoms prior to falling. This makes laminated root rot particularly dangerous when occurring in a developed site. More tolerant hosts that develop butt rot may break at the butt or lower stem as decay advances with age.

Recognizing laminated root rot is not always easy but skill in doing so improves with experience. Many infected hosts, especially of the highly susceptible tree species, do show crown symptoms typical of major root diseases (Fig. 14), especially when individual root systems have half or more of their roots affected. These symptoms include crown thinning, foliage chlorosis, growth decline, and formation of stress cone crops. Some infected trees exhibit basal resin flow. *Phellinus weirii* occasionally produces flat buff-colored conks, but these are cryptic, difficult to find, and uncommon enough that they have little diagnostic value. Laminated root rot centers are frequently characterized by an abundance of windthrown trees, with only stubs of roots remaining (Fig. 22). Laminated decay that separates easily at the growth rings and is pitted on both sides of the layers is usually evident in the broken off roots (Fig. 24). It can also be detected in excavated roots of standing infected trees or in the stumps of infected trees that were previously cut.

Diagnostic evidence of *P. weirii* is occurrence of tufts or mats of reddish-brown setal hyphae between the sheets of characteristically decayed wood (Fig. 23). Because of their small size, confirming the presence of setal hyphae is easiest when the evaluator uses a hand lens. On the roots of infected living trees, excavation of roots can reveal the ectotrophic mycelium of *P. weirii* (Fig. 21) as a grayish-buff, crusty sheath of fungal material on the surface of the bark that cannot be readily rubbed off. Close examination shows that this ectotrophic mycelium often contains tufts of setal hyphae. Chopping into roots of infected trees can reveal a reddish stain in

**Fig. 22 –** *Rootballs with missing major roots, as shown here, are decayed by* Phellinus weirii.

**Fig. 23 –** *Setal hyphae, the red-brown, fuzzy material shown here, are diagnostic for laminated root rot.*

**Fig. 24 –** *Laminated decay as shown here is caused by* Phellinus weirii.

the wood in advance of the occurrence of the ectotrophic mycelium. On the cut surface of the stump of an infected tree, stain will often appear in a crescent shape in the wood that is visible for a week or two after the tree is cut. Hollows or crescent-shaped areas containing advanced decay are also encountered on stumps of some infected trees. In long-established recreation sites, a history of frequent removal of dead and windthrown trees can mean that finding *P. weirii* decay in old stumps is particularly useful and important because stumps are the only indicators left of disease in the particular area.

Management of laminated root rot centers is important for long-term prevention of future hazard trees. This is done by determining the boundaries of the root disease center by using crown symptoms and root excavations to identify the disease. Include a buffer around the disease center that extends at least two trees beyond the last tree with confirmed root disease. Many of the trees within this buffer, if of susceptible species, probably will be infected and failure prone. It is recommended that recreation personnel work with silviculturists or pathologists in developing treatment options for developed sites with laminated root rot.

When laminated root rot is diagnosed in a developed site, trees in and around root disease centers vary in failure potential depending on tree condition, size, species, and the location relative to adjacent diseased trees. *Phellinus weirii*-infected trees of highly susceptible host species often represent the highest possible failure potential. Given the history of damaging failures due to laminated root rot in recreation sites in the Pacific Northwest, the often unpredictable nature of these failures, and the difficulty frequently associated with detecting the disease and determining the actual extents of affected areas, laminated root rot should be of particular concern to hazard evaluators and managers of developed sites.

**Port-Orford-cedar root disease** is caused by *Phytophthora lateralis*. It is an introduced pathogen that causes cambial death and subsequent tree mortality but not decay. The main host is Port-Orford-cedar, although Pacific yew also can be infected on rare occasions (Table 6). The diagnostic symptom is a cinnamon-colored stain in the inner bark of roots and lower stems. The disease is found mainly in southwest Oregon, although it appears in other areas where ornamental Port-Orford-cedars are grown. Port-Orford-cedar root disease is common along roads, watercourses, and in poorly-drained areas. It has been found killing cedar in recreation sites. As with black stain root disease, affected trees die standing and then have **high-failure potential.** Live trees with disease signs and symptoms have **low-failure potential** (Table 1).

**Schweinitzii root and butt rot** is caused by *Phaeolus schweinitzii*. It vies with laminated root rot as the most common cause of conifer failure in developed sites across Oregon and Washington. On the westside of the Cascade Range, significant butt decay may be indicated by occurrence of the conspicuous fruiting body, referred to as the "cow-pie fungus" or "velvet-top fungus", and often by a swollen butt on host trees (Fig. 26). Fresh conks are velvety to the touch and have brightly colored yellow margins. As a conk ages, it dies, turns brown, and lasts about two years (Fig. 25). On the eastside of the Cascade Range, infection and decay may be as common but are often present without indicators. As such, it is less often discovered until significant wind events and tree failures have occurred. Tree mortality and windthrow are unusual unless associated with Armillaria root disease in eastside forests.

Decay of the butt extending as much as 30 feet up the tree occurs on old trees (>150 years). Butt swell, which develops over many decades, is apparent on trees, especially Douglas-fir with extensive butt defect (Fig. 26). Trees with butt rot often fail under high-wind conditions leaving a characteristic barber chair and shattered butt. Unfortunately, the presence of significant decay in roots and butts is not always indicated by the presence of the characteristic conks, even on the Westside where they are most commonly produced. Also, the presence of conks does not always indicate significant decay in the roots or butts. Therefore, suspect trees (those with conks, butt swell,

**Fig. 25 –** *Older mushrooms of* Phaeolus schweinitzii *often resemble "cow-pies."*

open cracks, or wounds) should be drilled near the root collar to determine the extent of decay and safe sound-rind thickness (Tables 3A and B). Since decay is commonly found throughout the roots and lower bole, decay found at the base of the tree by drilling should be reason for concern.

**Fig. 26 –** *Butt swell of Douglas-fir is often associated with root and butt decay caused by* Phaeolus schweinitzii.

The advanced decay is a brown cubical rot. The incipient stain, while distinctive, is rarely observed except on freshly cut log ends. The incipient stain is light green, occurring immediately adjacent to areas of advanced decay. Damage most often occurs in overmature Douglas-fir and Sitka spruce on the westside (Table 6). Douglas-fir, western larch, ponderosa pine, and lodgepole pine are frequently damaged on the eastside. In SW Oregon, Douglas-fir, ponderosa pine and sugar pine are frequently decayed. For all but lodgepole pine, the pathological rotation age is approximately 150 years. For lodgepole pine, that value is a range of years from 100 to 120 depending on site quality, site productivity, and growth history. The high end of the range coincides with the best lodgepole sites. It is important to remember that for lodgepole pine, age becomes a limiting factor in susceptibility to mountain pine beetle beginning at about 80 to 100 years.

Trees are apparently infected by this pathogen at any age. Fresh trunk wounds caused by mechanical injury or fire probably are not infected directly by spores but instead the wounds exacerbate decay in previously infected roots and butts. Many infections, especially on the eastside, also occur by mycelial spread from diseased to healthy roots through litter and organic residues to root tips. Infections are confined to heartwood and are sequestered as relatively innocuous heartwood lesions. When trees are immature, smaller roots with heartwood are decayed. As trees advance in age, larger roots are decayed with increasing deleterious effects on anchorage.

When Schweinitzii root and butt rot is encountered in developed sites, trees should be carefully and thoroughly evaluated rather than automatically removed. This root disease appears to be quite slow to weaken trees to hazardous levels. Evaluations should include examination for obvious leans, recent root wrenching or partial failure, butt swell, shake or cracking of the butt, and evidence of ant or wood borer activity in the butt. Additionally, each of the major lateral roots should be exposed and drilled within 2 feet or so of the root collar to detect any hidden defect in the roots that provide major anchorage. If most of the major root anchorage is not decayed, the tree may be retained and monitored each year or every other year depending on the extent of defect and decay. Trees with seriously compromised anchorage and inadequate sound-rind thickness should be removed or the hazard otherwise mitigated.

On mesic and wetter sites where conks are more abundant, a single fruiting body indicates that the evaluator should take note and examine the defective tree more closely. Once trees with fruiting bodies have been examined, those susceptible hosts immediately adjacent to them should be evaluated in the same way.

**Tomentosus root and butt rot** is caused by *Inonotus tomentosus*. The infection and spread biology of tomentosus root rot is similar to that of annosus root disease. Inter-tree spread occurs via an ectotrophic mycelium, and spores are involved in infection of new wounds and freshly cut stumps. The importance of spores in local spread is poorly understood. In developed sites, Engelmann spruce is most often affected (Table 6), and damage is manifested typically as windthrow or wind shattering of severely butt-rotted, mature trees. Tomentosus root and butt rot typically does not cause extensive damage in developed sites but is locally important in the Cascade and Blue Mountains. This disease may be completely hidden in trees including some with extensive butt rot. Trees with crown symptoms are not common, making this disease difficult to detect.  Also, infection in developed sites usually is not in concise disease centers as occurs with laminated root rot or Armillaria root disease.

Tomentosus root and butt rot is identified in the field by its characteristic fruiting bodies, which are small, yellow to cinnamon-colored, leathery, and may appear in the fall near the bases of defective trees. Even when infection and decay are common, fruiting bodies are seldom produced in some localities, especially in the Blue Mountains. Incipient decay in spruce roots has a distinct pink color that can be detected by drilling (Fig. 27). Healthy wood is cream-white. Advanced decay is a white, pocket rot. Ectotrophic mycelia may occur, but in no instance should ectotrophic mycelia alone be used to diagnose a specific root disease; three of the root diseases discussed in this guide produce surface mycelia, and there is chance of confusion. Other, better indicators are available for each root disease (see Appendix), and several diagnostic clues should be used for each correct diagnosis. Check spruce with potential targets with a drill or borer to detect decay, regardless of external indicators.

When tomentosus root and butt rot is encountered in developed sites it should be addressed immediately. Resistant and tolerant hosts should also be regenerated in tomentosus root and butt rot centers where practical (Table 6). When tomentosus root and butt rot is diagnosed in developed sites, host trees (usually only spruce) in root disease centers can have **high or medium-failure potential** depending on the extent of butt decay (Table 1).

**Yellow root rot** or **stringy butt rot** is caused by *Perenniporia subacida* which can cause tree mortality or butt rot in suppressed or stressed trees especially Douglas-fir, true firs, and western hemlock as well as many hardwood species (Table 6). Affected trees may be easily windthrown. The conks are white, crust-like or leathery and flattened against the wood or bark on the undersides of roots, logs, fallen trees, or exposed roots. Early decay is a light-brown stain that resembles wetwood. Advanced decay is composed of irregularly shaped pockets of decayed springwood that coalesce into masses of stringy fibers with black flecks. Annual rings may separate into a laminated decay. Yellow-white mycelial mats may form between the laminated sheets of wood. Because signs and symptoms are below ground, the disease is difficult to detect in live trees. Host trees can have **high or medium-failure potential** depending on the extent of butt decay (Table 1).

**Fig. 27 –** *Stain in a spruce root often is caused by* Inonotus tomentosus.

## Other Root Problems

Other important root defects include undermined roots that result from erosion, seasonally high waterline or flooding events, and excavation or construction activities. Other root problems include severed roots that are mechanically induced by various construction, road building, and maintenance activities; and loosened, cracked, or broken roots which are caused by high winds and typically result in partial failures. Tree-failure potential is determined by the amount of structural roots remaining in the ground (Table 1).

**Undermined roots** are often associated with road-building or trail-building activities in and around developed sites. Otherwise, they frequently are observed at waters' edge adjacent to lakes, streams, or rivers (Fig. 28). When soil is eroded away from tree roots by the action of swift current or by waves, anchorage is compromised. Erosion also occurs during and after heavy precipitation, when rainfall intensity, duration, and accumulation exceeds the soil infiltration rate (capacity of the soil to absorb water). The result is high runoff; sheet, rill or gully erosion; and often root undermining. Extreme amounts of undermining can cause tree failure from insufficient anchorage.

**Severed roots** act as entrance points for decay fungi. They are commonly associated with utility installations, road building, and trail-building activities. Many of the fungi that enter at these points of injury will cause root and butt decay that eventually predisposes trees to windthrow or other types of failure. Other activities that are associated with severed roots are tent-pad construction or ditching to divert runoff in areas where tents are routinely pitched, building construction, and excavation for placement or repair of water or sewage lines or toilet facilities. While severing of roots is not often immediately hazardous, the damage is always detrimental in the long term and should be avoided as much as possible. In addition to providing anchorage and support, roots are essential for water and nutrient uptake. Significant reductions in root system uptake and translocation capacity by root severing diminish tree vigor and resistance to attacks by bark beetles and root pathogens.

**Loosened, cracked, or broken roots** predispose trees to failure during high winds. Wind events, saturated soils, and soil disturbances occurring singly or in combination, often lead to loosening, cracking, or breakage of roots. Soil saturation is a leading factor in windthrow of shallow-rooted species, or of any

**Fig. 28 –** *Undermined roots, as shown here, can result in tree failure.*

species growing in high density or in shallow soil. Indicators of root damage include:

- Trees with newly developed or newly accentuated leans (Fig. 29); soil and litter are not in contact with the base of the tree on the side away from the lean (there is a conspicuous gap) and
- Cracks, mounds, or ridges of recently heaved soil adjacent to major lateral roots (Fig. 30).

Roots of trees located in heavily used areas frequently become exposed to the air and are subsequently damaged. This is particularly true in areas where tents are routinely pitched, adjacent to fire rings, barbecue pits, picnic tables, or in any area where protruding roots are an inconvenience to users, such as in hiking or biking trails.

## Leaning, Root-sprung, Broken, or Uprooted Trees Supported by Other Trees

Root-sprung trees are likely to fail because their roots are compromised by being partially pulled out of the ground. Such trees are dangerous and are seen as failures in progress. Leaning trees (≥15 degrees) result from root and butt decay, and from high winds that cause root wrenching. Tree leans are either recent or old. All leaning trees should be examined for evidence of severe root and butt rot.

Trees with recent lean (<5 years) may have soil and litter disturbed

**Fig. 29 –** *Newly developed leans lack tops that point upward (uncorrected).*

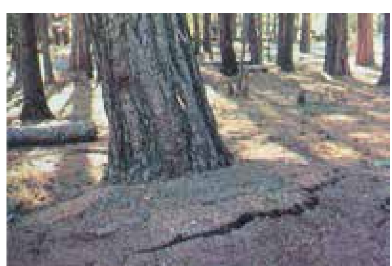

**Fig. 30 –** *Cracks in the soil around leaning trees indicate that such trees have a high-failure probability.*

and not in contact with the base of the tree on the side away from the lean resulting in a conspicuous gap (Fig. 30). Cracks, mounds, or ridges of recently heaved soil may be adjacent to major lateral roots of leaning trees. Recently leaning trees are tilted over their entire length. Since there is no evidence of subsequent reinforcement of the root system, examiners must assume that such partially failed trees exhibit a **high-potential for failure**. Hazard associated with recently leaning trees should be addressed immediately.

**Fig. 31 –** *Old leans with righted or corrected tops have low-failure probability.*

Old, leaning trees are those that have been leaning for a considerable time and have grown a vertical top in the time since the lean developed (corrected lean) (Fig. 31). If they don't fall, leaning 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, old, corrected, leaning trees have **low-failure potential.** Trees that are uprooted or broken but supported by other trees have **high-failure potential** (Table 1).

# Heart Rots

Heart rots are most damaging to mature and overmature trees (old growth), regardless of tree size. By definition, heart rots are confined to the true heartwood. There are some "heart rots" that will affect both the sapwood and the heartwood of living trees. The extent of defect is best correlated with tree age and not diameter. Most of the damage associated with heart rot fungi in most conifer species will occur in trees that are more than 150-years old. Especially decay-prone species such as western hemlock and grand fir, however, may have substantial decay at even younger ages (Table 5). Most fungi that cause stem decay gain access through wounds caused by humans, animals, fire, lightning, snow, high winds, bark beetles, or other agents. Some fungi commonly enter through branch stubs. Wounds, callus tissue, conks, mushrooms, punk knots, swollen knots, old snow breaks, crook, shake, frost cracks, wetwood, bole flattening, or depressions are all potential indicators of internal defect.

In most cases, when stem decay is extensive enough within the bole of a tree to be hazardous, it can be detected by the occurrence of conks, punk knots, and open wounds (Fig. 32). Heart rots, however, may be present when there are few or no external indicators. For example, when conks have fallen from a defective tree and are not observed on the ground, or in dry-habitat types where conks are rarely or not regularly produced. Trees without indicators can be evaluated for the presence of heart rots by several methods.

One way to detect a hollow or decay column is by striking the tree trunk with a rubber mallet or the butt of an axe. To use this method, though, the examiner must develop an ear for recognizing the unique sound of a hollow or decay, and thick-bark species are often difficult to sound. Additionally, detection of a hollow does not mean that the affected tree is a serious hazard to people or property. To evaluate the structural integrity of the suspected tree, the examiner must bore into the tree at the point of defect, either with an increment borer, or a cordless drill, and determine the thickness of the remaining rind of sound wood (Tables 3A and B).

**Fig. 32 –** *Tree bole with an open wound where the sapwood is exposed*

If the suspected defect is well above the ground, very valuable trees can be climbed and drilled; otherwise, most decay and defect high in a tree should be assessed with binoculars and professional judgment rather than by climbing. Trees that are large and mature or overmature routinely will have the greatest amount of stem decay. Some of that defect will be hidden and inaccessible to the examiner by conventional means of evaluation. Risks associated with defects that have been identified but not directly evaluated by boring, or those that are suspected (based on detection

**Table 7. Heart rots in Oregon and Washington; frequency of occurrence by host species where 1=common, 2=occasional, 3=infrequent, 4=rare, and blank means non-host or unknown occurrence**

| Host species | Ash trunk rot | Annosus stem decay | Aspen trunk rot | Brown cubical rot | Brown cubical rot of birch | Brown stringy trunk rot | Brown top rot | Brown trunk rot | Hardwood trunk rot | Incense-cedar pecky rot | Inonotus trunk rot | Juniper pocket rot | Maple trunk rot | Mottled rot - Pholiota | Red cedar pencil rot | Red heart rot - Stereum | Red ring rot / white speck | Redwood cubical rot | Rust-red stringy rot | White spongy trunk rot | White trunk rot | Yellow pitted rot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alder** | | | | | | 2 | | | | | | | | 3 | | 3 | 4 | | | 3 | | |
| **Aspen** | | | 1 | 3 | | | | | | | 2 | | | 3 | | | | | | 3 | | |
| **Ash** | 2 | | | | | | | | 3 | | 3 | | | | | | | | | | | |
| **Birch** | | 3 | | 3 | 1 | | | | 3 | | | | | | | 3 | 3 | | | 1 | | |
| **Buckthorn** | | 3 | | | | | | | 3 | | | | | | | | | | | | | |
| **Cedar** | | | | | | | | | | | | | | | | | | | | | | |
| **Alaska** | | | | | | | | | | | | | | | | | 4 | | | | | |
| **Incense** | | | | | | | | | | 2 | | | | | | | 4 | | | | | |
| **Port-Orford** | | | | | | | | | | | | | | | | | 4 | | | | | |
| **Western red** | | | | 3 | | | | | | | | | | | 1 | | 3 | | | | | |
| **Cherry** | | | | 3 | | | | | 3 | | | | | | | 3 | | | | 3 | | |
| **Chinkapin** | | | | | | | | | 3 | | | | | | | | | | | | | |
| **Cottonwood** | | 3 | | 3 | | 1 | | | 3 | | 2 | | | 3 | | | | | | 3 | | |
| **Dogwood** | | | | | | | | | 3 | | | | | | | | | | | | | |
| **Douglas-fir** | | | | 3 | | | 2 | 2 | 4 | | | | | | | 3 | 1 | | | | | |
| **Hemlock** | | | | | | | | | | | | | | | | | | | | | | |
| **Mountain** | | 1 | | 3 | | | 3 | 2 | | | 2 | | | 3 | | 3 | 1 | | 1 | | 3 | 2 |
| **Western** | | 1 | | 3 | | | 3 | 2 | | | 2 | | | 3 | | 3 | 2 | | 2 | | 2 | 3 |
| **Juniper** | | | | | | | | | | | | 2 | | | | | 3 | | | | | |
| **Larch** | | | | 3 | | | 3 | 2 | | | | | | | | 3 | 1 | | | | | |
| **Madrone** | | 3 | | | | | 4 | | 3 | | | | | | | | | | | | | |
| **Maple** | | 4 | | 2 | | 2 | | | 3 | | 2 | | 2 | 3 | | 3 | 3 | | | 3 | | |
| **Myrtle** | | | | 2 | | | | | | | | | | | | | | | | | | |
| **Oak** | | 3 | | 2 | | 2 | | | 3 | | 2 | | | | | 3 | 3 | | | 3 | | |

**Table 7. Heart rots in Oregon and Washington; frequency of occurrence by host species where 1=common, 2=occasional, 3=infrequent, 4=rare, and blank means non-host or unknown occurrence** *(continued)*

| Host species | *Ash trunk rot* | *Annosus stem decay* | *Aspen trunk rot* | *Brown cubical rot* | *Brown cubical rot of birch* | *Brown stringy trunk rot* | *Brown top rot* | *Brown trunk rot* | *Hardwood trunk rot* | *Incense-cedar pecky rot* | *Inonotus trunk rot* | *Juniper pocket rot* | *Maple trunk rot* | *Mottled rot - Pholiota* | *Red cedar pencil rot* | *Red heart rot - Stereum* | *Red ring rot / white speck* | *Redwood cubical rot* | *Rust-red stringy rot* | *White spongy trunk rot* | *White trunk rot* | *Yellow pitted rot* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pine** | | | | | | | | | | | | | | | | | | | | | | |
| **Jeffrey** | | | | | | | 4 | 2 | | | | | | 3 | | 3 | 1 | | | | | |
| **Knobcone** | | | | | | | 4 | 4 | | | | | | 3 | | 3 | 1 | | | | | |
| **Lodgepole** | | | | 3 | 3 | | 4 | 2 | | | | | | 3 | | 3 | 1 | | | | | |
| **Ponderosa** | | | | 3 | 3 | | 4 | 2 | | | 3 | | | 3 | | 3 | 1 | | | | | |
| **Sugar** | | | | 3 | 3 | | 4 | 2 | | | | | | 3 | | 3 | 1 | | | | | |
| **Western white** | | | | 3 | 3 | | 4 | 2 | | | | | | 3 | | 3 | 1 | | | | | |
| **Whitebark** | | | | | | | 4 | 4 | | | | | | 3 | | 3 | 1 | | | | | |
| **Redwood** | | | | | | | | | | | | | | | | | | 3 | | | | |
| **Spruce** | | | | | | | | | | | | | | | | | | | | | | |
| **Brewer** | | 3 | | 3 | | | 3 | 3 | | | | | | 3 | | | 2 | | | | | 3 |
| **Engelmann** | | 3 | | 3 | | | 4 | 3 | | | 3 | | | 3 | | 3 | 2 | | 3 | | | 3 |
| **Sitka** | | 3 | | 3 | | | 3 | 3 | | | 3 | | | 3 | | 3 | 2 | | | | | 3 |
| **Tanoak** | | | | | | | | | | | | | | | | | | | | | | |
| **True Fir** | | | | | | | | | | | | | | | | | | | | | | |
| **Grand** | | 1 | | 3 | | | 4 | 3 | | | 3 | | | 2 | | 3 | 1 | | 1 | | 3 | 3 |
| **Noble** | | 2 | | 3 | | | 4 | 3 | | | | | | 2 | | 3 | 2 | | 2 | | 3 | 2 |
| **Pacific silver** | | 1 | | 3 | | | 4 | 3 | | | | | | 2 | | 3 | 2 | | 2 | | 3 | 2 |
| **Shasta red** | | 2 | | 3 | | | 4 | 3 | | | | | | 2 | | 3 | 2 | | 2 | | 3 | 2 |
| **Subalpine** | | 2 | | 3 | | | 4 | 3 | | | | | | 2 | | 3 | 2 | | 2 | | 3 | 2 |
| **White** | | 1 | | 3 | | | 4 | 3 | | | 3 | | | 2 | | 3 | 1 | | 1 | | 3 | 3 |
| **Willow** | | | | 2 | | | | | 3 | | | | | | | 3 | | | | 3 | | |
| **Yew** | | | | | | | | | | | | | | 3 | | | 2 | | | | 3 | |

clues) but not clearly identified, should be carefully considered. When the potential risks are considered unacceptable if hazardous levels of decay are known to exist, the potential hazard should be more thoroughly investigated or mitigated, but never ignored.

Failure potential of trees with internal decay is directly related to trunk diameter and average thickness of sound wood at the conk or defect. Because living trees can compartmentalize decay within wood infected when stems were wounded, affected trees often have hollows or decayed areas within a cylinder (rind) of sound wood that was added after wounding (Fig. 9). Conifers can lose approximately 70% of the total cross-sectional area to wood decay (which is equivalent to about 1/3 of its strength or resistance to failure) without significantly increasing the level of hazard, as long as the defect is heart rot uncomplicated by other defects. This is equivalent to having a sound rind of 15% of the diameter inside bark (Table 3A, Wagener 1963). If the shell of sound wood is thinner than the thickness displayed in Table 3A for a comparable trunk diameter, failure potential is high. These guidelines are adequately buffered for trees with internal decay but no additional defects.

Trees with wounds or cankers opening to the outside have a much greater failure potential than trees having equivalent rinds of sound wood but no openings (Fig. 32). A hollow tree with an open wound or canker should be considered hazardous if the sound-rind thickness at its thinnest point meets or is below the suggested standard for the diameter. Minimum sound-rind thickness should be increased by at least 25% for hollow trees with open wounds (Table 3B).

Extra caution should be taken when evaluating trees with multiple defects including stem decay, and the sound-rind thickness guidelines should be used with caution since they were developed for trees with a single defect. For example, forked trees with evidence of heart rot, such as a conk directly below the fork, should be evaluated carefully, and the evaluator should assume the fork to be unstable.

The rate of radial growth affects future sound-rind thickness. If growth rate is rapid, strength loss from advancing decay will be partially offset or perhaps even negated by the added strength of new wood. This is because decay is often compartmentalized within a column that is the size of the tree when it was first wounded; new wood formed after wounding usually does not decay unless the tree is wounded again. The condition of callus growth around wounds is an indicator of health and tree vigor. Vigorous callus activity (abundant new wood and wound parenchyma produced over wounds), emergence of a new cambial region and a thin, healthy, new bark indicate rapid growth.

Major heart rots that result in tree hazards in developed sites in the Pacific Northwest include the following:

**Ash trunk rot** is caused by *Perenniporia fraxinophilus*. Oregon ash is the only host species (Table 7). Trees with one or more conks have **medium-failure potential.** Conks are perennial, woody, shelf-shaped to hoof-shaped with a rough dark-brown to black upper surface and a brownish under surface. Conks can be a width of 1 ft. or more. The incipient decay appears first as a brownish discoloration then developing white spots with time. Advanced decay is straw-colored to white, soft and crumbly, with longitudinal white areas on the radial face.

**Annosus stem decay,** common in conifers and some hardwoods (Table 7), is caused by the same fungi that cause annosus root disease (p. 45). Infection occurs by airborne spores through wounds that develop into butt or stem rot. Butt and stem decay predisposes trees to windthrow and breakage. Tree-failure potential depends on sound-rind thickness.

Some defect rules for estimating extent of *Heterobasidion*-caused stem decay of true firs, hemlocks, and spruces are as follows:

1) When a *Heterobasidion* conk is visible near the root collar of a tree (not a very common occurrence), the lower 16-foot section of the butt log is defective,
2) Defect extends four feet above and below any stem wound with verified annosus decay that is 10-years old or older,
3) For wounds less than 10-years old, expect internal defect to run the length of the wound.

**Aspen trunk rot** is caused by *Phellinus tremulae*. A single conk generally indicates considerable internal decay; such trees have **medium-failure potential**. Conks of the fungus are perennial, hard, woody, and generally triangular shaped in longitudinal section (Fig. 33). Conks of *P. tremulae* have an under surface that is brown

**Fig. 33 –** *Typical conk of* Phellinus tremulae *indicates internal decay in this aspen.*

with small and regular pores. Early 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.

**Brown cubical rot** is caused by *Laetiporus conifericola* in conifers and *L. gilbertsonii* in hardwoods (both formerly *L. sulphureus*) (Table 7). Decay is usually well advanced before conks develop, so trees with $\geq$1 conks have **high-failure potential**. The distinctive conks are known as the sulfur fungus or "chicken of the woods." Conks are annual and orange-yellow with multiple brackets, usually found on the butt and lower bole but also commonly occurring on stumps. Older, dead conks may persist for a year or two and are bleached chalky-white and brittle. Conks are commonly observed on dead trees or tree parts. Early decay is a light-brown stain. Advanced decay has red-brown cubes with white mycelial felts.

**Brown cubical rot of birch,** caused by *Piptoporus betulinus*, is restricted to birch. A single conk generally indicates considerable internal decay, and such trees have **medium-failure potential**. Conks are annual and leathery with short, thick stalks. The upper surface is light brown turning dark brown and scaly with age and a margin that extends below the pore surface. The under surface is white becoming light brown and tooth-like with age. Decayed wood is yellow-brown and breaks into cubes with thin white mycelial fans in the cracks. Advanced decay easily crumbles to powder.

**Brown stringy trunk rot** is caused by *Spongipellis delectans* and occurs in hardwoods (Table 7). A single conk generally indicates considerable internal decay, and such trees have **medium-failure potential**. The conk is quite distinctive, annual, and emerges from the butt or bole with several shapes but generally is shelf-like. Conks are white- to cream-colored, fleshy to leathery with tawny-colored rounded lips. The underside has small, uniform pores. Decay is initially streaky brown and retains most of its structural strength. As decay advances, it turns a uniform brown and the texture becomes stringy but sometimes laminated. Decay occurs in pockets of various sizes mostly in the main stem, and pockets coalesce as decay progresses. Decay continues after the host dies.

**Brown top rot** is caused by *Fomitopsis cajanderi* and occasionally damages conifers (Table 7). The fungus causes a brown-cubical heart rot in living trees. It is usually found in trees that had past top damage resulting from wind or ice and snow loading. Conks sometimes form on the lower bole, probably as a result of a very old top-break or bole wound. Wood strength may be moderately affected before any discoloration or texture change becomes evident. A faint brownish or yellow-brown stain, sometimes marked by greenish-brown zone lines, may be seen in the early decay stages. Advanced decay is yellowish to reddish brown, soft, and with irregular cubes. Thin mycelial felts that vary from white to faintly rose-colored may develop in the cracks between the cubes.

The amount of decay is proportional to the diameter of the broken stem with decay progressing downward into the main stem and eventually upward into any new leaders that form after infection. Boles and new leaders on trees with one or more conks at the base of a new leader have a **medium-failure potential**. New leaders and boles on trees with top-breaks but no conks would have **low-failure potential**. Such trees, however, should be monitored for future conks.

The conks of *F. cajanderi* are perennial, woody, bracket-like to hoof-shaped with pink to rose-colored undersurfaces and inner tissue; hence, the common name, "rose-colored conk". The conk's upper-surface is brown to black and usually cracked and rough. Conks often appear stacked in a shelf-like arrangement. Because conks are relatively small, those associated with top breaks may need to be viewed with binoculars. The conks are very difficult to detect, and even highly experienced evaluators easily overlook their presence.

**Brown trunk rot** is caused by *Fomitopsis officinalis*, the quinine or chalky fungus and occurs in conifers (Table 7). The presence of brown trunk rot, as shown by even one conk, indicates **high-failure potential** for host trees. 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. The advanced decay is a yellow-brown, reddish-brown, or purple-brown cubical rot (Fig. 34). The decay is crumbly with large, brown cubical chunks, and mycelial felts are conspicuous in shrinkage cracks that form in the cubical decay. Felts may be one-quarter inch thick and may extend several feet in length in one

**Fig. 34 –** *Advanced decay caused by* Fomitopsis officinalis *is a brown-cubical rot.*

**Fig. 35 –** *Quinine conks of* Fomitopsis officinalis *are distinctive and indicate considerable stem decay.*

continuous sheet. Mycelial felts are bitter to the taste and resinous pockets or crusts are formed throughout their length. The incipient stain is yellow-green to brownish-green (very similar to that of Schweinitzii root and butt rot). The coloration of incipient stain in ponderosa pine is brown or reddish-brown.

Conks are not common but unmistakable. The conks are usually large, white, hoof-shaped to pendulous, and are perennial (Fig. 35). They have a chalky-white upper surface and a white pore surface. The interior of most conks is soft and crumbly. Conks develop at branch stubs, over old wounds and especially at the site of old top breaks. Punk knots may be observed at large, older branch stubs that have usually rotted and fallen off. Punk knots may have a yellowish-brown exudate that stains the bark below. If a conk is located ≥50 ft. above ground, the entire top-half of the tree has decay. If a conk is <50 ft. above ground, then the entire tree has decay. Depending on target location and value, trees with quinine conks should be mitigated in any developed site.

**Hardwood trunk rot** is caused by *Phellinus igniarius*, the false-tinder fungus and occurs on many hardwood species (Table 7). A single conk generally indicates considerable internal decay; such trees have **medium-failure potential**. Conks are perennial, woody, and generally hoofed-shaped with the lower surfaces nearly horizontal. The upper surface is gray-black to black and rough when old. The under surface is brown with small and regular pores. Early 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.

**Incense-cedar pecky rot** is caused by *Oligoporus amarus* and is common in mature incense-cedar. Unless there are other indicators, trees with conks have **low-failure potential**. Tree failure is not common with pecky rot even when decay is extensive. Decay, which is a pocket-rot of the heartwood, is not limited to the butt log, and it may occur along the entire length of the bole. The advanced decay is a brown cubical rot similar to that occurring in western redcedar with pencil rot. Conks are common but ephemeral. Conks are annual, fruiting at knots in late summer or autumn. They are hoof-shaped to half-bell shaped, tan to buff-colored on the upper surfaces, bright sulphur yellow on the undersides (pore surface) with small tubes that exude clear drops of a yellow liquid (Fig. 36). As conks age they turn brown and hard. Insects, birds, and squirrels destroy conks, leaving "shot-hole cups", which are apparent at and below the knot where conks were attached. Presence of a shot-hole cup also indicates decay. Large, open knots or open branch stubs are also indicative of extensive decay. Woodpeckers like to work around old, punky, open knots, and evidence of old woodpecker work also indicates old conk locations and decayed trees. Dry sides (p. 72) are not typically associated with this decay of incense-cedar. Decay is almost always present in incense-cedar >40 in. dbh with basal wounds or old dead limbs.

**Fig. 36 –** *Conks of* Oligoporus amarus *on incense-cedar are annual and disintegrate relatively rapidly.*

***Inonotus* trunk rot** is caused by two species of fungi, either *Inonotus dryophilus* or *Inonotus dryadeus*, both of which occur on conifers and hardwoods. A single conk of either species generally indicates considerable internal decay; such trees have **medium-failure potential.** Conks of *I. dryophilus* have buff to reddish-brown upper and lower surfaces. The advanced decay is a white rot of the heartwood of living trees with a conspicuous brown mycelium in the decayed wood. Conks of *Inonotus dryadeus* are annual, firm to woody, and exude amber colored droplets on the upper surface when young and on the outer edge when older; the lower surface is buff colored and becomes dark brown and cracked with age. *Inonotus dryadeus* causes a white rot of the heartwood in butts and roots of living trees.

**Juniper pocket rot** is caused by *Pyrofomes demidoffii* and is common in mature juniper. Trees with $\geq$1 conks have considerable decay but rarely fail and therefore have **low-failure potential**. Trunk conks are perennial and hoof-shaped with a brown to black upper surface with a buff to black rim. The under-surface is buff-colored with round pores.

Early decay is a light-yellow color. Advanced decay is a white rot with abundant buff-colored mycelial felts in the decayed wood.

**Maple trunk rot** is caused by *Oxyporus populinus*. This fungus is known as the mossy-maple polypore. Conks generally indicate considerable internal decay, and such trees have **medium-failure potential**. Conks are usually associated with wounds, scars, or cracks. The conk is perennial with multiple shelf-like brackets occurring on the lower butt of decayed trees. The lip and the underside of each bracket are white while the upper-surface is white to gray. Pores on the under-surface are very small. Older conks are distinctive with moss and/or liverworts growing on the upper-surface. Decay is a white heart rot.

**Mottled rot** is caused by either *Pholiota adiposa*, the yellow cap fungus, or *P. limonella*, the lemon cap fungus and affects both conifers and hardwoods. Failure potential of trees with one or more conks depends on the amount of sound-rind thickness (Table 1). The mushrooms have gills and are annual, fleshy, yellow on their upper surfaces, and sticky when wet. They have a yellow stem and yellowish to brown gills. Mushrooms develop singly or in close groups from a common base and appear in the fall, usually on host stems. Incipient decay is light yellow and is usually confined to small pockets in the heartwood. Advanced decay has discolored areas that enlarge and darken to a honey color. Brown streaks appear, causing a mottled look that the decay is named for. Decayed wood breaks into stringy strands in the last stages after separating at the annual rings. Trunks can become completely hollow. Most decay is in the lower bole but can extend 45 to 60 ft. above ground. Mushrooms are most common on dead trees or on decadent trees with areas of dead stem wood.

**Redcedar pencil rot** is caused by *Postia sericiomollis*. It is a severe stem decay and butt rot of western redcedar. Failure potential of redcedars with pencil rot depends on the amount of sound-rind thickness (Table 1). In redcedar, decay is usually confined to the butt (first 40 feet) of affected trees. Fruiting bodies are annual, thin, flat, white crusts that are not common and are of limited use in estimating decay presence. The advanced decay is a brown, cubical pocket rot. When decay is minor in affected stems, it appears as long, thin "pencils" of brown cubical decay. As decay becomes more extensive, this pencil rotting is more abundant, and these thin rot columns begin to coalesce. In severely damaged trees, most of the heartwood is decayed and pencil rotting is less obvious, but it can be observed at the outer margins and upper reaches of decay.

No cull rule is defined for this decay. Decayed trees, however, are often used by cavity-nesting birds, and their cavities are a good indicator of advanced decay. Trees with significant decay may display a conspicuous bole flattening at the butt called a "dry side" or "dry face" that resembles a canker. Trees with evidence of a dry side should be sounded with an axe or mallet and drilled to determine the extent of decay and the sound-rind thickness. Dry sides may extend 40 feet or more up the stem. They are normally covered with bark which hides from view 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 wood of the tree to the outside. Dry sides may be confused with irregularities in the butt associated with butt swell or fluting.

**Red heart rot** is caused by *Stereum sanguinolentum* and is commonly found in conifers. All dead trees with conks have a **high-failure potential**. Fruiting bodies are found on infected wounds of live trees and on the bark of dead trees. The conks are numerous, annual, and leathery. The upper-surface is gray to light-brown and zoned; the lower-surface is wrinkled, gray to light brown but turning red when bruised (common name of bleeding fungus). Incipient decay appears as a red-brown heartwood stain. Advanced decay is light-brown and soft with thin mycelial felts that may be present.

**Red ring rot** or **white speck** is caused by *Phellinus pini* and is the most common stem decay of living Pacific Northwest conifers. Failure potential of trees with red ring rot depends on tree species, number and size of conks per tree, and associated indications of extensive decay such as open cracks or weeping frost cracks (Table 1). Many stands of old-growth Douglas-fir, pine, larch, hemlock, or true fir exhibit some of this defect. Conks are hoof-shaped and are formed at branch stubs or knots (Fig. 37). Pore surfaces are cinnamon-brown to tan with pores that are irregular rather than round. The interior of the conk has the same cinnamon-brown coloration as the pore surface. On hemlocks especially, but occasionally on other species, conks may be abundant on the undersides of branches (limb conk).

**Fig. 37 –** *Typical conk of* Phellinus pini *often indicates low-failure potential.*

**Fig. 38 –** *Wood with decay caused by* Phellinus pini*, commonly called whitespeck, is relatively sound compared to wood decay caused by other fungi.*

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 that have fallen off (see Appendix). Individual limb conks may be 12 to 18 in. long with their long axis parallel to the limb; conks may extend 2 or 3 in. out on either side of a limb. Limbs with conks extending up to 2 or 3 feet away from the main stem are common in some areas.

Punk knots are common on severely decayed trees. 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 occupies 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. Often branch stubs, bark flaps, burls (Fig. 54), and other features can look like conks or punk knots. Close evaluation with binoculars is important to assure the indicator is in fact a conk or punk knot.

The decay caused by *P. pini* is a white pocket rot (Fig. 38) that occurs in rings separated by sound wood until decay becomes very advanced (very soft and crumbly). When this decay is encountered in developed sites, it must be evaluated carefully. Wood decayed by this pathogen maintains some strength against failure. When Douglas-fir, pine, cedar, or larch have ≥3 large conks (>6 in. wide) within a 3-ft. trunk cylinder, the hazard evaluator can expect that damage to the heartwood probably is extensive (Table 1). With many small or separated large conks, these resinous tree species may have adequate strength to withstand high winds. If an evaluator suspects that a tree is marginally safe based on indicators, the evaluation of damage potential, target value, and alternative hazard-mitigation strategies must direct the course of the hazard-management decision. Where damage potential is high, the evaluator should measure the sound-rind thickness at the point of greatest defect, usually near the largest conks. This may require climbing affected trees to drill near the biggest conks. When boring a tree with *P. pini* decay, consider firm (not crumbly) wood with white speck or red discoloration as sound wood (Table 1).

In southern Oregon, red ring rot is more severe in older stands, in pure stands of host trees, on steep slopes, on shallow soils, and on sites dominated by secondary shrub, herb, or forb vegetation (vine maple, vanilla-leaf, oxalis, or rose rather than salal, twinflower, or rhododendron).

**Redwood cubical rot** is caused by *Oligoporus sequoiae*. The fruiting body develops as a thin, white crust composed of fungal strands and a spore-producing pore surface. The fruiting bodies rarely exceed 2 in. long by 1 in. wide and form in fire scars and bark crevices. Incipient decay is a dark-brown stain that forms pockets of brown, charcoal-like dry rot that shrinks and cracks into cubes when advanced. Redwood is a relatively decay-resistant tree species, so failure potential should be determined by measuring sound-rind thickness.

**Rust-red stringy rot** is caused by *Echinodontium tinctorium*, the Indian paint fungus. It is the most damaging stem decay of older true firs and hemlocks. The presence of rust-red stringy rot as indicated by conks results in either **high- to low-failure potential** depending on number and size of conks per tree and associated indications of extensive decay (Fig. 39) such as open cracks or weeping frost cracks (Table 1). Trees with a single conk on average have as much as 40 feet of continuous decay within the trunk (see Appendix).

**Fig. 39 –** *Advanced decay caused by* Echinodontium tinctorium, *the Indian paint fungus, can result in tree failure.*

**Fig. 40 –** *Conks of the Indian paint fungus are distinctive and common on true firs.*

Trees can become infected at a relatively early age through tiny (0.5 mm), dead branchlet stubs. Thereafter, the fungus becomes dormant until re-activated by tree wounding. Infected saplings and poles are often released from their suppressed condition, and they resume vigorous radial growth, often encasing dormant infections in heartwood. Following re-activation of the dormant infection by injury near the point of original infection, heartwood is decayed.

Advanced decay is a rust-red stringy rot that may result in nearly hollow stems (Fig. 39). When decay is advanced, large, hoof-shaped conks with a spiny lower surface are produced. Young conks have mostly a light-colored pore surface with a dark top. Older conks have a fissured upper surface and they are rough, dull black, and woody (Fig. 40). The interior of the conk and the cores of infected branch stubs are rusty-red to bright orange-red. Conks appear on the bole at the site of old branches. Where conks appear at multiple, old branch whorls, greater defect is indicated.

**White spongy trunk rot,** caused by *Fomes fomentarius*, produces conks that are found on dead trees or dead portions of hardwoods. Trees often have multiple conks indicating extensive decay and **high-failure potential**. This decay occurs almost exclusively in hardwoods. The perennial conk is hoof-shaped with a concentrically zoned, smooth, and gray to gray-black upper surface. The underside is brown with small, regular-shaped pores. Early decay is brown and firm. Advanced decay is soft and spongy, yellow-white with dark to black zone lines.

**White trunk rot** is caused by *Phellinus hartigii* and is found in living conifers and hardwoods (Table 7). Trees with one or more conks have **medium-failure potential**. The decay often occurs in a section of wood radiating in from the sapwood. Incipient decay is straw-colored to purple stain that is irregular in shape. Advanced decay has a bleached look with occasional light-brown areas or streaks. Trees with white trunk rot often fail within 20 feet of the ground. The conks are perennial and, if on the main stem, appear hoof-shaped with a dark-brown to black upper-surface and a brown and poroid lower surface. When formed on the lower surfaces of branches, the conks are flat against the branch and often occur where the branch joins the main stem; hence, the common name, "armpit fungus." The conks are commonly associated with hemlock dwarf-mistletoe infections (p. 83).

**Yellow pitted rot** is caused by *Hericium abietis*, the coral fungus, and occurs in some conifers (Table 7). Trees with one or more conks have **medium-failure potential**. The fruiting bodies are distinctive, soft, creamy-white, coral-like, annual conks. They occur at wounds on living trees. Incipient decay is a yellow to brown stain with scattered darker spots that give the wood a mottled appearance. Advanced decay is composed of elongated blunt-end pits, about ½ in. long; hence, the old common name, "long-pocket rot."

# Sap Rots

**Sap rots** are decays that occur in the sapwood (Table 8). Most sap-rotting fungi cause rapid decay of dead sapwood only. When these fungi have decayed all of the available dead sapwood, then decay ceases and in most cases no heartwood is decayed. They compete poorly with other fungi that decay heartwood, and are seldom found past the heartwood/sapwood interface. In living trees, sap rots occur on wood tissue killed by other agents, most often bark beetles and mechanical or 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 hemlocks, sapwood is fully rotted within 1 to 2 years of tree death. 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.

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 decays very rapidly once it dies, 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 using a cordless drill, increment borer, or axe. Living hardwoods with sap rot in one or more stem quadrants have a **medium-failure potential** (Table 1).

Trees killed with a full complement of foliage, normally develop sap rot at a rapid rate. Trees killed by crowning fire or trees with broken tops, however, exhibit delayed sap rot development. In such trees, the level of xylem sap remains high, and it rather quickly ferments, turning sour.

**Table 8. Sap rots affecting trees on developed sites in Oregon and Washington.**

| Common name | Scientific name of causal fungus | Major hosts |
|---|---|---|
| Brown crumbly rot | *Fomitopsis pinicola* | Most tree species |
| Gray-brown sap rot | *Cryptoporus volvatus* | All conifers |
| Pitted sap rot | *Trichaptum abietinum* | All conifers and some hardwoods |
| Silver leaf disease | *Chondrostereum purpureum* | Mostly hardwoods |

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. When bark beetles do attack such trees, breeding success is poor. In trees with soured sap, the succession of microorganisms and invertebrates is very different than that occurring in normal trees killed by bark beetles. With any of the following sap rots, dead trees have **high-failure potential** in developed sites.

**Fig. 41 –** *Red-belt conk of* Fomitopsis pinicola, *the most common decayer of dead wood in the Pacific Northwest.*

**Fig. 42 –** *Pouch-fungus conks of* Cryptoporus volvatus *often indicate considerable sap rot.*

**Brown crumbly rot** is caused by *Fomitopsis pinicola*, the red-belt fungus. This fungus causes a sap rot of dead trees but sometimes also a heart rot of living trees, especially those with trunk wounds. Live trees with >1 conks may have low- or medium-failure potential depending on the extent of dead sapwood (Table 1). Bark beetles transport propagules of the fungus to infested trees. Conks are leathery to woody, perennial, and bracket-shaped (Fig. 41). When young, the conks appear white and round. As they mature, the upper surfaces turn dark-gray to black, the lower pore surfaces remain white, and conspicuous reddish margins develop between the two surfaces; hence, the common name "red-belt conk." Conks are often seen on dead and down trees. After tree or tissue death, decay develops rapidly in the sapwood and then progresses to the heartwood. Incipient decay is a faint yellow-brown to brown stain. Advanced decay is light reddish-brown and forms a crumbly mass of rough, small cubes with mycelial felts between the shrinkage cracks.

**Gray-brown sap rot** is caused by *Cryptoporus volvatus*, the pouch fungus. It is one of the most easily recognized of the sap-rotting fungi.

**Table 9. Fungal cankers and stem rusts in Oregon and Washington; frequency of occurrence by host species where: 1=common, 2=occasional, 3=infrequent, 4=rare, and blank means non-host or unknown occurrence.**

| Host species | *Atropellis canker* | *Ceratocystis canker* | *Comandra blister rust* | *Cryptosphaeria canker* | *Cytospora canker* | *Hypoxylon canker* | *Madrone canker* | *Mistletoe canker* | *Nectria canker* | *Phytophthora canker of golden chinkapin* | *Ramorum canker* | *Redcedar pencil rot* | *Red ring rot canker* | *Sooty-bark canker* | *Stalactiform rust* | *Sterile conk trunk rot* | *Western gall rust* | *White pine blister rust* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alder** | | | | | 3 | 3 | | | 3 | | | | | | | 3 | | |
| **Aspen** | | 2 | | 3 | 2 | 3 | | | 2 | | | | | 2 | | | | |
| **Ash** | | | | | 3 | | | | 3 | | | | | | | | | |
| **Birch** | | | | | 3 | | | | 3 | | | | | | | 2 | | |
| **Buckthorn** | | | | | | | | | 3 | | | | | | | | | |
| **Cedar** | | | | | | | | | | | | | | | | | | |
| **Alaska** | | | | | | | | | | | | | | | | | | |
| **Incense** | | | | | | | | 3 | | | | | | | | | | |
| **Port-Orford** | | | | | | | | | | | | | | | | | | |
| **Western red** | | | | | | | | | | | | 3 | | | | | | |
| **Cherry** | | | | | 3 | | | | 3 | | | | | | | | | |
| **Chinkapin** | | | | | | | | | | 2 | | | | | | | | |
| **Cottonwood** | | 4 | | 3 | 3 | 3 | | | 3 | | | | | 2 | | 4 | | |
| **Dogwood** | | | | | 3 | | | | 3 | | | | | | | | | |
| **Douglas-fir** | | | | | | | | 3 | | | | | | | | | | |
| **Hemlock** | | | | | | | | | | | | | | | | | | |
| **Mountain** | | | | | | | | 2 | | | | | | | | | | |
| **Western** | | | | | | | | 2 | | | | | | | | | | |
| **Juniper** | | | | | | | | 3 | | | | | | | | | | |
| **Larch** | | | | | | | | 3 | | | | | | | | | | |
| **Madrone** | | | | | | | 1 | | | | | | | 3 | | | | |
| **Maple** | | | | | 3 | | | | 3 | | | | | | | | | |
| **Myrtle** | | | | | | | | | 3 | | 3 | | | | | | | |
| **Oak** | | | | | | | | 1 | 3 | | 3 | | | | | | | |

| Host species | *Atropellis canker* | *Ceratocystis canker* | *Comandra blister rust* | *Cryptosphaeria canker* | *Cytospora canker* | *Hypoxylon canker* | *Madrone canker* | *Mistletoe canker* | *Nectria canker* | *Phytophthora canker of golden chinkapin* | *Ramorum canker* | *Redcedar pencil rot* | *Red ring rot canker* | *Sooty-bark canker* | *Stalactiform rust* | *Sterile conk trunk rot* | *Western gall rust* | *White pine blister rust* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pine** | | | | | | | | | | | | | | | | | | |
| **Jeffrey** | | | 4 | | | | | 3 | | | | | | | | | | |
| **Knobcone** | | | 4 | | | | | 3 | | | | | | | | | 1 | |
| **Lodgepole** | 2 | | 3 | | | | | 3 | | | | | | | 2 | | 1 | |
| **Ponderosa** | 3 | | 1 | | | | | 3 | | | | | | | 3 | | 2 | |
| **Sugar** | 3 | | | | | | | | | | | | | | | | | 1 |
| **Western white** | 3 | | | | | | | | | | | | | | | | | 1 |
| **Whitebark** | 3 | | | | | | | | | | | | | | | | | 1 |
| **Redwood** | | | | | | | | | | | | | | | | | | |
| **Spruce** | | | | | | | | | | | | | | | | | | |
| **Brewer** | | | | | | | | | | | | | | | | | | |
| **Engelmann** | | | | | | | | | | | | | | | | | | |
| **Sitka** | | | | | | | | | | | | | | | | | | |
| **Tanoak** | | | | | | | | | | | 1 | | | | | | | |
| **True Fir** | | | | | | | | | | | | | | | | | | |
| **Grand** | | | | | 3 | | | 2 | | | | | 2 | | | | | |
| **Noble** | | | | | 3 | | | 3 | | | | | 3 | | | | | |
| **Pacific silver** | | | | | 3 | | | 3 | | | | | 3 | | | | | |
| **Shasta red** | | | | | 3 | | | 3 | | | | | 3 | | | | | |
| **Subalpine** | | | | | 3 | | | 3 | | | | | 3 | | | | | |
| **White** | | | | | 3 | | | 2 | | | | | 1 | | | | | |
| **Willow** | | | | | 3 | 3 | | | 3 | | | | | 3 | | | | |
| **Yew** | | | | | | | | | | | | | | | | | | |

The fungus is routinely introduced by tree killing bark beetles and wood borers. 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 by a hard membrane; hence, the common name, "pouch fungus" (Fig. 42). Conks bleach to a dirty white after one year. Early decay has gray areas that develop in the sapwood beneath the conks. Advanced decay appears the same and may completely destroy the sapwood.

**Pitted sap rot** is caused by *Trichaptum abietinum*, the purple conk. The fungus infects its host via airborne spores through openings in the bark. Since this fungus is primarily a saprophyte, conks infrequently form on live trees but are numerous on dead trees and logs. Conks are small, annual, thin, and shelf-like. The upper surface is light gray, fuzzy, and zoned. Old conks become dark gray to black. The under surface is violet to purple when fresh that turns light brown with age. As conks age, the angular pores become elongated and separate into spines or ridges. Incipient decay is light yellow to tan and soft; advanced decay has small pits that become elongated in the direction of the grain, with a honeycombed look.

**Silver leaf disease** is caused by *Chondrostereum purpureum*. It occurs mostly on dead hardwoods but has been reported on living trees. The conks are annual, shelf-like, and often in groups. The upper surface is grayish-white to purple and zoned with a light margin. The lower surface is usually smooth, bright purple when young and brown-violet when old. Early decay is a reddish-brown stain; advanced decay is white-mottled to pale yellow.

# Fungal Cankers and Stem Rusts

**Fig. 43** –*Atropellis canker is a common disease of lodgepole pine that can result in stem breakage.*

Fungal cankers and stem rusts are caused by many species of fungi that infect and kill portions of a tree bole. Cankers and rusts frequently occur on the stems and branches of pines and hardwoods. Canker fungi cause top-kill, branch death, or stem malformation. Stem malformations can be infected and subsequently decayed by other fungi, thus increasing the likelihood of

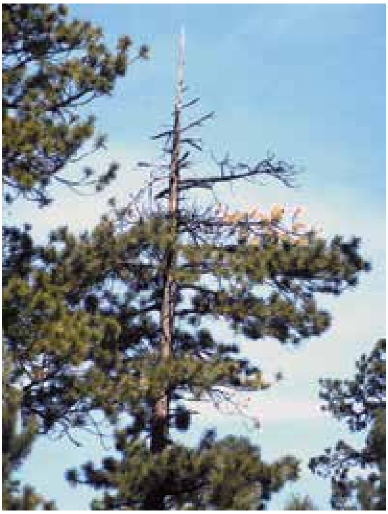

**Fig. 44 –** *Dead tops of ponderosa pine, caused by Comandra blister rust, often are resin-impregnated, decay-resistant, and therefore of very low-failure potential.*

stem breakage. Cankered areas on true fir, hemlock, spruce, or hardwoods are more likely to be associated with failures than those on resinous species: Douglas-fir, pine, or larch and also decay-resistant cedar (Table 1). Failure potential does not significantly increase until the face of the canker is deeply sunken, or the cross-section of the bole with sound wood is small (Fig. 9). Failure potential increases as cankers develop.

Major cankers and stem rusts that result in tree hazards in developed sites in the Pacific Northwest include the following:

**Atropellis canker** is caused by either *Atropellis piniphila* or *A. pinicola* (Table 9). It frequently occurs on the boles of pine species, 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 circumference at that point (Fig. 43). When the cankers result in <50% cross-section of the bole with sound wood, and the depressions are deep, **failure potential is high** (Table 1). This is most likely to occur in heavily infected stands where trees have multiple cankers and where individual trees have two or more cankers at the same height on the bole.

**Ceratocystis canker,** caused by the fungus *Ceratocystis fimbriata*, occurs on aspen and cottonwood (Table 9). Ceratocystis cankers are target-shaped with or without bark adhering to the surface of the canker. Infected wood behind the canker usually is stained. Macroscopic fruiting bodies may be produced on the cankers. Most of the cankers on aspen ultimately girdle the bole and kill the upper part of the tree.

**Comandra blister rust,** caused by *Cronartium comandrae*, occurs on ponderosa pine and sometimes lodgepole pine in Oregon and Washington. Mortality can occur, especially in young, infected trees. Large infected pines exhibit dead tops that progressively die downward

(Fig. 44). Infected and dead tops are relatively decay resistant because of the copious resin associated with infection. These dead tops have **very low-failure potential**, even after several years, and rarely fail.

**Fig. 45 –***Dwarf mistletoe bole infections are especially common on grand and white fir, western hemlock, and western larch.*

**Cryptosphaeria canker,** caused by the fungus *Cryptosphaeria populina*, occurs on aspen and cottonwood. Cankers are elongated with some bleeding at the margins. Several, highly visible, black fruiting bodies form in the bark. Stain and decay may be extensive behind the cankers and determine the degree of failure potential.

**Cytospora canker** is caused by *Cytospora chrysosperma* on hardwoods and *C. abietis* on true firs. Cankers occur on boles, branches and twigs, forming long, dead areas with well defined borders. Several years after infection, dead bark lifts away from the bole and falls off.

**Fig. 46 –***True mistletoe bole and branch infections can cause cankers and subsequent decay in oaks.*

**Hypoxylon canker,** caused by *Entoleuca* (*Hypoxylon*) *mammata,* is found only on hardwoods, including alder, cottonwood, aspen, and willow. The canker first appears as sunken, yellow-orange areas on the bark that is centered around dead branch stubs or injuries. Older cankers have mottled bark with small, dead patches. Cankers can be 3 ft. in length.

**Madrone canker,** caused by *Fusicoccum arbuti* and *F. aesculi,* occurs only on Pacific madrone. The causal fungus attacks weakened madrones, especially trees that are drought-stressed, have mechanical wounds, or are suddenly exposed to full sunlight. The fungus causes a stem and branch canker with branch, trunk, or complete tree dieback. Infected branches develop a purplish-black color, appear dry and cracked, and eventually die. Older stem cankers are sunken into the bark. Failures usually are infrequent until branches or stems have been dead for several years.

**Mistletoe-bole and branch cankers** are caused by dwarf mistletoe (*Arceuthobium* spp.) infection of the bole in conifers (Fig. 45), and true mistletoe (*Phoradendron* spp.) infection in the branches and boles of oaks (Fig. 46), incense-cedars, and junipers. Dwarf mistletoe bole infections are especially common on grand and white fir, western hemlock, and western larch. 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 not a serious issue. 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 be found decaying mistletoe-induced bole swellings.

**Nectria canker** is caused by *Nectria cinnabarina* and 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.

**Phytophthora canker of golden chinquapin** is caused by *Phytophthora cambivora*. The disease can cause tree mortality with leaf flagging being a common symptom of infected trees. In the inner bark, the girdling, basal cankers are reddish-orange and extend upward from infected, necrotic roots. The inner bark turns brown when the trees are dead; **failure-potential then is high.**

**Ramorum canker** is caused by *Phytophthora ramorum*, also the cause of sudden oak death. The causal agent, a fungus-like water mold, was introduced into southern Oregon in about 2000. This disease causes significant mortality of black and live oaks, tanoaks, and California bay in California.  Ramorum canker is mentioned in the context of developed-site hazard 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. Although other tree species can serve

**Fig. 47** –*Sooty-bark canker, as seen on this infected aspen, can result in tree failure.*

as foliar hosts in the PNW: maple, madrone, myrtlewood, cascara, and Douglas-fir, none of these species have 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 are completely dead. Recently infected and dead oaks and tanoaks in developed sites have **high-failure potential**.

**Red ring rot canker** is caused by *Phellinus cancriformans* in southwestern and west-central Oregon and occurs on true firs (Table 9). The conks of the fungus are small and numerous with their upper surfaces being rough, dark, and furrowed (butterfly conks). They closely resemble *P. pini* conks (p. 72) but are smaller and occur in groups. The conks grow from a sunken area on the trunk with decayed wood beneath it (a canker). Substantial amounts of stem breakage can occur with this fungus.

**Sooty-bark canker,** caused by the fungus *Encoella pruinosa,* occurs on aspen and cottonwood. Sooty-bark cankers often have arcs of blackened bark tissue as a result of infection (Fig. 47). Fruiting bodies that form on the cankers are silver gray.

**Stalactiform rust** is caused by *Cronartium coleosporioides* and occurs primarily on lodgepole pine and less commonly on ponderosa and Jeffrey pine. Older infections form diamond-shaped cankers that can extend to 30 ft. long. Tree mortality may occur if boles are completely girdled.

**Fig. 48 –***Lodgepole pine with western gall rust can break if stem cross-sectional area of sound wood is too low.*

**Fig. 49 –***Tops of trees killed by white pine blister rust are often resin-soaked with little decay and have very low-failure potential.*

**Sterile conk trunk rot** is caused by *Inonotus obliquus* and affects some hardwoods (Table 9). Unless there is evidence of extensive decay (cracks or exposed rot), trees with ≥1 sterile conks have a **medium-failure potential**. The sterile conks are conspicuous, perennial, black masses of fungal tissue that erupt from stem cankers. The conk surface is rough and cracked; the interior is yellow- to rust-brown. The tree trunk is often thickened at the conk. Incipient decay is yellow-white in irregular zones. Advanced decay appears as alternating zones of white and light reddish-brown wood. White veins of mycelium are common near the cankers.

**Western gall rust** is caused by *Endocronartium harknessii* and is common on lodgepole and knobcone pine. It frequently 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" are caused when the main stem flattens and broadens as it grows around bole infections (Fig. 48). 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.

**White pine blister rust** is caused by *Cronartium ribicola* and is found throughout the range of 5-needle pines in Oregon and Washington. The fungus causes branch flagging, top-kill, and death usually of pines <8 in. dbh (Fig. 49). Mountain pine beetles often attack 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 the bole cankers. Infected and dead tops are relatively decay resistant because of the copious resin associated with infection. Blister-rust-killed tops have **very low-failure potential** even after several years and rarely break and fall.

# Other Bole Defects

**Cracks and splits** in the main stem frequently occur and are often overlooked or regarded as insignificant. Cracks usually tell an important story and may reveal to the examiner that a closer inspection of the heartwood is warranted. Cracks and splits can be entry points for decay-causing micro-organisms or activate dormant spores of decay fungi, such as the Indian paint fungus (p. 74).

Cracks and splits are produced in several ways: tension and compression failure associated with older injuries and internal decay, lightning strikes, wind shake, and frost action. Cracks can form by tension and compression failure when trees with extensive heart rot bend back and forth under the stress of high winds. The sound rind on the windward side of affected trees is under great tension when winds are strongest. The side of the tree to the lee of the wind becomes compressed by that same wind force. This difference in forces, when most exaggerated, creates a shearing action in the middle of the bole where the two forces meet, and the bole develops a vertical crack somewhere between the ground and where the extent of heart rot is the greatest. An open crack with independent movement of its sides indicates **high-failure potential** because the trees have already partially failed.

**Lightning strikes** cause cracks when electrical discharges are grounded through trees. When the discharge is insufficient to explode the tree or its parts, damage 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. On the other end of the spectrum, groups of trees may be synchronously killed by lightning without any apparent evidence of mechanical damage.

**Fig. 50** –*Frost cracks often indicate low-failure potential unless they are weeping, as shown here, then failure potential is medium to high.*

**Wind shake** can cause cracks, especially on trees growing at higher elevations. High winds regularly impact conifer forests, and winds are often turbulent and twist trees in different directions. 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 radially outward toward the bark. In time, this 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. Wind-shake cracks also incite dormant Indian paint fungus (*E. tinctorium*) infections to develop active decay (p. 74).

Extreme cold can cause bole cracks. **Frost cracks**, common at higher elevations and in cold-air drainages, appear on bark as raised nearly vertical callus lines that extend to the ground where the air is coldest (Fig. 50). 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 extracellular ice formation and produce a contraction on the circumference of the bole with no radial contraction. These cracks begin at the tree base, usually from an old wound, 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 unless they are weeping and have sound-rind thickness <20% of the stem diameter (Table 1). Older frost cracks develop "frost ribs," a series of raised vertical ridges parallel to the frost cracks themselves. If frost cracks have exudates (weeping), they indicate


**Fig. 51 –** *Forked tops, such as this hardwood that is weeping and cracked (A) and this cedar with open cracks (B), have high-failure potential. The ponderosa pine with only embedded bark (C) has medium-failure potential.*

either **high- or medium-failure potential** depending on the sound-rind thickness (Table 1).

**Codominant stems, forked tops, or trees with multiple tops** that are tightly V-shaped, can split and break from the green weight of foliage, heavy snow loads, or internal decay. Since a broad-angled-branch connection was not differentiated at the time the branch first formed, new radial growth at the point of branch convergence forces the acute angle further apart. Eventually, new radial growth will weaken the crotch to such a point that wind or snow load, or the added weight of new foliage causes a branch failure. This not only occurs in mature, forked conifers but also in conifers with severe ramicorn branching and hardwoods with large, spreading crowns. Tree crotches should be regularly examined with binoculars, because defect indicators such as open cracks, decay, mushrooms, or conks often suggest weakening and predisposition to failure (Fig. 51). Trees with these indicators have a **high-failure potential** (Table 1). Tree crotches with only embedded (included) bark (Fig. 51) without the above indicators have **medium-failure potential**. V-shaped tops without defect indicators or U-shaped tops generally have **low-failure potential** (Table 1). Forked tops of ponderosa pine in central Oregon have a potential-failure-zone radius of 1.5 times the length of the broken fork

# Defective Branches

Hazards associated with defective branches are often exaggerated. The incidence of failure in this category is lowest of any listed in Table 4. Table 4 does not indicate the magnitude of personal loss associated with branch failures, but personal injury and property damage are usually less serious than that associated with trees that fail at the roots, butt, or bole. Defective branches fall essentially straight down from the point of failure, and their impact area is considerably smaller than that of a tree failing at the roots, butt or bole. The potential-failure zone is the same radius as the length of the branch. While **failure probability is medium** for attached defective branches, free-hanging limbs should be removed immediately if they hang over a target.

**Hardwoods**, especially poplars, cottonwoods, maples, and alders, are more susceptible to branch failure than most conifers because their crotches are structurally weaker, the lignin content of the wood is low by comparison, and their long branches are heavily weighted at the extremities with green foliage and fruit. As with conifers, crotches of major branches should be regularly examined for defect indicators such as open cracks, splits, or embedded (included) bark that suggest weakening and predisposition to failure or infection by decay fungi. Forked tops with open cracks have **high-failure potential** (Table

1). Also, heart rots of hardwoods often extend into major branches creating higher potential for failure. Dead branches on resinous conifer species remain attached longer than on non-resinous species, and limbs of hardwoods fail sooner than those of most conifers.

**Fig. 52 –***Douglas-fir dwarf mistletoe brooms that are dead and ≥10ft. in diameter have high-failure potential.*

**Black cottonwood branches** have an increasingly high potential to break from the crown as the tree matures. Breakage will often occur at sound wood, although decay is also common and will increase failure potential. Breakage potential is greatest in the summer season when branches are weighed by foliage and cell structure is weakened by high transpiration. Black cottonwoods are a poor choice for long-term maintenance in developed sites, and location of targets should be well removed from large cottonwoods that will be retained.

Each year, **winter storms** occur in developed sites and often cause failure of the most defective branches, tops, and trees. Severe storms have a sanitizing effect in an overstory that has many defective branches; few remain that are defective enough to fail during the next year under their own weight. This sanitation effect is especially common in the higher elevations. At lower elevations, severe storms may be less frequent or different in kind or abundance, and heavy snow/ice loads may be infrequent or may not occur at all.

**Large dwarf mistletoe brooms** (≥10 ft. in diameter), especially on Douglas-firs but sometimes on ponderosa pines, that are dead and hanging directly over stationary targets of value or over areas that are routinely exposed to heavy transitory traffic, should be removed by pruning (Fig. 52). In areas of normally high snow loading or violent winter storms, this hazard is often mitigated as brooms break off with snow and ice loading. Brooms with a high-failure probability will often fail in winter when sites are closed or visitor use is limited. Pruning of large, live brooms may improve the vigor of infected trees and may slow the spread of the parasite to the upper crown that eventually results in tree death or top-kill. Candidates for live-branch pruning are trees with dwarf-mistletoe brooms only in the lower one-third to one-half of the live crown, and trees with live-crown ratios that will still be $\geq$40% after pruning. With Douglas-firs consider using MCH pheromone around trees pruned in spring or summer to prevent lethal attack by bark beetles.

**Treat hazardous defective branches** by removal (Table 10). Candidates for this treatment are dead, broken, or free-hanging branches (completely loose and lodged), or large, dead, dwarf-mistletoe-broomed branches that are above permanent targets or heavily used areas. Trees in need of treatment are climbed and pruned as needed. Some success has been reported using another pruning technique which eliminates climbing. A line is shot over the distal end of a defective branch via a crossbow or compound bow, and both ends of the line are pulled downward in a sharp movement, thereby breaking off and removing that portion most prone to failure. If the limb does not break readily with pulling, it is unlikely to fail within one season.

**Pruning** of live branches should be done with care to avoid excessive bole wounding and decay. At the junction of the main stem and a branch, both coniferous and hardwood trees exhibit a folding of bark tissue called the branch collar. This collar is important in the production of a barrier zone of cells that wall-off tissues damaged by wounding and reduce the potential for decay. Pruning cuts should be made flush with the branch collar. A longer stub is a more suitable entrance court for decay fungi and it is less readily overgrown by callus tissues in the healing process. Wound dressings on pruning cuts or other wounds are not only unnecessary, but may even be detrimental. Dressings act as a moisture barrier and maintain for longer periods a suitable environment for decay fungi. Pruning is best done in the late fall and winter when trees are fully dormant. Also, possible insect attack by pitch moths or bark beetles is less likely in the fall and winter than in the spring and summer.

# Dead or Broken Tops

Dead tops on live trees eventually break out and fall to the ground (Fig. 53). Before tops fail 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 cause top failure.

**Fig. 53 –***Failure potential of trees with dead tops depends on whether the tree species is resinous like Douglas-fir or non-resinous like white fir.*

In developed sites, trees with dead, highly defective tops are often jarred by people or their vehicles. When dead tops are encountered in developed sites, hazard should be assessed immediately. Unacceptable hazards should be mitigated.

The failure potential of dead tops of cedar, Douglas-fir, larch, and pines with rust-killed tops is normally very low (Table 1). Dead tops of true firs, hemlock, spruce, 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 a hazard.

Trees with old, broken tops may have rot present below the break. This is especially true of non-resinous conifer species, although resinous species with top breaks are prone to brown top rot caused by *Fomitopsis cajanderi* (p. 67) or brown trunk rot caused by *Fomitopsis officinalis* (p. 68). If the upper branches in the remaining top are thrifty and vigorous in their appearance, additional top failure is unlikely in the near future, though trees with tops broken out should be monitored regularly. The potential that new tops arising from upturned lateral branches will fail is also low unless indications of internal defect are evident.

# Burls

Burls are abnormal swellings on stems and branches (Fig. 54). Usually, burls are composed of undecayed wood and, as such, trees with burls have **low-failure potential**. Burls vary in size but can be several feet in diameter. Their cause is mostly unknown, but they are common among high-elevation tree species such as lodgepole pine and subalpine fir. When high in the tree or covered with moss or lichens, burls sometimes resemble conks and therefore require careful examination with binoculars.

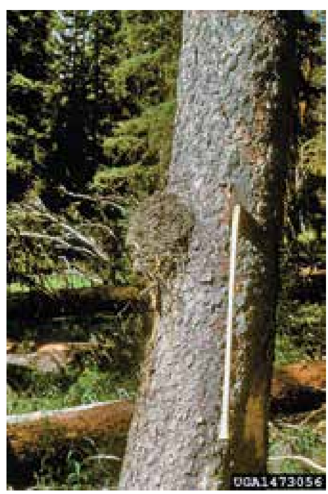


**Fig. 54 –** *Burls are often large woody growths of unknown cause on conifers and hardwoods that resemble conks but indicate low-failure potential.*

# Fire-Caused Damage

**Fig. 55 –** *Fire-damaged trees have failure potentials that depend on the amount of sound wood remaining.*

Fire-damaged tree boles or limbs may be so badly burned with associated wood consumption that they are structurally weakened which may cause the bole or limb to break and fail (Fig. 55). Root systems may be partially consumed by fire, and the entire tree may fall. Before burning, the tree may have had conks or mushrooms that indicated severe decay. These may have burned off, eliminating their value as indicators of root disease or heart rot. Therefore, the tree may be less stable than the visible indicators suggest. Likelihood of failure is determined by tree species (resinous or non-resinous), the amount of sound wood remaining, and if the tree is dead (Table 1). Large pines, cedar, larch, or Douglas-fir with old, basal, fire scars may have compensated for any defect or decay by increasing their butt diameter; such trees have **low-failure rates** unless a subsequent burn causes additional loss of support. Fire-damaged trees may still have green crowns but dead cambium at their bases; essentially they are dead trees. Long lasting and smoldering fires at the bases of large pines usually kill the fine roots and may eventually contribute to death of the tree usually by predisposing it to bark beetles and wood borers. Fire-killed trees are rapidly infested by wood borers that introduce wood-decay fungi. Tunneling by larvae facilitates wood decay.

Substantial damage, especially on ponderosa pine and Douglas-fir, can occur in trees that have old, resin-impregnated wounds that reburn. This seems to be especially true when fires are hot, burn after a long period without fires, and the trees involved have deep mounds of exfoliated bark and duff around their bases at the time of the fire. Trees with old catfaces or firescars should be examined carefully after a fire to determine how much damage to the cross-section of sound wood has been caused by reburning. For recent fire damage (<5-years old), use "fire-damaged trees" in Table 1; for older fire damage, use "bole wounds."

# High Height-to-Diameter Ratios

Live trees with a high height-to-diameter ratio (an index of slenderness) may fail depending on the ratio (Table 1). These trees can break or bend permanently usually from snow or ice loading in the winter. Tall, thin trees with dwarf-mistletoe brooms may be particularly prone to bending or breakage. To calculate height-to-diameter ratio, estimate the total tree height in feet and divide by the dbh measured in feet. For example, a tree 100 ft. tall and 1 ft (12 in.). dbh would have a height-to-diameter ratio of 100. Bending or breaking of tall, thin trees is most likely to occur after densely stocked stands or groups of trees are thinned.

# Insect-Caused Damage

Forest insects can weaken roots, stems, tops, or branches and introduce fungal spores that result in wood decay and physical degradation. Insects interact with fungal pathogens to cause damage or directly kill trees or their parts. Bark beetles in the family *Curculionidae* are important in the Pacific Northwest in causing tree mortality. The most important beetles are 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. 56).

Wood borers also are involved in killing trees but usually prefer weaker hosts than bark beetles. They also colonize recently killed trees. Wood borers can significantly lower the structural integrity of infested trees because they bore into the sapwood and even into the heartwood.  In SW Oregon, the flatheaded fir borer actively kills low-elevation Douglas-fir. Wood borers and bark beetles introduce decay fungi as trees are being killed. Trees with wood-borer holes in exposed wood need to be closely examined.

**Fig. 56 –** *Bark beetles often kill trees and form pitch tubes on attacked pines.*

Carpenter ants and termites can colonize and further weaken trees that are already decayed. Defoliating insects such as the western spruce budworm and the Douglas-fir tussock moth can kill tops or entire trees. Dead tops of Douglas-fir can remain sound for several decades; dead tops of true firs, however, can fail relatively rapidly. Defoliator-killed trees or parts should be evaluated in the same fashion as other dead trees or parts.

## Multiple Defects

Trees are often encountered with two or more (multiple) defects. The potential for tree failure increases dramatically with the combined effects of multiple defects. In the case of multiple indicators, one condition (indicator) often worsens another; they interact synergistically. Some examples of multiple defects that indicate increased potential for failure are:

1. Heart rot and cankers, stem injury, or saprot
2. Root rot and lean
3. Cracked forks and heart rot
4. Wind shake and butt rot
5. Leaning trees with hollow stems (Fig. 57)

**Fig. 57 –** *Multiple medium-failure indicators can imply high-failure potential such as this maple with hollow, leaning stems.*

The sound-rind thickness guidelines (Table 3A and B) should be used with caution when other tree defects that worsen the condition are present. In this case, trees may fail with more than the minimum sound-rind thickness.

# Chapter 4 - Hazard-Tree Management

## Evaluations Prior to Site Development

Ideally, hazard-tree management begins before there is a final decision on where to locate a proposed developed site. A thorough hazard evaluation of proposed sites prior to capital investment reveals the prudence and feasibility of establishing the site, and it alerts managers to problems prior to the investment of scarce resources. Examination of sites with old-growth trees prior to site development is particularly important because of the predictable decadence of many trees on these sites. Unfortunately, this has seldom occurred, as most current sites were established many years prior to the advent of vegetation management or hazard-tree management.

Old-growth stands, while more aesthetically appealing to many recreationists, are less well suited to developed site recreation. Not only is defect more abundant, but when old-growth stands are opened to establish access, parking, permanent camping spots, and structures, the probability of windthrow will usually increase, and continue increasing with each repeated salvage or hazard removal entry. Young, thrifty stands are more wind-firm, and they respond better and more rapidly to spacing entries. Trees in such stands readily re-establish wind-firmness, and they resist repeated attacks of insects, diseases, and the damage caused by visitors until they reach their pathological-rotation age.

One possible approach is to conduct a two-phase evaluation. The first phase is a thorough evaluation of the stand on the candidate site to determine if the candidacy should be further considered. If root disease is found, the site should be eliminated from further consideration as a developed-recreation site. If the candidate site does not have root disease, the second phase is a detailed hazard evaluation of each tree.

The best time to prepare a complete vegetation-management plan is after an informed decision is made to develop a site. This plan should include a stem map and information on the condition of each tree within striking distance of proposed stationary or moving targets. With this information in hand, the forest-resource manager can finalize designs, taking advantage of openings where hazardous trees will be removed. If it is desirable that the stand be opened in certain areas to introduce more light, or increase visibility, trees with varying degrees of hazard can be prioritized for removal, and treatment can occur during the construction phase.

If a vegetation-management plan has not been developed prior to establishing a developed site, hazard management will be reactive rather than proactive. In these situations, creativity is important in treating hazardous trees. Tree removal may be the least desirable option. If the character value, scenic value, wildlife value, or historic value of a defective tree is high enough, moving a valuable target may be the preferred option. It is always wise to consult with appropriate forest-resource specialists to accurately determine the resource value of some hazard trees.

## Management of Existing Sites

Some hazard trees can be treated without their removal. Others must be removed. Trees affected by root diseases and standing, dead trees fall into the latter category (see Table 10 for treatment options by category of damage). Since resistance to failure is related to the amount of sound wood remaining in the butt and stem, many trees with butt defects do not require immediate treatment but must be monitored if they are retained. Treatment likely will be required at some time in the future. Defective trees that present an acceptable amount of risk in the current year should be monitored at regular intervals to track intensification of the hazards.

It is important to avoid creating new hazards while treating others. For example:

- If large, defective trees are to be felled, care should be taken to prevent injury to surrounding trees.
- In sites where stocking levels are high, care should be taken not to create canopy gaps that open the stand up for windthrow.
- Prune defective limbs properly to avoid future stem decay. Prune branches flush with the branch collar, not flush with the stem. Stubs extending beyond the branch collar, both on living and dead branches, can allow decay fungi to enter. After pruning, do not paint cuts; wound dressings have been shown to increase decay in some cases.
- When removing true firs, hemlocks, and, on dry sites, ponderosa pine, consider treating the newly made stumps with an EPA-registered boron compound to reduce the potential for *Heterobasidion* spp. colonization and subsequent incidence of annosus root disease (p. 45).
- During construction and rehabilitation activities, avoid damaging tree boles and roots to prevent future decay and associated hazards.

**Table 10. Tree damage and treatment options for developed sites in Oregon and Washington**

| Defect | Pruning | Topping | Cabling or Bracing[1] | Tree Removal |
|---|---|---|---|---|
| **Root and butt rots** | | | | X |
| **Undermined, severed, or broken roots** | | | X | X |
| **Heart rots** | | | X | X |
| **Sap rots** | | | | X |
| **Cracked/split boles** | | | X | X |
| **Bole cankers** | | | X | X |
| **Bole flattening** | | | X | X |
| **Forked or multiple tops** | | | | X |
| **Dead or broken tops** | | X | | X |
| **Mistletoe brooms** | X | | | |
| **Defective branches** | X | | | |
| **Detached branches, tops, or bark** | | | | remove piece |
| **Leaning trees** | | | X | X |
| **Fire-damaged trees** | | | X | X |
| **Dead trees** | | | | X[2] |

[1]Cabling or bracing only should be considered when retaining defective but highly valuable or historic trees.

[2]Dead trees should always be removed when valuable targets are nearby. Developed sites are poor places to maintain snags for wildlife.

In all cases, site closure, target removal or relocation, and/or exclusion of visitors from the impact zone are treatment options either alone or in combination, so they are not listed above.

Topping trees within striking distance of valuable targets is recommended only to remove dead tops. Topping live crowns is rarely recommended. Removal of live foliage reduces a tree's ability to feed itself through photosynthesis. Topping also creates a large wound that can become an entry court for decay fungi. Topping live crowns may also attract bark beetles and other damaging insects. Topping may eventually lead to forked or multiple tops that may themselves subsequently fail. If topping of living crowns is done to create wildlife habitat, such trees should not be within striking distance of valuable targets.

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*For additional information and references about hazard trees, see http://www.fs.fed.us/r10/spf/fhp/hazard/index.htm*

# 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 crumbling 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

**Azimuth -** a compass reading in degrees going from $0^0$ (north) to $359^0$

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

**Barrier zone of cells –** Cells within a plant or tree that form around injured tissue as a response to wounding and microorganism invasion. These cells restrict the movement of the invading microorganisms

**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

**Branchlet stub -** the remnant of a branchlet (small branch or twig) that breaks off near the main branch; often an entrance point for decay fungi, especially the Indian paint fungus

**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

**Cabling or bracing** – cabling is the installation of a cable within a tree between limbs or leaders to limit movement and provide supplemental support. Bracing is the installation of lag-threaded screws or threaded steel rods in limbs, leaders, or trunks to provide supplemental support. Both may be used to extend the time trees or their parts remain intact. Proper cabling and bracing require skill, hard work, and a keen understanding of tree construction. The treatment often wounds trees.

**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 innermost 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

**Catface** – a partially healed or grown-over **wound** on a tree stem resulting from fire or equipment use; similar to a **scar**

**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

**Climax stage -** the last stage of natural forest **succession;** a late-successional stage usually containing shade-tolerant tree species

**Codominant stems –** two tree stems of equal size that are joined at the base or partway up the trunk

**Compartmentalization –** a process in living trees where wound-infecting microorganisms and subsequent decayed wood are confined to compartments within the tree. At least four interior walls restrict the movement of microorganisms and decay to adjacent compartments. Wall 4, the **barrier zone**, forms at the cambium after wounding and confines decay within a wood cylinder present at the time of wounding. Given enough time, all walls eventually will fail resulting in complete wood decay. Compartmentalization is repeated each time a tree is wounded

**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

**Cull (tree) –** a tree or tree part that is so highly defective as to be lacking in commercial value as a sawlog; a tree that is decayed through much of its length

**Cull rules –** Values of **defect** and **decay** extent that are usually based on tree age, dbh, number of indicators (**conks, punk knots**), or distance of indicators above the ground. Cull rules sometimes provide a crude estimate of tree-failure potential.

**Dbh -** the **d**iameter of a tree at **b**reast **h**eight; 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**

**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 weirii* and some other decay fungi

**Developed forest sites** – areas within the forest that contain human-developed structures, such as buildings, ski lifts, boat ramps, parking lots, picnic tables, or campsites that are used for recreation or administration

**Disease –** a prolonged disturbance of the normal form or function of a tree or its parts; usually caused by organisms such as fungi or mistletoes 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 weirii*; also called a mortality center or infection center

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

**Drip line -** the maximum radial extension of the tree crown projected to the ground

**Duff –** the partially decomposed organic material of the forest floor beneath the litter of freshly fallen twigs, needles, and leaves

**Dwarf mistletoe -** a parasitic flowering plant with stems and seeds that develops extensive absorption systems in the xylem tissue 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 weirii* 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 inturned 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

**Frost ribs -** parallel ridges of **callus** that form on either side of **frost cracks** which are repeatedly (often annually) aggravated by extreme cold

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

**Fungal thallus -** the entire assimilative phase of an individual fungus

**Fungus** (pl. fungi) **-** a non-**vascular** plant 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**

**Gill** – blade-like formation on the underside of some **fruiting bodies** (mushrooms) that bears **spores**

**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 that is within striking distance of a permanent or transitory **target** of value

**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

**Highly defective -** trees or tree parts that possess such substantial decay or defect that they are extremely likely to fail

**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

**Inoculum - spores** or tissue of a **pathogen** that serve to initiate disease

**Larva** (pl. larvae) – the immature stage between egg and pupa in insects such as **bark beetles** or wood borers; examples are maggots, caterpillars, or grubs

**Lichens** – a type of green plant composed of an alga and a fungus that grow in symbiotic association. Lichens often grow on tree boles and branches and can hide conks or cavities.

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

**MCH-pheremone** – a natural chemical used to protect down or standing high-value Douglas-fir trees from attack by the Douglas-fir beetle

**Mesic -** requiring a moderate amount of moisture

**Minor defect -** damage that does not alter the structural integrity of a tree or tree part in any significant way

**Moderate defect -** damage that reduces the structural integrity of trees or tree parts but does not render them in immediate danger of failure; trees with moderate defect should be monitored.

**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 ostoyae*, 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

**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

**Parenchyma -** the soft tissue of higher plants commonly used for food storage

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

**Pathological rotation (age) -** age of a forest stand when **heart-rot** fungi decay more wood than is produced; can also refer to loss of wood due to mortality induced by root diseases

**Photosynthesis –** the manufacture of organic compounds, particularly carbohydrates, in the chlorophyll cells of plants from carbon dioxide, water, and enzymes in the presence of light as the energy source

**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**

**Plant association or community** – a plant-group type based on land-management potential, **successional** patterns, and species composition

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

**Prophylactic treatment -** action to reduce potential of infection or infestation

**Pruning** – the removal, close to the branch collar, of side branches (live or dead) or multiple leaders from a standing tree

**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 fire-fighting 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

**Ramicorn branch –** a branch that protrudes at an acute angle

**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 wood 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 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.

**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 or healing)

**Second-growth (forest) -** a relatively young forest that has been regenerated either naturally or artificially after some drastic disturbance such as extensive felling, wildfire, insect or disease attack, or blowdown; also called young-growth (forest)

**Seral stage -** the first stage of natural forest **succession**; an early **successional stage**

**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 *Phellinus 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**)

**Silvics** – study of the life history and general characteristics of forest trees and stands with particular reference to environmental factors

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

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

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

**Springwood** – that part of the annual ring of wood that is less dense and composed of large-diameter, thin-walled, secondary xylem cells laid down early in the growing season; also called earlywood

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

**Stocking (level) –** an indication of growing-space occupancy relative to a pre-established standard; common indices of stocking are percent occupancy, stand density index, basal area, relative density, and crown competition factor

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

**Succession** (forest) - a continuum of forest development where one community of plants is gradually replaced by another

**Successional stage -** a condition within forest succession; starts with the early **seral stage** and ends with the **climax stage**

**Symptoms (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

**Topping -** removal of some of the upper crown of a tree; not recommended for live crowns

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

**Vascular (plant or system) -** Specialized cells (phloem and xylem) within a plant that transport water and nutrients to and from roots and foliage

**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.

*Forked tree, Jubilee Lake campground, Umatilla National Forest*

*Hazard trees at Biglake Campground, Willamette National Forest*

# Appendix

**Cull rules used to identify the extent of red ring rot in *Douglas-fir west* of the Cascade Crest in Oregon and Washington.**

| Tree age (yrs.) | Red ring rot extent |
|---|---|
| < 125 | Trees with conks and defects warrant periodic evaluation |
| 125 to 150 | 4 ft. above/below conks (punk knots); 2 ft. above/below swollen knots |
| 151 to 200 | 10 ft. above/below conks (punk knots); 5 ft. above/below swollen knots |
| 201 to 250 | 13 ft. above/below conks (punk knots); 7 ft. above/below swollen knots |
| 251 to 300 | 18 ft. above/below conks (punk knots); 9 ft. above/below swollen knots |
| 301 to 350 | 22 ft. above/below conks (punk knots); 11 ft. above/below swollen knots |

**Cull rules used to identify the extent of red ring rot in old-growth (>125 years) *western hemlock and true firs west* of the Cascade Crest in Oregon and Washington.**

| Number of conks | Red ring rot extent extent |
|---|---|
| Single conk | 8 ft. above/below conk; 4-ft. above/below swollen knots when accompanying conks |
| Multiple conks | 16 ft. above/below lowest and highest conk or punk knot);<br>8 ft. above/below swollen knots |

**Cull rules used to identify the extent of red ring rot in *Douglas-fir, ponderosa pine, and western larch east* of the Cascade Crest in Oregon and Washington.**

| Tree age (yrs.) | Red ring rot extent |
|---|---|
| < 125 | 4 ft. above/below conks (punk knots); 2 ft. above/below swollen knots |
| 125 to 200 | 8 ft. above/below conks (punk knots); 4 ft. above/below swollen knots |
| 201 to 250 | 12 ft. above/below conks (punk knots), 6 ft. above/below swollen knots |
| 251 to 300 | 16 ft. above/below conks (punk knots); 8 ft. above/below swollen knots |
| 301 to 350 | 20 ft. above/below conks (punk knots); 10 ft. above/below swollen knots |
| >350 | 24 ft. above/below conks (punk knots); 12 ft. above/below swollen knots |

**Cull rules used to identify the extent of red ring rot in *true fir, hemlock, and spruce east* of the Cascade Crest in Oregon and Washington.**

| Tree age (yrs.) | Red ring rot extent |
|---|---|
| <200 | 8 ft. above/below conks (punk knots); 4 ft. above/below swollen knots |
| ≥200 | 16 ft. above/below conks (punk knots); 8 ft. above/below swollen knots |

**Cull rules used to identify the extent of red ring rot in *western white pine and sugar pine east* of the Cascade Crest in Oregon and Washington.**

| Tree age (yrs.) | Red ring rot extent |
|---|---|
| **<200** | **4 ft. above/below conks (punk knots); 2 ft. above/below swollen knots** |
| **>200** | **8 ft. above/below conks (punk knots); 4 ft. above/below swollen knots** |

**Cull rules for white and Shasta red fir in southwest Oregon used to estimate defect extent caused by the Indian paint fungus (Filip et al. 2009).**

| Conk age, number, and location: | Rust-red stringy rot extent: |
|---|---|
| Conk is single, small, and young | 8 ft. above and below conk |
| Lowest conk is 0 to 32 ft. from ground Multiple conks are separated by <25 ft. | 12 ft. below lowest conk; 21 ft. above highest conk |
| Lowest conk is >32 ft. from ground Multiple conks are separated by <25 ft. | 20 ft. below lowest conk; 21 ft. above highest conk |
| Conks are in bottom third of tree | Decay in the middle and bottom third of tree |
| Conks are in top third of tree | Decay in top and middle third of tree |
| Multiple conks are separated by >25 ft | Decay in the entire tree |

**Cull rules used to estimate defect extent caused by the Indian paint fungus for all species in Oregon and Washington.**

| Tree dbh (in.) | Rust-red stringy rot extent: |
|---|---|
| <19 | 18 ft. above and below conks |
| 19 to 26.9 | 18 ft. below lowest conk; 20 ft. above highest conk |
| 27 to 34.9 | 21 ft. below lowest conk; 20 ft. above highest conk |
| > 34.9 | 22 ft. below lowest conk; 20 ft. above highest conk |

**Signs and symptoms of damaging agents in developed sites in Oregon and Washington. X = the sign/symptom is routinely evident; O = the sign/symptom is occasionally evident**

| Sign or symptom | AR | CV | ET | FC | FO | FP | GA | HA | HE | IT | LW | OA | PI | PL | PP | PS | PT | PW | SS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reduced height growth | X | | | | | | | X | | O | X | | | X | | O | | X | |
| Yellow foliage | X | | | | | | | O | | | X | | | X | | | | X | |
| Slow crown decline | X | | | | | | | X | | O | X | | | | | O | | X | |
| Distress cones | X | | | | | | | O | | | X | | | | | | | X | |
| Rapid tree death | X | | | | | | | O | | | X | | | X | | | | O | |
| Basal resinosis | X | | | | | | | | | | X | | | | | | | O | |
| Windthrown live trees | | | | | | | | X | | X | | | | | | X | | X | |
| Live-stem breakage | | | X | X | X | | X | X | | X | | | X | | O | X | X | X | |
| Insect galleries under bark | X | X | | | | X | | X | | | X | | | X | | | | X | |
| Mushrooms | X | | | | | | | | | O | | | | | | X | | | |
| Mycelial fans under bark | X | | | | | | | | | | | | | | | | | | |
| Mycelia in decay | | | | O | X | X | | O | | O | | | | | | X | | O | O |
| Rhizomorphs | X | | | | | | | | | | | | | | | | | | |
| Perennial conks | | | X | X | X | X | X | O | | | | | X | | X | | X | O | |
| Annual conks | | X | | | | | | | X | X | | X | | | | X | | | X |
| Setal hyphae | | | | | | | | | | | | | | | | | | X | |
| Root pustules | | | | | | | | X | | | | | | | | | | | |
| Ectotrophic mycelium | | | | | | | | O | | O | | | | | | | | X | |

Damaging agents: AR=*Armillaria* spp., CV=*Cryptoporus volvatus*, ET=*Echinodontium tinctorium*, FC=*Fomitopsis cajanderi*, FO=*Fomitopsis officinalis*, FP=*Fomitopsis pinicola*, GA=*Ganoderma* spp., HA=*Heterobasidion* spp., HE=*Hericium abietis*, IT=*Inonotus tomentosus*, LW=*Leptographium wageneri*, OA=*Oligoporus amarus*, PI=*Phellinus igniarius*, PL=*Phytophthora lateralis*, PP=*Phellinus pini*, PS=*Phaeolus schweinitzii*, PT=*Phellinus tremulae*, PW=*Phellinus weirii*, SS=*Stereum sanguinolentum*

**Signs and symptoms of damaging agents in developed sites in Oregon and Washington. X = the sign/symptom is routinely evident; O = the sign/symptom is occasionally evident**

| Sign or symptom | AR | CV | ET | FC | FO | FP | GA | HA | HE | IT | LW | OA | PI | PL | PP | PS | PT | PW | SS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delamination pits - 1 side | | | | | | | | X | | | | | | | | | | | |
| Delamination pits - 2 sides | | | | | | | | | | | | | | | | | | X | |
| Yellow stringy decay | X | | | | | | | | | | | | | | | | | | |
| White-spongy decay | | | | | | | X | X | | | | | | | | | X | | |
| Rust-red-stringy decay | | | X | | | | | | | | | | | | | | | | |
| Red-brown-cubical decay | | | | X | X | X | | | | | | | | | | X | | | |
| White pocket rot | | | | | | | X | O | | | | | X | | O | | | | |
| Honeycomb decay | | | | | | | | | X | X | | X | | | | | | | |
| Conk looks like cow pie | | | | | | | | | | | | | | | | X | | | |
| Conk with spines | | | X | | | | | | | | | | | | | | | | |
| Conk at branch stubs | | | X | | X | | | | | | | X | O | | X | | | | |
| Conk is rose-colored | | | | X | | | | | | | | | | | | | | | |
| Conk bottom is easily etched | | | | | | | X | | | | | | | | | | | | |
| Conk is hoof-shaped | | | X | | O | | | | | | | | X | | O | | O | | |
| Conk looks like coral | | | | | | | | | X | | | | | | | | | | |
| Conk looks like popcorn | | X | | | | | | O | | | | | | | | | | | |
| Conk has a red margin (belt) | | | | | | X | | | | | | | | | | | | | |
| Conks turn red when bruised | | | | | | | | | | | | | | | | | | | X |

Damaging agents: AR=*Armillaria* spp., CV=*Cryptoporus volvatus*, ET=*Echinodontium tinctorium*, FC=*Fomitopsis cajanderi*, FO=*Fomitopsis officinalis*, FP=*Fomitopsis pinicola*, GA=*Ganoderma* spp., HA=*Heterobasidion* spp., HE=*Hericium abietis*, IT=*Inonotus tomentosus*, LW=*Leptographium wageneri*, OA=*Oligoporus amarus*, PI=*Phellinus igniarius*, PL=*Phytophthora lateralis*, PP=*Phellinus pini*, PS=*Phaeolus schweinitzii*, PT=*Phellinus tremulae*, PW=*Phellinus weirii*, SS=*Stereum sanguinolentum*

### Equipment recommended for hazard-tree evaluations

| Equipment | Intended Use |
|---|---|
| Pulaski | Exposing roots and checking for decay, signs and symptoms |
| Axe or rubber mallet | Sounding boles and inspecting stems for sap rot, heart rot, insect attack, or dead sapwood |
| Binoculars | Examining stems for conks, punk knots, swollen knots and other indicators of stem decay, and for examining tree crowns for hazardous branches, dead or forked tops, and other defects |
| Diameter tape | Measuring tree or branch diameter |
| Tape measure | Measuring distances to targets or for stem mapping |
| Compass | Recording azimuths for stem mapping and relationships to reference points |
| Laser measurer | Measuring tree heights and distances |
| Cordless drill/ increment borer | Estimating the rind thickness of sound wood in the bole; detecting root and stem decay |
| Hand lens(10X) | Examining advanced decay for setal hyphae and other indicators |
| Field guides | Identifying tree species, diseases, insects, and defects by their indicators |
| Data forms | Recording data and observations |
| Tree tags | Providing a semi-permanent numbering system for trees that will be re-evaluated annually (tags are aluminum, numbered in series) |
| Aluminum nails | Securing tags to trees; steel nails rust |
| Tree paint or tree flagging | Identify trees to be felled or treated; treatment should be immediate after marking |

This equipment list can be modified to suit budgets and individual needs. These items have been routinely used to do a thorough job of recording a baseline evaluation to which subsequent annual evaluations and monitoring exams could be tiered.

## HAZARD-TREE DATA FORM

Page___of___

Site name: ________________________ Unit No. or Location:____________________

Date: ______ Recorders:__________

| Tree no. | Tree species | Tree dbh (in.) | Tree height (ft.) | Defect height (ft.) | Target distance (ft.) | Root/butt disease symptom[1] | Rind (in.)[2] | Root/butt cause[3] | Stem disease defect[4] | Risk rating[5] | | Recommended treatment[6] | Treat-ment date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | FP | DP | | |
| | | | | | | | | | | | | | |
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[1]**Root/butt disease symptom:** DEAD=dead tree, REGR=reduced-height growth, DETO=dead top, DEBR=dead branches, THCR=thin crown, YECR=yellow crown, RESN=basal resinosis or weeping, CONK=conk(s) present, FANS=mycelial fans, ECTO=ectotrophic mycelium, WNDS=wound, CRACK=cracks

[2]**Sound-rind thickness** in inches; average of four drillings at defect

[3]**Root/butt disease cause:** PW=*Phellinus weirii*, AR=*Armillaria* spp., HE=*Heterobasidion* spp., PS=*Phaeolus schweinitzii*, IT=*Inonotus tomentosus*, X=unknown, etc.

[4]**Stem disease/defect:** MECH=mechanical injury, FIRE=fire damage, STCR=stress crack, FRCR=frost crack, CANK=stem canker, FORK=forked or multiple top, HANG=detached branch, top, or bark, DMBR=dead mistletoe broom $\geq$10 ft. wide; for conks, ET=*Echinodontium tinctorium*, PP=*Phellinus pini*, CONK=unknown species, etc.); for dwarf mistletoe in live trees, use DMR5=dwarf mistletoe rating of 5, BB=bark beetle attack.

[5]**Risk rating:** FP=failure potential (rating: 1 to 4) and DP=damage potential (rating 1 to 4) where 1=very low, 2=low, 3=medium, and 4=high

[6]**Recommended treatment:** TOPx=top tree where x is the remaining tree height, PRUN=prune branches, FELL=fell tree, BRAC=bracing or cabling of tree, MOTA=move target, EXPE=exclude people from target area, MONI=monitor tree

## HAZARD-TREE EVALUATION

Facility: ____________________________ Date: _____________ Evaluators: ______________

Location:
Site ID _____Ref. Pt. _______________ Bear _____ Dist.____
Tree ID_______ Species______________DBH ______Ht. _____

Top:
OK
Dying
Dead Recent/ Old

Branches:
OK
Dying
Dead
Detached

Stem:
OK
Conks _______________
Cracks Old Recent
Forks Splitting Included bark
% Lean _______
Scar
Cavity
Canker
Open Length______
Closed $Ft^2$__________
Decayed Min rind Thickness Needed Dia. ___ X 0.15 ________
Reading ___________________________________ Av. ______

Ratings:
Failure Pot. ____
Damage Pot. ____
Hazard Rating ____

Photo☐

Roots:
OK
Exposed Wounded Decayed % Impaired___

Targets_____________________________
_____________________________
_____________________________

Comments_____________________________________________________________

Location:
Site ID _____Ref. Pt. _______________ Bear _____ Dist.____
Tree ID_______ Species______________DBH ______Ht. _____

Top:
OK
Dying
Dead Recent/ Old

Branches:
OK
Dying
Dead
Detached

Stem:
OK
Conks _______________
Cracks Old Recent
Forks Splitting Included bark
% Lean _______
Scar
Cavity
Canker
Open Length______
Closed $Ft^2$__________
Decayed Min rind Thickness Needed Dia. ___ X 0.15 ________
Reading ___________________________________ Av. ______

Ratings:
Failure Pot. ____
Damage Pot. ____
Hazard Rating ____

Photo☐

Roots:
OK
Exposed Wounded Decayed % Impaired___

Targets_____________________________
_____________________________
_____________________________

Comments_____________________________________________________________

Location:
Site ID _____Ref. Pt. _______________ Bear _____ Dist.____
Tree ID_______ Species______________DBH ______Ht. _____

Top:
OK
Dying
Dead Recent/ Old

Branches:
OK
Dying
Dead
Detached

Stem:
OK
Conks _______________
Cracks Old Recent
Forks Splitting Included bark
% Lean _______
Scar
Cavity
Canker
Open Length______
Closed $Ft^2$__________
Decayed Min rind Thickness Needed Dia. ___ X 0.15 ________
Reading ___________________________________ Av. ______

Ratings:
Failure Pot. ____
Damage Pot. ____
Hazard Rating ____

Photo☐

Roots:
OK
Exposed Wounded Decayed % Impaired___

Targets_____________________________
_____________________________
_____________________________

Comments_____________________________________________________________

## HAZARD-TREE DATA FORM

PAGE _____ OF _____

SITE: ______________________________

DATE: _______ / _________ / _________

RECORDERS: _______________________

| Tree # | Species | Location Memo | Condition/Notes | DBH | Sound Rind | DMR | Stem Decay | Root Disease | Fail. Pot. | Dam. Pat. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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## HAZARD-TREE DATA FORM

SITE:_____________________________ Date:_______________

Examiner:_________________________ Page___of_____

| Tree # | Site ID: | | Ref. Pt. | | |
|---|---|---|---|---|---|
| Distance: | | | Azimuth: | | |
| Species | DBH | Height | Dead | Lean | Top/branch defect |
| | | | | | |
| Stem defect/ decay | Butt rot | Open wound/ crack | Diameter inside bark | Sound rind thickness | Root disease |
| | | | | | |
| PF + | PD = | RATING | Recommended TREATMENT | | |
| | | | | | |
| Target(s): | | | | | |
| Date & Treatment completed: | | | | | |
| Remarks or drawing: | | | | | |

| Tree # | Site ID: | | Ref. Pt. | | |
|---|---|---|---|---|---|
| Distance: | | | Azimuth: | | |
| Species | DBH | Height | Dead | Lean | Top/branch defect |
| | | | | | |
| Stem defect/ decay | Butt rot | Open wound/ crack | Diameter inside bark | Sound rind thickness | Root disease |
| | | | | | |
| PF + | PD = | RATING | Recommended TREATMENT | | |
| | | | | | |
| Target(s): | | | | | |
| Date & Treatment completed: | | | | | |
| Remarks or drawing: | | | | | |

## 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 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

# Long-Range Planning for Developed Sites in the Pacific Northwest:

## The Context of Hazard Tree Management

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1992

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## List of Figures and Tables

# Introduction

Pathogens and insects are responsible for causing substantial damage to forest trees in the Pacific Northwest. This damage should be considered and carefully evaluated in the light of specific management objectives on all forest sites. On developed sites where pest damage may pose a hazard to the safety of visitors or their property, disease and insect effects should be of particular cOl1cern. Of the many tree-disease-insect interrelationships common to natural ecosystems, relatively few threaten personal safety and most of these occur on developed sites. Developed sites are places where people often congregate and are exposed for longer than normal time periods to damaged or defective trees. The longer the time frame of exposure to tree hazards, the greater is the potential for property damage or personal injury.

Many managers of developed recreation programs on federal lands have been playing catch-up ever since their sites were formally developed. All too often these managers have been faced with extremely difficult decisions concerning the best way to address tree hazards. Campground closure decisions have been unpopular and therefore seldom made. No-action decisions have been considered irresponsible in most cases, and these were not often made. Most recreation sites were kept open, tree hazards were mitigated only in the short term, and the decision to remedy the deteriorating condition of vegetation was postponed indefinitely.

In natural systems, ecological succession proceeds toward a climax condition in response to minor disturbances, providing major disturbances such as stand replacement wildfire do not occur. Tree and stand decadence increase with advancing age and forest community succession. Over a period of 40 to 50 years of recreation site use and tree hazard mitigation, we have accelerated both succession and the rate of increasing decadence. Now, hazard tree management frequently dictates the visual quality characteristics of a site, and these characteristics are becoming less acceptable to site users and managers.

## Evolution of Developed Site Recreation

As technology and increased prosperity have reduced the labor and time needed to account for personal survival, larger segments of our society have been able to devote more time and money to recreational pursuits. During the early decades of this century the Forest Service offered a strong invitation to the public to come and recreate on National Forest lands. The recently renewed Summer Homes legislation is an enduring witness of that period.

Accompanying increased visibility and use of recreation sites was the land managers' preoccupation with the need to remove obviously defective trees that might threaten the safety of this new immigration of users. For decades, site management has consisted of pre-season clean up, maintenance and upgrading of facilities, and timely tree hazard mitigation. Even our most highly trained recreation site managers have been caught up in the annual cycle of reacting to identified tree hazards through mitigation measures without evaluating the long-term consequences of those actions. This reactionary cycle is still with us. We continue to mitigate tree hazard each year while postponing the decision to begin management of vegetation that will be sustainable.

Most sites that have been developed for recreation were discovered by the public long before developers knew of their existence. Their continued use and increasing popularity as underdeveloped sites usually incited us to bring about their full scale development, often to channel uses. Many of the sites that were developed are on public forest lands in stands of large old trees with all of their inherent grandeur and decadence. Recreation benefits provided by forest land included beautiful scenery (Figure 1),cool, shaded surroundings (Figure 2), wildlife viewing opportunities (Figures 3-4), proximity to water (Figure 5), and serene settings (Figure 6). Large stands of great tall trees were an integral partof those experiences.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Even though trees are a renewable resource, there has been considerable resistance to removing large, old, highly defective trees from developed sites simply because it takes centuries to grow them. Managers characteristically avoided this consequence by opting for minimum action alternatives. In doing so, a management prescription was implemented which called for the gradual removal of only the most hazardous trees. These tended to be the older pioneering and seral species; the ponderosa pine, western larch, western white pine, and lodgepole pine, which are the species most resistant to fire, disease and/or insect damage. They were well advanced in age, were stressed by competing vegetation, and their decline was accelerated under heavy recreation pressure.

The gradual removal of seral species released shade tolerant conifers and incited further regeneration of these conifers. Successive hazard tree removals eventually promoted dramatic shifts in vegetation toward climax conditions. These late succession stands are the ones our current managers have inherited today. They are far more susceptible to damage by insects and diseases in their present composition than in any prior composition. They are also more in need of aggressive management to reduce tree hazards and conditions conducive to damage than were stands of any prior period.

On a positive note, the planned and carefully executed removal of large old trees from recreation sites can produce very beneficial changes in vegetation diversity and vigor. Such stand openings increase sunlight penetration to the forest floor, providing an opportunity to modify the abundance, diversity, and vigor of shrub and herbaceous species while giving existing trees more room to grow. Variety in stand structure, function, composition, color, texture, and big game forage, are some other favorable results.

# Chapter 1

## The Fallacy of Mitigating Tree Hazard Without Long-Range Planning

To maintain a balance of benefits in the long-term, managers of developed sites must contend with forest pests (Figure 7). The. most obvious effects that forest pests have on developed sites occur through their influence on forest succession. Insects, diseases, and abiotic factors such as wind, drought, and snow cause the deterioration and demise of trees, shrubs and herbs, but their effects on trees are of greatest consequence to developed recreation sites. Forest pathogens and insects reduce competition for water, sunlight, and nutrients by killing the most susceptible conifer species or those with the least vigor. The results are some form of stocking reduction, a localized increase in the shade tolerance of residual vegetation, an accumulation of highly combustible ground fuels, and developing strata of green crowning fuels.


Figure7

In a natural scenario, stand replacing fire would reset succession to a seral condition, thereby reducing tree hazards. In the current managed scenario, we do not allow natural fire to regenerate vegetation and forest succession moves steadily toward the climax condition - a vegetation which is most susceptible to damage by pathogens and insects and poses the greatest hazards to personal safety.

To manage the impacts of these damaging agents to vegetation, we must know the location and health condition through time, of individuals, populations, and communities of trees and other plants. Knowledge of the kind and amount of use a site receives or will receive, and the effects of this use on vegetation is also essential. Without this background information, recreation resource managers will respond to tree hazards and deteriorating conditions based upon their perception of priorities at that time, and only short term remedies will emerge. Trees regarded as posing an unacceptable risk to users will be treated as they are discovered, and disturbance to a site will be accepted as the price paid for safety.

Eventually, hazard mitigation will result in the complete removal of the very trees that attracted users to an area. Without an organized plan for their replacement, which tailors the structure and composition of vegetation to match the growing conditions and management needs, these actions will lead to the destruction of the recreation resource that was the focus of the original development effort. With background information, the demise of stately old trees can not only be anticipated and appropriate replacements made available, but sometimes forestalled by lavishing special care or cultural treatments on the defective individuals (topping, pruning, fertilization, irrigation, prophylactic chemical treatment).

## Hazard Tree Management in Proper Context

In proper context, hazard tree management is only one in a large set of management actions prescribed in a vegetation management plan. Hazard management dovetails with all other management actions to achieve a common set of goals.

Many old-growth stands are highly favored recreation areas. It takes two or more centuries for vegetation to develop to the old-growth condition, and not all management scenarios result in old growth. Even greater time is needed to regenerate and manage a declining old growth forest to a future old growth forest with acceptable risk. Development of an old growth recreation resource with acceptable risk is only possible with long range planning, where hazard is managed at low levels by design rather than by mitigation. Many future recreation sites will occur in second growth stands because they are more abundant, more hazard free, and more easily managed.

Long-range plans are essential to achieve and maintain any desired future recreation conditions. Their importance increases as management objectives increase from single to multiple use.

Successful achievement of long-range goals can be realized if plans are developed by interdisciplinary teams with all of the appropriate disciplines represented. With plans in hand, recreation resource managers can alter vegetation structure, age, and composition, and expand, reduce or move uses, while understanding the long range effects of their actions.

## Objectives of this Guide

Hazard tree exams have been conducted on public lands for decades but without a standardized rationale or process. Tree hazards have long been evaluated and monitored but without standardized methods or regularity. Standardized evaluation criteria have not been available to evaluate tree hazard severity. Scientific studies that correlate level of defect with likelihood of failure have not been conducted nor has an acceptable amount of empirical data on known tree failures been accumulated, analyzed, or disseminated. Tree removal and monitoring decisions have been based on personal experience and judgement, and often with overly conservative criteria. When trees had obvious butt or main stem decay at any level detectable by conks or other indicators, they were typically removed.

This lack of standardization of techniques, and scientific and resource management basis, has led to an increasing indefensibility of management decisions in Tort Claim actions against the agency. Without adequate record-keeping, knowledge of individual tree hazards or hazardous stand conditions has been lost, and the agency has often been unable to defend its actions in the face of litigation, though they may have been appropriate. High quality record-keeping is as essential to ensuring the personal safety of our visitors as it is to the defense of our management actions. It is also absolutely essential to ongoing vegetation management planning and plan monitoring.

The objectives of this guide are to:

1) present the need to develop long term management plans for developed sites and outline a suitable process;

2) present a standard for evaluating tree hazards;

3) provide an up-to-date field aid for accurate identification of insects and diseases and their damages;

4) introduce a new method for evaluating the probability of tree failure in the form of a tree collapse model available for most portable or desk-top computers; and

5) present a standard for recording developed site evaluations.

We hope that vegetation management plans resulting from this process will contain all of the background information necessary for site management and hazard monitoring. The hazard rating system should provide a uniform standard of safety, should reveal that there are often numerous hazard management or mitigation alternatives, should improve understanding of acceptable vs. unacceptable hazards, and should aid in setting treatment priorities. Standardized recording facilitates improved defensibility of management actions, comparability of observations between sites, setting work and scheduling priorities, and perhaps most importantly, reduced frequency and intensity of future site evaluations.

The long-term planning and hazard tree evaluation and management portions of this guide should have application to any public or private developed sites.

## What Constitutes a Human Safety Hazard?

In the context of recreation resource management, hazard is some exposure to the possibility of loss or harm. With reference to trees, it is the recognized potential that a tree or tree part will fail and cause injury or damage by striking a target.. All standing trees, alive or dead, within areas occupied by people, structures, and property present some level of hazard. Potential for failure by itself does not constitute a hazard. Hazard exists when a tree of sufficient size and mass to cause injury or damage is within striking distance of any object of value (target). Hazard increases with increasing tree defect, potential for failure, potential for damage. and target value. Management actions are taken to mitigate the hazard when risks (the product of damage potential and consequences of damage) are unacceptable.

Risk is defined as acceptable (we will not mitigate the hazard) when:
1) all components of hazard have been fully evaluated, and
2) failure and/or damage probability is very low.

Risk is unacceptable (we will mitigate the hazard) when:
1) the amount of defect indicates failure is likely, and
2) the potential for failure and relationship to targets indicates damage is likely, and
3) target value is moderate or high.

Hazard evaluations assess the potential for failure, damage, and loss. Risk assessment addresses the consequences of damage or loss.

## Hazardous Trees and Associated Liabilities

All trees within striking distance of a target pose some hazard no matter how sound. Since gravitational forces are always at work, anything that is standing, including trees, has failure potential. Time, weather, diseases and insects interact to increase the likelihood of failure. If visitors wish to recreate in forested habitats, they must accept a certain amount of hazard. Land managers must learn to recognize the signs of increasing hazard so that reasonable levels can be maintained.

Visitors can be grouped into three distinct classes: invited, licensed, and trespassing. In the context of lands maintained open to the public, all visitors are considered invited and we are liable to an extent for their safety. The USDA Forest Service Manual (FSM 2303, 2330, 6703, 6730) outlines specific objectives, policies, and responsibilities for managers of recreation sites. These include documented recreation area hazard tree evaluations, and may include corrective actions or treatments.

Some liability for injury or loss lies with the landowner or agent for the land. The extent of liability depends in large part on the preventative actions of the managing agent. The Federal Tort Claims Act of 1946 holds the federal government liable in the same way as any private party for negligent acts or omissions. It also waives the doctrine of sovereign immunity, allowing individuals the right to sue the government without its specific consent.

In most states, a Recreational Use Statute or similar legislation provides protection to landowners by holding them free of liability resulting from accidents or deaths occurring on their lands held open for public use. The Oregon and Washington State statutes that apply are ORS 105.655 et sec. and RCW 4.24.200 et sec., respectively. This protection does not extend to landowners when a fee is levied. In this situation, and when gross negligence, intentional wrongdoing, or wanton misconduct are factors, Federal Tort Claims rules apply. Landowners should carefully consider the benefits of protection afforded by Recreational Use Statutes carefully before deciding to apply a user fee.

Informing the public that dangerous conditions exist does not eliminate liability. It is the responsibility of the land manager or their agents to discover and correct any unreasonably dangerous conditions so as to minimize the potential for injury to invited users or damage to their personal property. Responsibility to actively minimize hazard is roughly proportional to the degree of development of a recreation area. Highly developed sites infer a greater degree of responsibility than undeveloped areas. It is imperative that site managers conduct high quality hazard tree evaluations and, as required, follow-up treatments that respond specifically to each unacceptable hazard.

Information received from The Office of General Counsel (OGC), suggests that judgements for the plaintiff are typically based on what a reasonable professional would have done. "Known hazards that are not apparent" is the legal notion often used to help determine liability and its extent. If managers or their charge know that a tree has hazardous levels of defect, or should know a tree to be hazardous, and fail to take appropriate mitigating action, liability for damages could be assigned to the manager and the government.

If no fee is levied for recreation site use, posting signs to expose tree hazards and associated risks can reduce liability of the landowner or manager. The Office of General Counsel suggests that they be contacted for assistance in developing the best warning language if signing is the selected option.

The goal in developing recreation sites is to provide facilities visitors will use. Often, large old-growth trees are the prime attraction, and those are the *very* trees that usually present the greatest threat to public safety. The goal in managing these sites is to maintain the old-growth appearance while eliminating unacceptable risk to visitors. Similarly, the goal in managing any developed recreation site is to maintain or improve the characteristics of the site that attracted visitors initially and that promoted formal development, while eliminating unacceptable risk to visitors.

### The **Goal of Hazard** Tree Management

While quality resource management requires a long-range vegetation management plan, hazard tree management of itself, does not. To be most effective, hazard tree evaluation and treatment plans should be incorporated into the vegetation management plan.

The goal of hazard tree evaluation and hazard management is to strike a balance between maximizing public safety, minimizing costs, and maintaining sustainability of the recreation resource.

## Chapter 2

### Assessing the Desired Future Condition: The Need for Long-Range, Site Specific Vegetation Management Planning

The vegetation management planning process is a vehicle to guide us in:

1) clearly defining our resource management objectives in an integrative rather than additive mode;

2) simultaneously considering a range of reasonable management options;

3) making value judgements based on valid points of comparison; and

4) selecting a management alternative that stands out from the rest as most likely to fulfill the desired objectives, most responsive to issues, and most able to capitalize on management opportunities.

A vegetation management planning document is the road map to achieving and maintaining a desired future condition. Fundamental to the development of this plan is the accumulation of in-depth information on the current condition of the site. This not only includes knowledge of the variety of conditions present on the site, but also of their state of health and sustainability. Developing a vegetation management plan is similar in process to developing a NEPA (National Environmental Policy Act) document. An interdisciplinary team is convened, with technical and subject matter specialists serving as team members or providing focused input when called upon. Goals and objectives are established by the Forest Plan and expanded upon by line officers for each unique project. Issues are developed and alternatives to address them are assembled. One management scenario is often preferred over the rest, because it has the best potential to meet the objectives in the appropriate time frame.

Vegetation management planning team composition will vary with each planning effort. Some disciplines should always be represented by either full team membership or as specialist input. They are: recreation resources, pathology, entomology, silviculture, visual resource management! landscape architecture, and ecology. Other disciplines that will often, but not always, be consulted are: timber management, engineering, logging systems, wildlife, fisheries, soils, hydrology, archaeology, public affairs, fire management, contracting, and perhaps some others.

The National Environmental Policy Act of 1969 provides tools and direction for developing management plans for natural resources. Although planning for recreation resources is the subject of this text, the same process and steps are appropriate for other resources. In some cases, project planning for rehabilitation of existing developed recreation sites or development of proposed sites will be less formal than that which occurs while planning for timber sales or other large scale vegetation management projects.

In most cases, decisions for recreation sites will need to be NEPA decisions with appropriate documentation,ie., categorical exclusion or environmental analysis. Project scoping should address this need at the earliest possible time. The deciding official should clearly indicate if a NEPA decision is needed and determine the level of documentation that is appropriate prior to initiating the analysis phase of the project. This should reduce or eliminate significant time losses and the production of non-implementable plans.

The following abridged project planning process is presented as a template for developing vegetation management plans for developed recreation sites.

**SCOPING PHASE**

Step #1 Review the Forest Plan; establish the critical linkages; identify the scale of the project and the level of management decision; determine whether the project warrants a NEPA decision and documents.

Step #2 Develop the project concept; establish what this project will accomplish and why.

Step #3 Conduct an extensive reconnaissance of the project site to determine at an early planning stage if the project concept will work.

Step #4 Prepare a feasibility report documenting the technical, social, and economic feasibility of the project.

**ANALYSIS PHASE**

Step #5 Verify that the project is appropriately scheduled on capital investment plans or 5-year timber sale action plans, or in an annual project work plan.

Step #6 Conduct intensive reconnaissance to obtain all of the on-the-ground knowledge of the project planning area needed to intelligently design the project.

Step #7 Generate and compare a range of alternatives all of which address the critical goals and objectives, and issues and opportunities to an acceptable degree.

Step #8 Select the best alternative for implementation.

**DOCUMENTATION PHASE**

Step #9 Finalize management plan documents: hazard tree evaluation and recommendations, site development plan, transportation plan, waste disposal plan, other resource management plans, vegetation management prescriptions package (silvicultural and other treatments).

**IMPLEMENTATION PHASE**

Step #10 Assemble the project plan to verify that each of the implementation components fully reflects the management direction and intent of the interdisciplinary team.

Step #11 Prepare a project implementation plan, including management action, timing, responsible persons, funding sources, relationships to other plans or management actions, and critical communication loops.

Step #12 Project layout and implementation

**MONITORING AND EVALUATION PHASE**

Step #13 Monitor and evaluate the implemented project, answering the questions:

a) Was the project implemented as designed (accountability), and

b) Did it work: should we make recommendations to modify similar future projects (efficacy).

In the Appendix (section B), we expand our discussion of steps 1 to 8. Documentation, Implementation, and Monitoring/Evaluation Phases are standard to any good planning process and are self-explanatory. They will not be developed further in this document.

# Chapter 3

## Components of Tree Hazard Analysis

Hazard rating consists of inspecting potentially hazardous trees and estimating the probability of failure and striking targets during the time between examinations, then ranking by risk, from high to low, and prioritizing for treatment. Since it is not reasonable to eliminate all hazards (i.e. all trees) from a recreation site, line officers must decide what constitutes an acceptable level of risk, then treat or mitigate as necessary to achieve that level while minimizing disturbances and impacts on aesthetics and recreation enjoyment. This not only requires inspecting each tree in the context of its location in the unit, it also suggests some level of documentation or tracking is needed to maintain an ongoing record of tree condition and date of examination or re-evaluation. Tracking maximizes the economic efficiency of hazard monitoring programs in the long run since only those trees needing re-evaluation in a given year are evaluated. A systematic tracking system also minimizes program disruptions or discontinuities in the event of personnel changes.

The degree to which a tree is hazardous hinges on four factors:

(1) its potential for failure;

(2) its potential for striking a target in the event of failure;

(3) the potential that serious damage will result; and

(4) the value of the potential target(s)

Minimum value for any factor results in significantly reduced risk.

## Potential for Failure

The job of estimating the potential for tree failure (the likelihood of failure) is difficult because of the many interacting variables that come into play, but it can be done and with reasonable assurance. Tree size, age, form, species, condition, and location must all be considered along with plant association, successional stage, stand structure, stand species composition, climatic and soil conditions, and presence and extent of defect. Failure potential is estimated by examining a tree, determining the factors and conditions that contribute to failure or weakening, and estimating the likelihood that those factors and conditions will simultaneously occur before the next inspection period. Variables that are evaluated include:

1) the lean of a tree and factors that contributed to the lean;

2) whether a tree has recently been root-sprung (lateral root anchorage has been compromised);

3) whether trees that leaned over some time ago have righted their tops subsequently and have acceptable lateral anchorage;

4) the presence of forked tops or a recent weakening of a forked top;

5) the presence and extent of lethal or weakening root, stem, or branch disease or insect infestation;

6) the season of the year when high winds are likely and its relationship to the visitor-use season;

7) the direction of prevailing winds and the potential for wind eddies;

8) the presence of damage caused by recreationists, roadbuilding or maintenance activities, installation of septic systems and drainage fields, tree poisoning by effluent from waste disposal stations or restrooms;

9) the presence of dead, broken, or hanging branches;

10) the presence of basal scars, trunk injuries, lightning strikes, wind shake, frost cracks, cankering, dead tops, broken tops, V-shaped branch crotches, stem swellings, bear damage, undermined roots, excessive soil compaction, slime flux, basal resinosis, mechanical injury, crooked stem (old snow break), and;

11) evidence of root disease infection and mortality, species composition of adjacent trees, opportunities for lateral spread of the disease, presence of natural barriers to disease spread.

There are many others, but this abridged list reveals the types of variables considered in the evaluation of tree failure potential.

### Potential for Striking a Target

The potential that a tree or tree part will strike a target is determined by evaluating where trees or their parts will likely land in the event of a failure, and whether those places of impact will be occupied by targets at the time. This determination is more straightforward for sites with characteristic high and steady occupancy than where intermediate or *low* occupancy occurs. Variables that are evaluated include:

1) the location of designated parking areas and other undesignated areas where people are prone to park their vehicles;

2) the location of tent pads, fire rings, barbecue pits, water pumps, waste disposal stations, restrooms, historic buildings, information boards, interpretive stations, trailside rest stops, scenic viewing areas where hikers are prone to/invited to pause and view, children's play areas;

3) seasonal use patterns including timing of use, type of use (weekend car camping vs. established elk camps vs. off-season use for motor homes by retired couples), and extent of use; and

4) the location of all potential targets or target areas to identified tree hazards.

### Potential that Serious Damage will Result

The amount of damage resulting from partial or complete failure of a tree is dependent upon the size of the failed portion. Damage potential is estimated by rating the size of the tree part that will strike a target. In total, damage potential incorporates evaluation of the likelihood that a partial or complete tree failure will impact a target, the likelihood and amount of damage, and the value of the potential target.

## Value of Potential Target(s)

The value of a potential target is estimated by determining the maximum extent of loss in the event that it is struck by a failed tree or tree part. Financial and emotional losses resulting from the death, injury, or dismemberment of a person are far greater than for the loss of picnic tables, buildings, or vehicles. Values are expressed in relative terms (low, moderate, and high) and are factors considered in evaluating damage potential. For example, if the target is a person or their parked vehicle, the value would be high. A target of moderate value may be a building or other developed structure or convenience such as a water pump or waste disposal station. Garbage cans, dumpsters, and information boards may be examples of lower value targets.

## A Standard for Rating

The standard system suggested here incorporates two important components. The first component addresses the potential for tree failure within a specified time period. Failure potential is rated on a scale of 1 to 4 in order of increasing potential:

1 = VERY LOW FAILURE POTENTIAL.

Sound trees that will not likely be exposed to extremes of weather.

2 = LOW FAILURE POTENTIAL.

Trees with only minor defects (stem decay with more than an acceptable rind of sound wood), in areas sheltered from weather extremes, or sound trees that will likely be exposed to weather extremes (wind, snow loads).

3 = MEDIUM FAILURE POTENTIAL.

Trees with moderate defects (at or near the threshold of acceptable rind thickness), or that are growing in shallow soil, are shallow-rooted, or are exposed to high water table, and that will likely to be exposed to strong winds and snow, (extent of defect alone does not justify removal or hazard mitigation); or highly defective trees in areas well-sheltered from weather extremes; or highly defective trees exposed to weather extremes which only occur in the off season.

4 = HIGH FAILURE POTENTIAL.

Highly defective trees in unsheltered areas, or trees with root anchorage limited by erosion, excavation, undermining, or adverse soil conditions; dead trees, or those with root disease.

The second component of hazard rating addresses damage potential in the event of a failure. This portion of the rating must incorporate the likelihood that a failed tree or tree part will strike a target, the likelihood of damage, and an estimate of target value. Damage potential is rated on a scale of 1 to 4 in order of increasing. potential:

1 = NO DAMAGE.

Target impact will involve only very small tree parts; or there is no chance that failed parts will cause damage when they impact a target.

2 = MINOR DAMAGE.

Failure of only small tree parts, and impacts in occupied areas are indirect; or failures will likely occur when area is unoccupied; damage when it occurs, is to low value target(s).

3 = MEDIUM DAMAGE.

Failure involves small trees or medium-sized tree parts, and impacts will likely occur in areas with targets; impacts will be direct, and damage will likely be moderate, and target value is moderate.

4 = EXTENSIVE DAMAGE.

Failure involves medium to large tree parts or entire trees, and impacts will be direct in areas with targets; target value is high, and damage to property will likely be severe; or serious personal injury or death is the likely result.

The hazard classification for each individual tree is determined by combining the values from the two parts of the rating system. Seven risk classes ranging from 2 to 8 are possible. Treatment priorities by risk class are as follows:

| Risk Class | Treatment Priority |
|---|---|
| 8 | very high |
| 7 | high |
| 6 | moderate |
| 2-5 | low |

Annual Site Examinations

Timing and frequency of examinations may vary, but all developed sites should be reconnoitered for new evidence of hazardous trees at least annually. Sites should be examined once the severe weather season(s) have passed. This translates to spring in many parts of the country because severe weather is most often associated with winter storms. When that is the case, examinations should be completed in the spring, after the snow is off and before new foliage emerges, to improve the sighting of branch, bole, and root defects. Winter storms often bring attention to the most severely defective trees or limbs, and the portions of stands with severe root disease or stem decay.

Annual site exams should be done systematically. They normally consist of a walk-through examination, where each tree and all areas of the developed site are observed for new evidence of hazard or defect. All trees within striking range of a target, either fixed or transitory, should be examined. Evaluations should begin at known or established reference points, and all trees in the near vicinity of those points systematically examined with pertinent observations recorded for each tree. Ideally, a benchmark or baseline hazard tree evaluation should already be completed for the site and notes from the walk-through examination can be used to modify or upgrade that information. If no such baseline evaluation exists for a site, one should be conducted.

## Establishing a Baseline Hazard Tree Evaluation

The development of a baseline evaluation requires a systematic approach that should be organized in planning sessions before going to the woods. The approach that follows is one we have used and modified over the years. We divide it into four stages:

1) identify and gather the necessary equipment;
2) determine the data needs and gather those data;
3) record the data and develop a permanent database; and
4) manage the unacceptable hazards.

### Equipment Needed for Baseline Hazard Tree Evaluations

| Equipment | Intended Use |
|---|---|
| Pulaski | Exposing roots and checking for decay, signs and symptoms |
| Cruisers axe | Sounding boles, inspecting stems for saprot, heartrot, evidence of insect attack |
| Binoculars | Examining stems for conks, punk knots, swollen knots and other indicators of stem decay, and for examining tree crowns for hazardous branches, dead, or forked tops, other defects |
| Diameter tape | Measuring tree diameter |
| Chain (trailer) | Measuring distances for stem mapping |
| Compass | Recording azimuths for stem mapping, and relationships to reference points |
| Relaskopl Clinometer | Measuring tree heights |
| Cordless drill, batteries, drill bits | Estimating the rind thickness of sound wood in the bole, evaluating root soundness (drill bits are flexible steel, 11-12 inches long X 1/8" wide, 9-10" flute, drill is heavy duty, battery packs are rechargeable) |
| Hand lens (1OX) | Examining advanced decay, other indicators |
| Field Ident. Guides | Aids for identification of defects by their indicators (timber cruiser and stand exam guides, this guide) |
| Data forms/pencils | Recording data |
| Tree tags | Provide a semi-permanent numbering system for trees that will be re-evaluated annually (Tags are aluminum, numbered in series) |
| Aluminum nails | To secure tree tags in trees |
| Tree paint or tree flagging | To identify trees that must be removed |

This equipment list can be modified to suit budgets and individual needs. We have routinely used these items to do a thorough job of recording a baseline evaluation to which subsequent annual evaluations and monitoring exams could be tiered. The portable drill replaces the increment corer of past evaluations. It improves the ease of non-destructive sampling of defect and annual monitoring of its progress.

Where and How to Collect Data

*Where to survey.* Trees should be evaluated adjacent to all roads, including the roads entering and exiting the site and all travel loops within the developed portion of the site. All trees of a height that if fallen would reach the road should be examined. The width of the survey area adjacent to roads *is* equivalent to the height of the tallest trees. Concurrently, all trees adjacent to structures, parking areas, restrooms, waste disposal stations, and water pumps must be evaluated. The width of the survey area around these developments is equal to the height of the tallest trees.

Within developed sites, all trees that can reach to tent pads, picnic tables, motor home parking areas, commonly used streamside or lakeside fishing spots, fire rings, barbecue pits and all other recognized gathering places or focal points of human activity should be carefully evaluated. If these are not known, they should be observed during periods of high use prior to establishing the baseline evaluation. At all times, examiners should be aware of the tree hazards that have some potential to impact human targets. These are most important to identify and mitigate to protect the safety of visitors.

Generally, only trees greater than 6 inches diameter at breast height (DBH) should be examined. Smaller trees cause little damage and are considerably less prone to failure under most conditions. Under certain circumstances, trees less than 6 inches in diameter may require periodic inspection if their proximity to a particularly sensitive target (a target that likely would be damaged by impact) suggests unacceptable hazard, but this is exceptional.

*How to survey.* To start, a system of reference points should be established. Permanent reference points are essential for generating maps and for documentation and relocation of individual trees. Since roads are a relatively permanent fixture on the landscape, they are an excellent location for placement of initial points. Spikes driven into the road centerline at regular intervals (nailheads highlighted with colored flagging) can be referenced to one another using azimuth and distance to each other point and the nearest main road junction or some other permanent landmark. Subsequently, a grid of points can then be established throughout the site, referenced to one another and the spikes in the road. We have found that a reference grid of a 2 or 3 chain interval, depending upon the density of vegetation and sighting distances, is sufficient. These within-site reference points should also be established as permanent references; capped, steel pipes (1 to 2" diameter X 2 to 3' length) work well. These can be driven into the ground with the cap exposed above the litter layer. Reference numbers should be visibly stamped on the pipe caps. Reference points should be numbered in series to avoid future confusion, starting at one end of the site and running to the opposite end.

Beginning with reference point #1 and continuing in order to the last, trees should be evaluated and observations recorded. A blank data form (TRF1-91) is provided in Appendix A. Another is provided (Appendix D) displaying several tree records as they might occur. One method of evaluating individual trees that has worked well *involves* an initial examination from a distance to allow comparison of the vigor and *overall* appearance of a tree to its nearest neighbors. This is followed by close-up inspection and examination of each individual tree (2>=6" DBH). The *view* from a distance allows the examiner to detect symptoms of root disease which can include reduced lateral branch and terminal growth, thinning crowns, chlorosis (yellowing), distress cone crops (abundant small cones), dead tops and branches. Evidence of defoliator activity, dwarf mistletoe infection, and bark beetle attack is often initially detected from a distance. Verification of the causal agents, assessment of tree damage and weakening, and potential for failure occurs with oareful root, stem, and upper crown inspection. Individual tree and stand-level clues should be used to make accurate diagnoses for each tree.

Each tree that is examined should be tagged with a numbered aluminum tree tag fixed to the tree with an aluminum nail. Nails should be *driven* through the tag leaving 3/4 to 1" of the nail sticking out to allow for new radial growth. Tags should be placed 1 or 2 inches below the surface of the litter layer so they are hidden from *view* yet easily found. Normally a cardinal compass direction should be selected and all tags should be placed facing in that direction. This will simplify the process of future tag relocation.

Recreation site records covering a 10-year period in the Pacific Northwest *revealed* the frequency of tree failure by position ofthe defect on the tree. Table 1 displays the tree data by species. Nearly two-thirds of all recorded failures occurred as a result of root or butt defects. Limb failures occurred more frequently in hardwoods than in conifers.

Table 1 - Distribution of failures by position of defect and tree species on Pacific Northwest recreation sites.

| Tree species | Up bole (%) | Low bole (%) | Butt (%) | Limb (%) | Root (%) | Total Number |
|---|---|---|---|---|---|---|
| Alder | 23 | 11 | 30 | 1 | 35 | 154 |
| Douglas-fir | 17 | 11 | 15 | 3 | 54 | 404 |
| Engelmann spruce | 0 | 3 | 34 | 0 | 63 | 38 |
| Grand fir | 12 | 18 | 18 | 0 | 53 | 34 |
| Incense cedar | 14 | 29 | 8 | 4 | 44 | 111 |
| Larch | 8 | 26 | 4 | 4 | 58 | 26 |
| Lodgepole pine | 13 | 8 | 7 | 3 | 69 | 637 |
| Madrone | 10 | 2 | 28 | 42 | 18 | 321 |
| Maple | 13 | 4 | 30 | 9 | 47 | 47 |
| Mountain hemlock | 12 | 77 | 0 | 0 | 12 | 43 |
| Noble fir | 37 | 11 | 0 | 0 | 53 | 19 |
| Pacific silver fir | 5 | 48 | 5 | 0 | 43 | 21 |
| Ponderosa pine | 42 | 6 | 5 | 0 | 47 | 280 |
| Poplar | 15 | 12 | 19 | 31 | 23 | 26 |
| Red fir | 16 | 30 | 13 | 1 | 40 | 87 |
| Sitka spruce | 18 | 27 | 18 | 0 | 36 | 11 |
| Spruce, unident. | 0 | 53 | 0 | 0 | 47 | 297 |
| Subalpine .fir | 55 | 3 | 24 | 0 | 17 | 29 |
| Sugar pine | 14 | 25 | 17 | 8 | 36 | 36 |
| Tanoak | 13 | 24 | 18 | 16 | 28 | 1614 |
| Western hemlock | 4 | 18 | 19 | 1 | 58 | 113 |
| Western red cedar | 0 | 15 | 12 | 10 | 63 | 41 |
| White fir | 6 | 53 | 15 | 0 | 26 | 34 |
| Average | 15% | 22% | 15% | 6% | 42% | 4423 |

Typically, there will be many readily available stand-level clues that will be overlooked if they are not brought to mind. Examiners should scout 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. Nearby stumps and old root tubes should be examined for evidence of advanced decay and conks of root and butt pathogens. Broken-out tops that are 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 (disease) and their identification often leads to detection and correct diagnosis of problems in adjacent apparently healthy trees.

When individual trees are evaluated, examiners should look for signs and symptoms of disease and evidence of insect attack (Figures 8-12). In the event that signs and symptoms indicate damage and a potential hazard, trees should be examined more thoroughly to determine the extent to which the damage has compromised structural integrity of the tree. Some defects

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

do not demand immediate hazard mitigation but suggest periodic re-examination. Such monitoring can range in frequency from one to three years depending on the degree of structural degradation. Systematic tree examination begins at the ground around the base of the tree, then proceeds to the butt, bole, limbs, and tree top. All sides of each tree should be examined. If basal resinosis, crown symptoms, conks, or evidence of decay indicates a root disease problem, examination of several roots via the pulaski will be necessary. Since many trees in recreation areas are tall and their tops are partially hidden from view by other tree crowns, binoculars may be necessary.

If root disease symptoms are evident, the root collar, butt, and major lateral roots should be inspected for signs of the causal agent(s) such as fruiting bodies, evidence of ectotrophic (surface) mycelium, signs of recent or old injuries. Some older injuries may be completely covered with callus tissue or bark. Evidence of older injury is often characterized by obvious fissures in the bark or they may be nearly unrecognizable except for a subtle flattening of the bole. At this point, if evidence points to root disease, the pulaski can be used to uncover roots (out to a distance of one meter if needed) and to chop into them to examine them for incipient stain or advanced decay. At least 2 major roots should be checked for root disease if preliminary evidence suggests that it is 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 tree exhibits signs of older injury, the cordless drill can be used to check for presence and extent of decay behind old wounds. The first place to drill is directly into the scar or flattened area. If decay is found, at least 3 more drillings should be made to the opposite and adjacent sides, to estimate the extent of decay. Tree species that display buttressing or fluted butts (e.g., western hemlock, western redcedar) may require more sampling since the distal portions of fluted areas are often thicker. The thickness of the remaining rind of sound wood should be recorded by averaging all measurements. Refer to Table 2 for minimum safe shell thickness. When the thickness of the rind (shell) of sound wood is insufficient for a trees' diameter (DBH), the failure potential would be recorded as 'high'.

Table 2 - Minimum safe-tree shell thickness at various DBH's.[1/]

| Tree DBH (in.) | Minimum Shell Thickness[2/] (in.) | Tree DBH (in.) | Minimum Shell Thickness (in.) |
|---|---|---|---|
| 4 | 1.0 | 40 | 6.0 |
| 8 | 1.5 | 44 | 6.5 |
| 12 | 2.0 | 48 | 7.0 |
| 16 | 2.5 | 52 | 8.0 |
| 20 | 3.0 | 56 | 8.5 |
| 24 | 3.5 | 60 | 9.0 |
| 28 | 4.0 | 64 | 9.5 |
| 32 | 4.5 | 68 | 10.0 |
| 36 | 5.5 | | |

1/ Modified from Wagener, 1963 by expanding the range of diameters covered.
2/ Minimum shell thickness for trees with open wounds is 25 percent greater than indicated in Table 2.

Drilling into all trees is not recommended since it is somewhat time consuming and is usually not warranted lacking other indicators of internal defect. Trees with substantial decay usually bear obvious indication of that defect.

Signs of significant pileated woodpecker activity (not to be confused with sapsucker work, or other woodpecker work after mass attack by bark beetles) such as partial cavity excavation, often indicates the presence of termites and/or carpenter ants. It might mean that insects are mining in the bark and are not affecting the integrity of the wood, or it may mean that the butt or the main stem has significant decay. Chopping the bark or drilling can confirm the presence and extent of defect. Be discrete with chopping so as not to suggest to visitors that it is an acceptable public activity.

The bole above the lower butt is the next logical section to examine. From this point upward, visual examination will be employed to estimate the extent of defect. Again, signs of past injury or fruiting bodies should be the target of observation.

Old-growth trees often exhibit fruiting bodies of stem decay fungi when decay levels are hazardous to personal safety. These fruiting bodies generally develop at the site of old branch stubs. Absence of conks, however, does not necessarily mean that a tree is free from defect. Record the presence of all signs of potential defect so that if treatment is not immediately warranted, the loss of a conk or misinterpretation of other signs will not lead future examiners to believe the stem is sound. If hazard evaluations are conducted on cloudy days, lighting conditions will be flat, and fruiting bodies of stem decay fungi will often be missed. Examinations are best done on sunny days when visibility and contrast are maximized.

While dead branches and dead tops are less hazardous to visitors than dead trees or those with root disease, tree tops should be examined thoroughly. Free hanging and dead branches should be evaluated and dealt with as needed. Dead tops should be examined for decay and instability indicated by crumbling sapwood, woodpecker activity, and nesting cavities. Binoculars are useful in this assessment.

## Recording an Evaluation

Individual tree examinations are complete at this stage. To provide evidence that a tree was examined, a tree record should be filled out (refer to Appendix D for an example record form). Recording results of recreation site evaluations is necessary from several vantages:

1) the assessment of current hazards and forest health provides orientation and framework for future vegetation management activities;

2) it shows the predominant defects in each campground making the job of future surveys easier;

3) it provides the database for future vegetation and hazard management and monitoring efforts;

4) it sets the baseline upon which to build other recreation opportunities, other vegetation structures and compositions, planning and investment horizons; and

5) it is the record of performance in the event of Tort Claims.

## Monitoring Recognized Tree Hazards

A primary benefit of establishing a baseline survey and permanent database is that future ,site re-inspections and hazard monitoring are simplified. Hazard and monitoring information are readily entered into relational databases like Paradox, dBase IV, RBase and perhaps Oracle. Answer files may be generated annually, listing the trees indicated in prior inspections that are to be monitored in a given year. Files would provide the locations of specific trees relative to reference points, their species, size, and type of defect, their prior extent of defect, the appropriate monitoring interval, prior hazard and risk ratings, and recommended treatments. Stem maps can be generated using the reference points and azimuth/distance information using AutoCAD or equivalent software and maps of virtually any specification can be generated: tree *removal* maps for contractors, annual tree visitation maps for defect monitoring and periodic re-evaluation, complete *developed* site maps for long-range planning and visual perspective projections. *Over* time, annual layers of information will be accumulated and *available* for trend analyses of *vegetation,* pathogen and insect populations, and management *activities.*

## Establishing a Semi-Permanent Tree Record

Whether or not a tree has defect, a complete tree record should be developed at the time of the baseline *survey* and updated with each re-*evaluation.* The tree record should contain all the data needed to discover trends for individual trees. When observed in aggregate, stand *level* trends will become obvious. Each tree record form should *have* columns for each parameter that is to be measured or observed periodically, and rows to enter the observations for each examination. The following information should be recorded:

1) recreation site name;
2) tree identification number;
3) tree species;
4) date of baseline *survey;*
5) closest reference point (RP);
6) distance to RP;
7) azimuth (degrees true);
8) date of current examination;
9) tree diameter at breast height;
10) tree height;
11) symptoms of root problems (injury, loss of anchorage, disease);
12) cause of root problems;
13) cause of butt problems;
14) symptoms of stem problems;
15) cause of stem problems;
16) thickness of remaining sound wood (rind);
17) other problems, dead or hanging limbs, dead top;
18) risk rating/tree *value* rating;
19) recommended treatment;
20) date treatment accomplished;
21) date of next scheduled examination; and
22) name of examiner(s).

Some of these data need to be recorded only once (#1-#7), others at specified or regular intervals (#8-#22), and some may not be appropriate to a specific examination. All columns, in each row, for each examination, should be entered. This will insure that some data are not overlooked. If no alpha or numeric data are needed in a specific column for a particular inspection period, a "-" is an appropriate entry. Appendix A contains an example of a data sheet that includes all of the *above* categories as well as a section for additional remarks.

Decisions on the soundness of individual trees can be a matter of life or death to site visitors. Care should be taken to do a thorough job. Adequate time must be allowed to evaluate and record data for each tree. Evaluations should be conducted, whenever possible, during bright sunny weather when defects and their indicators are most easily observed. Trees in developed recreation sites have great aesthetic value and are difficult to replace. Removal decisions should be based on careful hazard evaluations, considering other hazard mitigation alternatives, such as seasonal closures, moving the location of potential targets, pruning, guying, bracing, topping and others.

# Chapter 4

## Developed Site Hazard Tree Evaluation: Tree Collapse Model

High wind is a primary cause of tree collapse. Its effects are intensified by internal root, butt, or stem decay or other structural or mechanical defect. In this chapter, we present a model for predicting tree collapse caused by wind forces, to trees with varying amounts of internal decay. The model is a decision aid which integrates knowledge of the strength properties of conifer woods, and their response to wind force loadings in the form of partial or complete tree collapse. In a recent publication, Ossenbruggen, et al (1986) developed a model to predict failure of defective trees under wind loading. This model for hazard tree evaluation is an extension of that work to Pacific Northwest conifers.

### Model Concept

The tree collapse model assumes that wind loading can be represented as a horizontal force that acts on trees to cause cracking and bending failures. Since conifers frequently are hollow as a result of butt rot or lower stem decay, failure is more often associated with the lower stem. In the Ossenbruggen, et al model, and in this model, trees are described as tapered, cantilevered cylinders loaded with horizontal wind forces. When these tapered cylinders are modelled with internal decay, decay columns are represented as elongated upright cones. In this model, if a tree has decay, it will most likely fail in the butt log. The model assumes that any decay column has zero strength, while the sound wood comprising the main stem and root collar region is assumed to be of equal strength.

The first effect modelled is radial cracking which occurs perpendicular to the direction of wind, on either side of a decay column, when wind force causes a tree to bend. This bending creates tension forces on the windward side and compression forces on the leeward side of the loaded tree. When maximum shear strengths have been exceeded under excessive wind loading for the diameter and density of the wood, the cylinder fractures along the plane of maximum shear stress and a crack is formed. After cracking, the tree segments act as two cantilevered half hollow cylinders.

Once cracked, the tree is classified as hazardous and potentially dangerous. The collapse subroutine of the model is initiated once a crack has occurred. Collapse can be delayed or it can occur immediately if there is wind force of sufficient magnitude. Cracking always precedes collapse even when both occur in the same wind event (Ossenbruggen, *et al. 1986).*

Tree collapse occurs when wind force is sufficient to exceed tension and compression strengths of the two half segments of the tree. At the point of failure, the modulus of rupture is exceeded for each half segment (the maximum loading capacity which is equal to the maximum moment borne by each half segment) and the tree collapses.

## The Model

The model determines the wind speed *(v)* needed to cause tree collapse. The equation used is:

$$v = \left[ \frac{\dfrac{2\sigma \left[ \dfrac{\pi}{128} (d_o^4 - d_i^4) - \dfrac{(d_o^3 - d_i^3)}{18\pi (d_o^2 - d_i^2)} \right]}{e \left[ \dfrac{d_o}{2} - \dfrac{2(d_o^3 - d_i^3)}{3\pi (d_o^2 - d_i^2)} \right]} + 0.328w - 7.426}{1.441 + 0.029w} \right] \times 1.1507794$$

where: $u$ = modulus of rupture of the tree
$d_o$ = diameter outside bark at root col!ar
$d_i$ = diameter of decay column at root collar
e = length of the moment arm
w = tree weight

Moduli of rupture for the conifer species in this model were extracted from the U.S.D.A. Agricultural Handbook No. 72. The length of the moment arm is 65 percent of total tree height in inches. Whole tree weights are computed for each tree, by species, as a function of their diameter at breast height (DBH) and height. Equations for weight calculations came from USDA FS GTR WO-42 and personal communication with Jim Howard, Pacific Northwest Forest and Range Experiment Station, Portland, OR.

This model was developed for four Pacific Northwest conifers for which data are available (Douglas-fir, western hemlock, western red cedar, and Engelmann spruce). It will be enlarged to include others as supporting data become *available.* For purposes of rough comparison until data are available for other conifer species, Douglas-fir can be used to conservatively predict tree collapse for western larch; western hemlock can be used for mountain hemlock, Port-Orford cedar, Alaska yellow cedar; Engelmann spruce can be used for lodgepole pine, ponderosa pine, white fir, noble fir, Pacific *silver* fir, California red fir, incense cedar, Sitka spruce, western white pine; western redcedar can be used for grand fir, subalpine fir. While some of the associations may seem obscure, species were related for con*servative* prediction purposes, based upon the similarity of their moduli of elasticity and rupture, and their compression and tension strengths.

When using the model, specific tree data are preferred, but the user has the option to default to a diameter/height regression equation if individual heights are not be measured. This regression equation, from Wykoff, et al (1982), has conifer species specific coefficients developed from Mt. Hood National Forest inventory data. Since there were significant differences in tree growth between small and large trees, coefficients were developed from tree data for trees larger than 10 inches DBH and greater than 36 feet in height. The regression provides an average height that may be different from the height of actual trees, we therefore recommend that tree heights are measured whenever possible. The model is quite sensitive to differences in height since tree height is an expression of the length of the moment arm. As height increases, resistance to collapse decreases. Users should validate model output heights in each locale to determine if the model will project reasonably accurate heights. This can be done by comparing a measured set of heights with a model projected set.

Using the Model

The tree collapse model is encoded in three forms: BASIC, MS-DOS, and HP-Basic for the HP-41 CV handheld calculator. Copies are available upon request from the Regional Office of FPM in Portland, OR, or Area Field Offices in La Grande or Bend, Oregon or Wenatchee, Washington.

Model operation is accomplished with input of as few as four data entries: tree species or tree species group, DBH, the outside diameter just above root collar or at the height of minimum shell thickness, and shell or rind thickness (thickness of sound wood surrounding decay column at the thinnest point). Additionally, height may be entered; when no tree heights are specified, the program will provide one. Output is in the form of minimum wind speed required to cause collapse of the modelled tree. The model assumes that trees are standing in the open and have no open-faced wounds or breaks in the shell. The user need only know the maximum wind speed that the tree is likely to experience in order to make a decision on whether or not, and how, to treat it.

Input required by the model:

(SPECIES ?) conifer species selected for this simulation. Conifer species are grouped in four groups. To select a species, enter the number which corresponds to the correct species group. The choices are: (1=DOUGLAS-FIR, 2=E. SPRUCE. 3=W. HEMLOCK. 4=W. REDCEDAR). With the HP-41 CV version, bypassing a selection will *reveal* the next choice. If none of the four currently available species groups is chosen on the first go-around the model will cycle through the choices again.

(DBH ?) is a standard diameter at breast height (4 feet). The user enters data in inches (and tenths if desired).

(BASE DIA. ?) is the diameter outside bark of the base just above the root collar or at the height of the thinnest rind.

(RIND ?) is the shell thickness for hollow stems. This can be estimated using a heavy duty cordless drill and a 11-12" long, flexible steel drill bit. Shell thickness is taken as the average of no fewer than four measurements of rind thickness of sound wood.

(HEIGHT ?) is entered if it can be measured. If height is not measured, the program defaults to the height algorithm providing a height based on the DBH of the tree. Measure and enter accurate heights whenever possible.

Model output is the minimum wind speed in miles per hour that, when directly 'impacting a tree, will topple that tree. This does not refer to wind speeds commonly occurring in the vicinity of the tree. If a tree is well sheltered, it will not be subject to the full force of wind.

This model was developed with the hypothesis that the variable most strongly influencing tree collapse is wind. Since this variable is not usually estimated with any degree of accuracy by the layman, it may be difficult for the recreation site manager to determine a safe wind speed resistance (see Beaufort scale Appendix A).

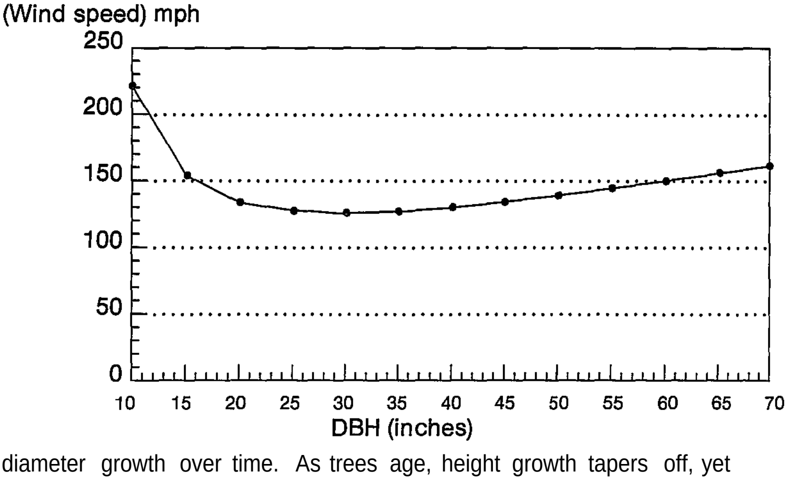
One method that may be used to determine wind speeds that have occurred in an area would be to locate trees that have failed and are on the ground. In most cases, the remnant base of a tree may be sufficient. Tree species, DBH, base diameter, and rind can be measured from the down tree or tree portion. If the entire tree is still present, its total height can be input as well, *otherwise* the model will supply a height.

When run, the model will indicate the minimum wind speed that would have caused the tree to collapse. If several failed trees are available in an area, each can be used to run the model. More observations of failed trees will improve the range of the sample of minimum wind speeds, thereby improving the estimate of wind speeds that frequent a given locale.

To test model output, we ran the model on Douglas-fir ranging in DBH from 10 to 70 inches. In all cases, we set the diameter at the root collar equal to DBH, rind of sound wood was set at 50 percent of the diameter (none of the trees had internal decay), and heights were supplied by the default regression equation. The results of these runs are illustrated in Figure 13.

Results shown in Figure 13 indicate that trees in the 20 to 40 inch DBH range are most susceptible to collapse even when sound. The shape of this curve is attributable to the relationship between height growth and

Figure 13. Relationship of minimum wind speed to cause tree failure for Douglas-fir without internal decay.

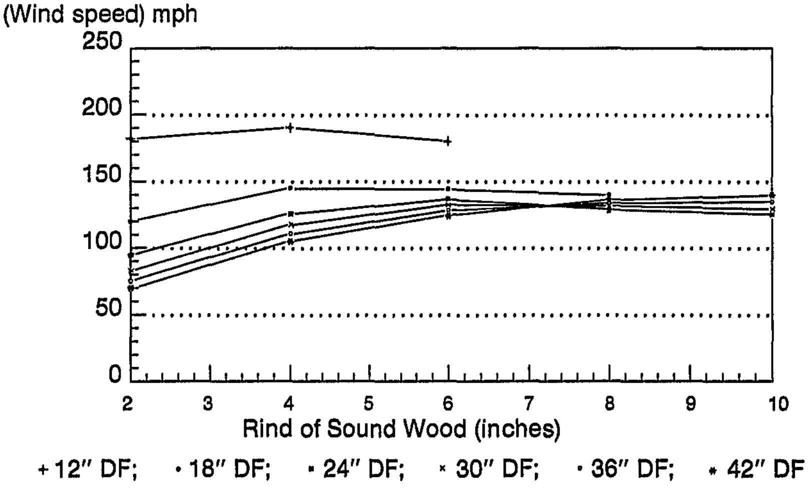



diameter growth over time. As trees age, height growth tapers off, yet diameter growth may steadily increase for many decades improving resistance to collapse. When trees are young, their live crowns are relatively long, dense, and broad, providing a large surface for wind interception. Site managers should be aware that even sound trees will collapse in high winds.

While this model refers to collapse as a result of stem failure, wind extremes also cause failure by uprooting. This is especially true for shallow rooted species, shallow soils, wet soils, and where natural barriers to wind *penetration* of a stand have been breached as in the case of closed stands that are opened to remove hazardous trees or by adjacent clearcutting.

To further test the model, we ran Douglas-fir at DBH's 12, 18, 24, 30, 36, and 42 inches with 2, 4, 6, 8, and 10 inches of sound rind to see what minimum wind speeds were required to cause tree collapse. The results of these runs can be seen in Figure 14.

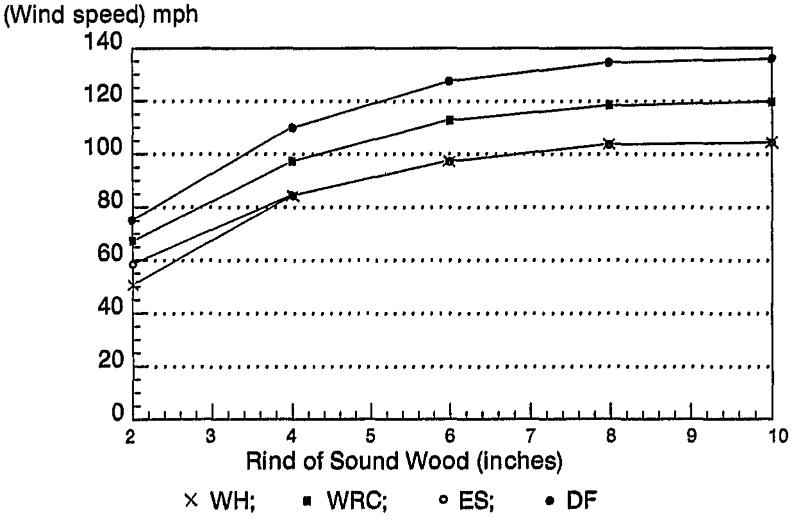
Figure 14. Relationship of minimum wind speed to cause tree failure for 12-42 in. Douglas-fir with varying widths of sound rind.




According to these projections, there is little added benefit when Douglas-fir of these diameters have sound rinds in excess of 8 inches.

Figure 15 compares minimum wind speeds causing tree collapse for 36 inch Douglas-fir, western hemlock, Engelmann spruce, and western redcedar with 2, 4, 6, 8, and 10 inches of sound rind. These projections indicate a similar trend. For each species modelled at 36 inches DBH, there was little added benefit of additional sound rind in excess of 8 inches.

Figure 15. Relationship of minimum wind speed to cause tree failure for 36 in. OF, WH, WRC, ES with varying widths of sound rind.



## Cautions and Conclusion

This model is only one of *several* tools available for use in the hazard tree decision-making process. Two other important tools are common sense and local experience. Since this is a mathematical model and algorithms were *developed* from empirical data, outputs are *average values.* For each of the conifer species modelled, strength properties represent a range of *values* rather than one absolute *value.* Equations in this model use mean *values* of each property. Some trees may collapse with somewhat less wind, while others may require more. Caution is *advised* against holding rigorously to results generated by the model. Prudence suggests that use of this model can aid the site managers' decision-making process, not make decisions. Keep in mind that model predictions *have* not been verified by rigorous testing.

# Chapter 5

## Identification of Tree Diseases and Defects that Result in Hazardous Trees

This section addresses common tree defects beginning with the roots and root collar, progressing to the butt and upper bole, and finally the limbs. This is also the progression used in evaluating potentially hazardous trees.

### Root and Butt Defects

Root and butt defects are most commonly associated with tree failures in the Pacific Northwest (Table 1). Root and butt defects arise from *several* sources. Principal among them are root disease pathogens which cause significant decay to roots and butts, and loss of anchorage of affected trees. In the Pacific Northwest, the root pathogens of greatest significance to developed sites are:

| Common Name | Scientific Name | Major Conifer Hosts |
|---|---|---|
| Laminated Root Rot | *Phellinus weirii* (PHWE) | true firs, hemlocks,<br>OF, ES |
| Armillaria Root Disease | *Armillaria ostoyae* (AROS) | true firs, OF<br>PP,LP |
| Annosus Root Disease | *Heterobasidion annosum*<br>(HEAN) | PP, true firs<br>hemlocks, spruces |
| Tomentosus Root Rot | *Inonotus tomentosus*<br>(INTO) | ES, true firs<br>PP, LP |
| Brown Cubical Butt Rot | *Phaeolus schweinitzii*<br>(PHSC) | pines, OF, WL<br>ES |

Other important root defects are undermined roots which result after erosion, seasonally high waterline or flooding events, excavation or (re)construction activities; severed roots which are mechanically induced by various construction, roadbuilding, and maintenance activities; and loosened, cracked, or broken roots which occur naturally under high winds and typically result in partial failures of one sort or another.

Root and butt diseases cause severe damage to root anchorage and tree vigor. The most conspicuous results are predisposition to attack by bark beetles, tree death, wind break and windthrow. Most developed site tree failures are the result of root disease. Unfortunately, root diseases and the defects they cause are difficult to detect, and detection efforts are time consuming. For these reasons, root disease damage and defect usually go undetected in developed sites until significant winds and failures occur and trees are jack-strawed across the site.

Symptoms of root disease (also Table 4) and the most common pathogens are:

1) bark beetle mass attack (Figure 16). PHWE, AROS, HEAN, INTO

2) general decline of the entire live crown characterized by chlorotic foliage, the shedding of older needles, terminal (and eventually lateral shoot) growth reduction (Figure 17), PHWE, AROS, HEAN, INTO

3) distress cone crops (Figure 18), PHWE, AROS, HEAN

4) dy'ing branches, thinning crowns, from the extremiHes inward (old growth) or from the interior crown outward (young growth or second growth) (Figure 19), PHWE, AROS, HEAN


Figure 16

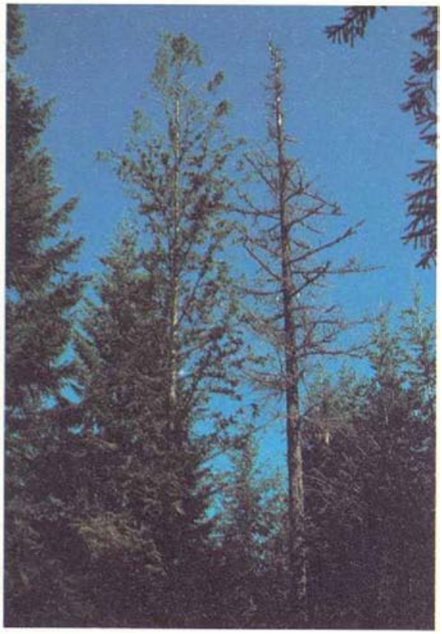


Figure 17


Figure 18

5) butt rot, as much as 30-35 feet (Figure 20), PH8C, INTO, HEAN, PHWE

6) basal resinosis (Figure 21), and/or b<:jrkstaining, AROS less often PHWE, HEAN

7) windthrow or wind shatter of surrounding trees (Figure 22), PHSC, PHWE, INTO, HEAN

8) standing dead: and dying trees (Figure 23), HEAN, AROS, PHWE, and

9) mushrooms or conks at root collars (Figure 24), PHSc, INTO, AROS, HEAN

Anyone of these symptoms or combination of these symptoms suggests problems with root disease in the rool system. Many trees may be visibly affected by Ihe root pathogen responsible for the damage: Many more may be invisibly influenced.

Root pathogens typically spread through a stand at a predictable rate; only a portion of their progress at anyone time is manifested by above-ground symptoms.

In extended drought periods, root disease diagnoses are a little more

Figure 19

Figure 20

complex. Drought conditions intensify the effect of root disease damage .on tree vigor and resistance to infection or damage. More bark beetle induced tree mortality and more total tree mortality from the combined effects of root diseases and bark beetles result during and after periods of drought than would result from root disease alone.

**Laminated** root rot. All five of the root diseases listed above are of significance to developed sites. Each is capable of causing significant butt defect which results in tree failure. Three of them consistently cause tree mortality. Of these, laminated root rot is most damaging to vegetation and most hazardous to recreationists. Laminated root rot spreads via an ectotrophic mycelium along roots that are in intimate contact with one another and across root grafts. The ectotrophic mycelium is a portion of

Figure 21

the fungal thallus which grows on the surface of infected roots and spreads thereby to healthy susceptible roots. Roots of all coniferous species are colonized by this fungus. Some species are highly susceptible to infection and damage. Others are tolerant or even resistant to infection and damage. All hardwoods are thought to be immune. See Tables 3 and 4 in Appendix C for the order of relative susceptibility of Pacific Northwest conifers to PHWE, AROS, and HEAN, and for a complete list of signs and symptoms for each major root disease pathogen.

The fungus which causes laminated root rot can remain viable and infective for 50 years or more after its host has died. Old stumps and standing dead

Figure 22

trees function as virulent inoculum for decades after a tree is killed or salvaged. To eliminate inoculum from a site requires stump pulling and root raking with no guarantee of eliminating small infective root pieces. Apart from radical stumping projects, disease progress can be halted via the removal (cutting) of all symptomatic trees and other susceptible conifer hosts within at least 50 feet of them in a buffer zone.

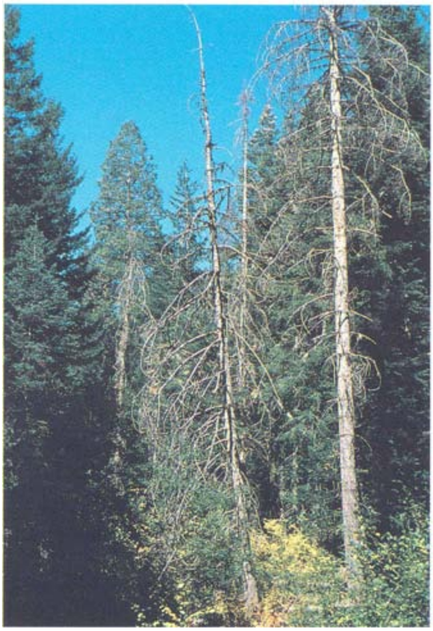


Figure 23

Since the extent of a center (focus of root disease infection and mortality) cannot be entirely identified by above-ground crown symptoms, confirmation of the total extent of spread must be made by partial root excavation and examination of trees next to the obvious center. Roots and root collars of trees immediately adjacent to those with crown symptoms should be examined for evidence of decay and ectotrophic mycelia (white fungal mycelium on the surfaces of conifer roots). These trees are examined because they are the ones that will most likely be infected (they are closest to known virulent inoculum), and their infections will yet be hidden (nonsymptomatic). The strongest diagnostic evidence for laminated root rot is the

Figure 24

presence of setal hyphae (reddish-brown hypha l tufts). in wood with advanced decay. Advanced decay typically takes the form of delaminated sheets that separate at the growth ring. A complete list of diagnostic clues, signs and symptoms for this and each of the other four root diseases is supplied in Table 4 in Appendix C.

All Pacific Northwest conifers are affected to some degree by laminated root rot. Resistant and tolerant conifers (pines, cedars, western larch) are infected but will usually *survive.* Such trees need careful evaluation for any hazard root rot may pose. The disease is maintained on sites for decades in this manner with little expression of damage, since the opportunity for spread to more susceptible species is minimized. This scenario was true during the period of natural fire history, prior to European settlement of most of the lower and middle elevation eastside Cascades landscapes.

When laminated root rot is diagnosed in developed sites, all symptomatic trees and those of a susceptible species adjacent to them within 50 feet should be removed immediately. Intermediately susceptible and tolerant conifers growing in known laminated root rot centers or the adjacent buffer zone, should be managed to their pathological rotation age (Table 6, Appendix C).

Armillaria root disease. Armillaria root disease is frequently found in developed sites, and its presence is a cause for great concern. This root pathogen functions either as a weak parasite of stressed, low vigor trees, or as an aggressive pathogen of susceptible host conifers. In the former case, the reduction or elimination of tree stresses may reduce or eliminate the possibility of great spread and damage by this fungus. In the later case, nothing short of reducing or eliminating the abundance of susceptible host conifers will reduce the amount of spread and mortality affected by this root pathogen.

Trees are readily killed by this root disease. Dead standing trees are hazardous to visitors and they must be removed. As long as susceptible host trees are adjacent to an Armillaria mortality center, root disease will progress in all directions at a rate of at least 1 foot each year. This is roughly equivalent to a doubling of the area in active root disease centers every time the radius of the center increases by 40 percent.

Armillaria root disease is found on most conifers throughout the Pacific Northwest Region, but empirical evidence suggests that conifer susceptibility varies with location (plant association, latitude, elevation, aspect, environment, edaphic factors), the specifics of which are not known. This area of understanding continues to be one of great interest to researchers and resource managers, and we can expect new information regarding site hazard rating for root diseases in the future.

Armillaria root disease is detected in much the same way as laminated root rot, using at first, above-ground symptoms which indicate a root disease problem. Upon excavation of the roots and root collar, other indicators are available including the presence of basal resinosis. a thick, white, latex-like mycelial fan just under the bark, and the appearance of resin-soaked decayed wood interspersed with straw-colored flecks. This root disease spreads by rhizomorphs (black root-like fungal structures which grow through the soil in search of host roots) and by mycelial extension between roots in intimate contact or close proximity to each other. Root rotting may be extensive and trees with this root disease should not be considered windfirm whether they are live or dead. When Armillaria root disease is encountered (see Table 4 in Appendix C for a list of signs and symptoms), dead and dying trees should be removed, and trees maintained in proximity to existing centers must be tolerant or resistant to this disease.

Annosus root disease. Annosus root disease can be a significant problem on developed sites of the grand fir, white fir, and subalpine fir zones of the eastside Cascades, the western hemlock, mountain hemlock, and Pacific silver fir zones of the westside Cascades, and the dry eastside climax ponderosa pine zone, where tree mortality is the outcome of infection.

Grand fir, white fir, and ponderosa pine on dry sites are killed by the pathogen. Other species usually experience butt and stem decay.

In addition to inter-tree spread by an ectotrophic mycelium (fungal mycelium which grows on the surface of roots), this fungus spreads via wind borne spores which infect fresh wounds and newly created stump surfaces. New infections through wounds, especially basal wounds, develop into butt rot and eventually roots are rotted and trees will collapse. When stumps are colonized, decay first develops deep in the protected interior of the stump, and that decay moves out into adjacent roots. Healthy tree roots of susceptible species come in contact with those infected roots, and the fungus is thereby spread to a new host.

In the western hemlock and mountain hemlock zones, the spread biology is much the same, though the result of infection is usually butt decay rather than tree mortality. This is true of either hemlock spp. and the associated noble fir, Engelmann spruce, and Pacific silver fir (although Pacific silver fir and mountain hemlock are occasionally killed). Significant butt decay is typically delayed until trees are well past maturity. Subalpine fir, when infected, is often killed by this root pathogen and associated bark beetles, most often the western balsam bark beetle *(Dryocoetes confusus).*

When annosus root disease is encountered in developed sites it should be addressed immediately. Hosts that principally suffer from butt rot should be managed to a pathological rotation age and regenerated. Pathological rotation age is the age on average, when overall tree vigor is declining and pathogenic influences become limiting. See Table 7 in Appendix C for a list of pathological rotation ages for intermediately susceptible, tolerant and resistant hosts of annosus root disease. In infection centers, all symptomatic susceptible hosts must be removed in the area of the obvious center and in an asymptomatic buffer zone 50 feet wide. Conifers that are less susceptible should be regenerated in those pockets.

There appears to be little hazard associated with growmg intermediately susceptible, tolerant, and resistant hosts in known infection centers as long as trees are robust and vigorous throughout their life, and their pathological rotation age is not exceeded. Defect rules are provided here and elsewhere to aid examiners in understanding the extent of defects based on their external indicators.

*Rules for determining the extent of decay when indicators are present:*
*For hemlocks, spruces, true firs:*

> *When an annosum conk is visible near the root collar, the lower 16-feet of the butt log are defective; or*
>
> *Defect extends 4-feet above the top of an infected basal scar when annosum decay is verified, whichever is greater;*
>
> *Defect extends 4-feet above and below infected stem wounds when annosum decay is verified;*
>
> *Defect rules apply to wounds that are at least* 10 years *old; date wounds and* scars *with a cruiser's axe; for wounds* less *than* 10 years *old, expect internal defect to run the length of the wound* or scar.

Tomentosus root rot. The infection and spread biology of tomentosus root rot is similar to that of annosus root disease. Inter-tree spread occurs via an ectotrophic mycelium, and spores are involved in infection of new wounds and freshly cut stumps. The importance of spores in local spread is poorly understood. In developed sites, Engelmann spruce is most often affected, and damage is manifested typically as windthrow or wind shattering of severely butt rotted mature trees. Tomentosus root rot is identified in the field by its characteristic fruiting bodies, advanced decay, incipient stain, and occasionally by the presence of ectotrophic mycelia. In no instance should ectotrophic mycelium alone be used to diagnose a specific root disease; three of the root diseases discussed here produce surface mycelia, and there is chance of confusion. Other, better indicators are available for each root disease, and several diagnostic clues should be used for each correct diagnosis.

When tomentosus root rot is encountered in developed sites it should be addressed immediately. Hosts that suffer from butt rot should be managed to a pathological rotation age and regenerated. See Table 3 in Appendix C for the order of host susceptibility to this disease. Resistant and tolerant hosts should also be regenerated in tomentosus root rot centers where practicable. See Table 7 in Appendix C for a list of pathological rotation ages for hosts of annosus root disease. Pathological rotation ages will be the same for hosts of tomentosus root rot.

Brown cubical butt rot. Brown cubical butt rot (Schweinitzii root and butt rot) is perhaps the most common root and butt defect in developed sites across Oregon and Washington. On the westside of the Cascade Range, significant butt decay is indicated by a conspicuous fruiting body, referred to as "cow-flop" or the "cow-pie" fungus, and often by swollen butts. Elsewhere, the defect may be as common, but it is often present without indicators. As such, it is less often discovered 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.

The advanced decay is a brown cubical rot. The incipient stain, while distinctive, is rarely observed except on freshly cut log ends. The incipient stain is light green, occurring immediately adjacent to areas of advanced decay. Damage most often occurs in overmature Douglas-fir on the westside. Douglas-fir, western larch, ponderosa pine, and lodgepole pine are frequently damaged on the eastside. For all but lodgepole pine, the pathological rotation age is approximately 150 years. For lodgepole pine that value is a range of years from 100 to 120 depending upon site quality, site productivity, and growth history. The high end of the range coincides with the best lodgepole sites. It is important to remember that for lodgepole pine, age becomes a limiting factor in hazard to mountain pine beetle beginning at about 100 years.

Trees are apparently infected by this pathogen at any age. Most infections occur by mycelial spread from diseased to healthy roots through litter and organic residues to root tips. A minority of infections develop via spores to wounds and basal fire scars. Infections are confined to heartwood and are sequestered as relatively innocuous heartwood lesions. When trees are immature, smaller roots with heartwood are decayed. As trees advance in age, larger roots are decayed with increasing deleterious effects on anchorage.

When brown cubical butt rot is encountered in developed sites, trees should be carefully evaluated rather than automatically removed. This root disease appears to be the slowest to weaken trees to hazardous levels. When indicators are present, those trees should be thoroughly evaluated. Evaluations should include detection of obvious leans, recent root wrenching or partial failure, butt swell, shake or cracking of the butt, and evidence of ant or woodborer activity in the butt. Additionally, each of the major lateral roots should be exposed and drilled with a cordless drill, within a half meter or so of the root collar, to detect any hidden defect in the roots that provide major anchorage. If most of the major root anchorage is undamaged, the tree may be retained and monitored each year or every other year depending upon the extent of defect. Trees with seriously compromised anchorage should be removed or the hazard otherwise mitigated.

On mesic and wetter sites where fruiting bodies are more abundant, a single fruiting body indicates that the evaluator should take note and examine the defective tree more closely. Once trees with fruiting bodies have been examined, those susceptible hosts immediately adjacent to them should be evaluated in the same way.

*Rules for determining the extent of decay when indicators are present:*

> *With conk(s) on the ground near the base of a tree, or on the tree at the base (old growth and older second growth, no scars or cracks), expect 8-feet of defect in the butt log;*
>
> *With conk(s) on scars or cracks at the base of old growth Douglas-fir, or western hemlock, or with conks on the ground near a tree base that is scarred or cracked, expect 16-feet of defect in the butt log; (expect 8-feet of defect only on the UMP);*
>
> *With conk(s) on scars or cracks at the base of young growth Douglas-fir or western hemlock, or conks on the ground near a tree base with scars or cracks, expect 8-feet of defect in the butt log;*
>
> *32-feet of the butt are defective when conk(s) occur on scars or cracks 8-feet or more above the ground;*
>
> *For dead tree defect rules, add 4-feet to the preceding rules.*

Undermined roots, are often associated with road-building or trail-building activities in and around developed sites. Otherwise they are frequently observed at waters' edge adjacent to natural or man-made lakes, streams, or rivers (Figure 25). When soil is eroded away from tree roots by the action of swift current or by waves, anchorage is compromised. Erosion also occurs during and after heavy rainfall, when rainfall intensity, duration, and accumulation exceeds the soil infiltration rate (capacity of the soil to absorb water). The result is high runoff, sheet, rill or gully erosion, and often root undermining. The result of extreme undermining is tree failure from insufficient anchorage.

Severed roots act as infection courts or entrance points for decay fungi. They are also commonly associated with road-building and trail-building activities. Many of the fungi that can enter at these points of injury will cause root and butt decay in the future which will eventually predispose trees to windthrow or other type of failure (Figure 26). Other activities that are associated with severed roots are tent pad construction or ditching to divert runoff in areas where tents are routinely pitched, building

Figure 25

Figure 26

construction, and excavation for placement or repair of water or sewage lines or toilet facilities. While severing roots is not often immediately hazardous, it is always detrimental in the long run, and it should be avoided as much as possible. In addition to providing anchorage and support, roots are essential for water and nutrient uptake. Significant reductions in root system uptake and translocation capacity by root severing, diminish tree vigor and resistance to attacks by bark beetles and root disease pathogens.

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 breakage of roots. Soil saturation is a leading factor in windthrow of shallow-rooted species, or of any species growing in high density or in shallow soil. Indicators of root damage include:

1) trees with newly developed or newly accentuated leans **(Figure** 27), soil and litter are not in contact with the base of the tree on the side away from the lean (there is a conspicuous gap), and

Figure 27

Figure 28

2) cracks, mounds, or ridges of recently heaved sOil adjacent to major lateral roots (Figure 28).

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 In all probability developed additional, often stronger, anchorage In the portion of the root system previously wrenched These older leaning trees have also been exposed to years or decades of high Winds and severe weather following the event that caused their Initial lean, and have In a sense proved that the root system has re-established ItS ability to hold the tree wlndflrm Trees with older leans should not be considered hazardous based upon their degree of lean alone They should be evaluated based upon

1) the length of time standing since the last partial failure;

2) the initial cause(s) of failure;

3) the current defect status; and

4) any new evidence of root breakage and leaning.

Roots of trees located in heavily used areas, frequently become exposed to the air, and are subsequently damaged. This is particularly true in areas where tents are routinely pitched, adjacent to fire rings **(Figures 29-30),** barbecue pits, picnic tables, or in any area where protruding roots are an inconvenience to users, as on hiking trails where roots may cause hikers to trip and stumble.

Figure 29

Figure 30

**Bole Defects**

Bole defects are responsible for more than one-third of the tree failures in recreation areas (Table 1). Common bole defects include heartrots, saprots, cracks, splits, dwarf mistletoe swellings, fungal cankers, flattened boles, and acute branch or main stem crotches.

**Heart** rots are most damaging to mature and overmature trees, regardless of their size. The extent of defect is best correlated with age not with diameter. Most of the damage associated with heartrotting fungi in conifers will occur in trees that are more than 140 or 150 years of age. Many of the fungi that cause decay to the heartwood gain access through wounds

Figure 31

caused by man, animals, fire, lightning, snow or high winds, bark beetles, other agents, and commonly branch stubs. Scars, conks, mushrooms, punk knots, swollen knots, old snow breaks, crook, shake, frost cracks, wetwood, bole flattenings or depressions, all provide some evidence of internal defect.

In most cases, when heartrot is so extensive within the bole of a tree as to be hazardous, it can be detected by conks, punk knots, and other indicators **(Figure** 31). Heartrots 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 when decay of the heartwood is so substantial that conk production has subsided, or in dry habitat types where conks are rarely or not regularly produced. Trees that are suspect can be evaluated for the presence of heartrot by several methods. Sounding the stem by striking the tree at breast height or higher with the butt of a cruising axe, will often reveal a hollow. To use this method, though, the examiner must develop an ear for recognizing the sound of a hollow, and thick bark species are often difficult to sound. Additionally, detection of a hollow does not mean that the affected tree is a serious hazard to personal safety. To confirm the structural integrity of the suspected tree, the examiner must bore into the tree at the point of defect, either with an increment corer, or a cordless drill, and determine the thickness of the remaining rind of sound wood. Refer to Table 2 for the relationship of safe rind thickness to DBH.

If the suspected defect is well above ground, trees must either be climbed and drilled, or drilled from the bucket of a "cherry-picker" or boom-truck. These later methods of examination are very costly and impractical, and will more than likely not be implemented. This brings to light an important set of risks that should be carefully considered by the examiner and presented to decision makers. Trees that are large and mature or overmature will routinely have the greatest amount of heartrot. Some of that defect will be hidden and inaccessible to the examiner by conventional means of evaluation. Risks associated with defects that have been identified but not evaluated, or that are suspected (based on detection clues) but not clearly identified, should be carefully considered. When the potential risks are considered unacceptable in the event that hazardous levels of defect (heartrot) do exist, the potential hazard should be mitigated or more thoroughly investigated, but never ignored.

Empirical data indicate that a conifer can lose approximately 70 percent of the total diameter inside bark to decay (which is equivalent to about 1/3 of its strength or resistance to failure) without increasing the level of hazard, as long as the internal defect is heartrot uncomplicated by other defects (Wagener 1963). Failure potential of trees with heartrots is directly related to trunk diameter and thickness of sound wood at the point of greatest decay development. If the shell of sound wood is thinner than the thickness displayed in Table 2 for a comparable trunk diameter, the hazard should be mitigated. These guidelines are adequately buffered; further buffering is not warranted.

Figure 32

Trees with cavities opening to the outside have a much greater failure potential than trees having equivalent rinds of sound wood but no open cavities. A hollow tree with an open cavity should be treated if the shell thickness at its thinnest point meets or is below the suggested standard for the DBH (Figure 32). Minimum safe rind (shell) thickness should be increased by at least 25 percent for hollow trees with open wounds.

The rate of radial growth affects future shell thickness. If growth rate is rapid, strength loss from advancing decay will be offset or perhaps negated by the added strength of new wood. The condition of callus growth around wounds is an indicator of health and tree vigor. Vigorous callus activity (abundant new wood and wound parenchyma produced over wounds), emergence of a new cambial region and a thin, healthy, new bark indicate rapid growth.

The principal heartrots that will be encountered in evaluations of developed sites are:

| Common Name | Scientific Name | Major Conifer Hosts |
|---|---|---|
| Rust-Red Stringy Rot | *Echinodontium tinctorium* (ECTI) | true firs, hemlocks |
| Red Ring Rot | *Phellinus pini* (PHPI) | pines, ES, OF, WL, true firs, hemlocks |
| Brown Trunk Rot | *Fomitopsis officinalis* (FOOF) | OF, WL, pines |
| Redcedar Pencil Rot | *Oligoporus sericeomollis* (OLSE) | WRC, true firs |
| Incense Cedar Pecky Rot | *Oligoporus amarus* (OLAM) | incense cedar |

These heartrots and numerous others are described in the "Timber Cruiser's Field Guide to Estimating Damages and Defects of Pacific Northwest Conifers" (in press) in the section on Stem Decays. The amount of defect associated with each indicator, and detection hints are given for each pathogen.

Rust-red stringy rot, caused by the Indian Paint Fungus, is the most damaging heartrot of mature true firs and hemlocks, though trees are infected when they are young and have been suppressed for a number of decades. When this defect is found in trees in developed sites, hazard must be mitigated. All trees with conks or obvious punk knots should be removed immediately or the hazard should be otherwise mitigated. Trees with no more than a single conk on average have as much as 40 feet of continuous decay in them.

Trees are infected at a relatively early age through tiny (0.5 mm) dead branch let stubs presumably via the old vascular traces. Thereafter the fungus becomes dormant until re-activated by tree injury in later life. Infected saplings and poles are often released from their suppressed condition and they resume vigorous radial growth often encasing dormant infections in heartwood. Following re-activation of the dormant infection by injury near to the point of original infection, heartwood is rapidly decayed.

When decay is advanced, large, hoof-shaped conks with a spiny lower surface are produced. 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. Conks appear on the bole at the site of old branches (Figure 33). Where conks appear at several old branch whorls, greater defect is indicated.

The following are standardized cull rules established to aid timber cruisers in estimating the extent of defect associated with conks of this fungus.

*Rules used to identify the extent of defect on the OLY, MBS, MTH, SIU, WIL, and the eastside NF's of Oregon and Washington:*

*DBH* $<$ 19 *inches;* 18 *feet above and below conks;*

*DBH* = 19 *inches to* 26.9 *inches;* 20 *feet above,* 18 *feet below conks;*

*DBH* = 27 *inches to* 34.9 *inches;* 20 *feet above,* 21 *feet below conks;*

*DBH>* 34.9 *inches;* 20 *feet above,* 22 *feet below conks.*

Figure 33

*Rules used to identify the extent of defect on the ROR, UMP, and SIS NFs:*

*Single small conk, young tree, defect is 8 feet above/below conk;*

*Lowest conk 0 to 32 feet from the ground, defect is 12 feet below the lowest conk, 21 feet above the highest conk;*

*Lowest conk> 32 feet above the ground, defect is 20 feet below the lowest conk, 21 feet above the highest conk;*

*Conks in the bottom one-third of the merchantable length, defect runs throughout the bottom and middle thirds;*

*Conks in the top one-third of the merchantable length, defect runs throughout the top and middle thirds;*

*Where two conks are separated by more than 25 feet, the entire tree is defective.*

Red ring rot is the most common heartrot 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. Empirical evidence suggests that branch stubs are the likely entrance point for infections by wind borne spores. Conks are hoof-shaped with cinnamon-brown to tan pore surfaces. 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. 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 (Figure 34). Unlike many forest diseases, there is some good evidence to suggest that dominant and codominant trees will more likely be host to this disease.

When this decay is encountered in developed sites it must be evaluated carefully. The fungus which causes the red ring rot defect produces a white pocket rot when decay is advanced. Unlike many others, wood decayed by this pathogen maintains some strength against failure. When

Figure 34

trees have many large conks, the hazard evaluator can be sure that damage to the heartwood is extensive. With few or single conks, affected trees may have adequate strength to withstand high wind forces. If an evaluator suspects that a tree is marginally safe based on indicators, the evaluation of potential for damage, target value, and alternative hazard mitigation strategies must direct the course of the hazard management decision. Where damage potential and target value are high, the evaluator must either evaluate the thickness of rind at the point of greatest defect (and find it sufficient) or remove the hazard.

*Rules used to identify the extent of defect on the OLY, MBS, GIP, MTH, SIU, WIL, ROR, UMP, SIS NFs:*
*For Douglas-fir (west of the Cascade crest):*

> *Trees < 125-years-old: with conks, defect warrants periodic evaluation;*
>
> *Trees 125- to 150-years-old: defect extends 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;*
>
> *Trees 151- to 200-years-old: defect extends 10-feet above/below conks (punk knots), 5-feet above/below swollen knots;*
>
> *Trees 201- to 250-years-old: defect extends 13-feet above/below conks (punk knots), 7-feet above/below swollen knots;*
>
> *Trees 251- to 300-years-old: defect extends 18-feet above/below conks (punk knots), 9-feet above/below swollen knots;*
>
> *Trees 301- to 350-years-old: defect extends 22-feet above/below conks (punk knots), 11-feet above/below swollen knots.*

*For old growth western hemlock and true firs (> 125-years):*

> *Trees with single conk: defect extends 8-feet above/below; 4-feet above/below swollen knots when accompanying conks;*
>
> *Trees with multiple conks: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots.*

*Rules used to identify the extent of defect on the OKA, WEN, COL, DES, OCH, FRE, WIN, WAlAI, UMA, MAL NFs:*
*For ponderosa pine, western larch, Douglas-fir (eastside):*

> *Trees < 125-years-old: defect extends 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;*
>
> *Trees 125- to 200-years-old: defect extends 8-feet above/below conks (punk knots), 4-feet above/below swollen knots;*
>
> *Trees 201- to 250-years-old: defect extends 12-feet above/below conks (punk knots), 6-feet above/below swollen knots;*
>
> *Trees 251- to 300-years-old: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots;*
>
> *Trees 301- to 350-years-old: defect extends 20-feet above/below conks (punk knots), 10-feet above/below swollen knots;*
>
> *Trees> 350-years-old: defect extends 24-feet above/below conks (punk knots), 12-feet above/below swollen knots.*

*Rules used to identify the extent of defect on the OKA, WEN, COL, DES, OCH, FRE, WIN, WAlAI, UMA, MAL NFs:*
*For true firs, hemlocks, and spruces:*

> *Trees <200-years-old: defect extends 8-feet above/below conks (punk knots), 4-feet above/below swollen knots;*
>
> *Trees 200-years and older: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots.*

*For western white pine and sugar pine:*

> *Trees <200-years-old: defect extends 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;*
>
> *Trees 200-years and older: defect extends 8-feet above/below conks (punk knots), 4-feet above/below swollen knots.*

Red ring rot is more *severely* damaging *moving* south in Oregon, in older stands, in pure stands of host trees, on steep slopes, on shallow soils, and on sites predominated by secondary shrub, herb, forb *vegetation (vine* maple, vanillaleaf, oxalis, or rose rather than salal, twinflower, or rhododendron).

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 limbconks 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 is caused by the quinine conk or the chalky fungus. Damage is *severe* stem decay occurring either as a toprot when it has entered a broken top, or as a heartrot 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 fir scars. The *advanced* decay is a yellow brown to reddish brown to purple brown cubical rot. It is crumbly with large brown cubical chunks, and mycelial felts are conspicuous in shrinkage cracks that form in the cubical decay.

Felts may be one quarter inch thick and may extend several feet in length in one continuous sheet. Mycelial felts are bitter to the taste and resinous pockets or crusts are formed throughout their length. The incipient stain is yellow green to brownish green (very similar to that of the brown cubical butt rot). The coloration of incipient stain in ponderosa pine is reddish brown or brown.

*Rules used to identify the extent of defect on all NFs:*

> *Live trees with conk(s) above 50-feet: the top half (length not volume) of the existing tree is defective;*
>
> *Live trees with conk(s) below 50-feet: the entire tree should be considered highly defective.*

Conks are rare but unmistakable. They are hard, perennial, hoof-shaped to pendulous, and often quite large. 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 exudate that stains the bark below.

Redcedar pencil rot is a severe stem decay and butt rot of western redcedar and occasionally true firs. In red cedar, decay is usually confined to the butt 40-feet of affected trees. The advanced decay is a brown cubical pocket rot. When decay is minor in affected stems, it appears as long thin pencils of brown cubical decay. As decay becomes more extensive, this pencil rotting is more abundant and these thin rot columns begin to coalesce. In severely damaged trees, most of the heartwood is decayed and pencil rotting is less obvious, but it can be observed at the outer margins of decay and at the upper reaches.

No cull rule is defined as yet for this decay. 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". Trees with evidence of a dry side should be sounded with a cruiser's axe and drilled 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 which hides from view 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. Evaluators should carry a cruiser's axe and sound the boles of suspicious trees for defect.

Incense cedar pecky 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. The advanced decay is a brown cubical pocket rot much the same as that o'ccurring in western red cedar with pencil rot. When decay is minor in affected stems, it appears as long thin pencils of brown cubical decay. As decay becomes more extensive, this pencil rotting is more abundant and these thin rot columns begin to coalesce. In severely damaged trees, most of the heartwood is decayed and pencil rotting is less obvious, but it can be observed at the outer margins of decay and at the upper reaches.

Conks occur rarely, but when they do they indicate a cull tree. Conks are annual, fruiting at knots in summer or autumn. They are hoof-shaped to half-bell shaped, tan to buff-colored on the upper surface, bright sulphur yellow on the underside (pore surface) with small tubes that exude clear drops of a sweet yellow liquid. 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> 40-inches DBH, and in trees with basal wounds or old dead limbs. In developed sites, incense cedar should be managed to a pathological rotation age which should not exceed 150 years.

Sap rots are defects unique to the sapwood. Most saprotting 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 which decay heartwood and they are seldom found past the heartwood/sapwood interface. In living trees, sap-rots occur on tissue killed by other agents, most often bark beetles, mechanical and weather damage. On dead trees, especially those killed by root diseases and/ or bark beetles, saprot 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 saprotting fungi to decay all of the available dead sapwood.

When trees are killed with a full complement of foliage, they normally develop saprot at a rapid rate. Trees killed by crowning fire, or trees with broken or blown tops exhibit delayed saprot development. In such trees, the level of xylem sap remains high and it rather quickly ferments, turning sour. Bark beetles will rarely attack such trees and the introduction of saprotting organisms will be delayed until bark splitting and sun checking or heart checking occurs. When bark beetles do attack them, breeding success is poor. In trees with soured sap, the succession of microorganisms and invertebrates is very different than that occurring in trees killed by bark beetles.

One of the most easily recognized of the sap rotting fungi and the most common, the pouch fungus *(Cryptoporus volvatus)* CRVO, is routinely carried by all major species of tree killing bark beetles (Scolytids). Most other sap rotting fungi infect their hosts via airborne spores through openings in the bark.

Hardwoods are also subject to saprotting and damage may be significant on live trees. As with conifers, saprotting 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 saprot are lacking, testing may be required. Saprot depth can be determined by using a cordless drill, increment borer, or axe. Hardwoods with saprot approaching half their circumference have a high failure potential.

Cracks and splits in the main stem frequently occur and they are often overlooked, or regarded as insignificant. Cracks usually tell an important story and may reveal to the examiner that a closer inspection of the heartwood is warranted. Cracks and splits are produced in a number of different ways; four of the most common are:

1) by tension and compression failure (often associated with older injuries and significant internal decay);

2) by lightning strike;

3) by wind shake; and

4) by frost action.

Cracks form by tension and compression failure when trees with extensive heartrot bend back and forth under the stress of high winds. The sound rind on the windward side of affected trees is under great tension when winds are strongest. The side of the tree to the lee of the wind becomes compressed by that same wind force. This difference in forces when most exaggerated, creates a shearing action in the middle of the bole where the two forces meet, and the bole develops a vertical crack somewhere between the ground and where the extent of heartrot is the greatest.

Figure 35

Cracks form by lightning strike (Figure 35) when violent electrical discharges are grounded with the atmosphere through trees. Damage to trees can be highly variable, ranging from shallow spiralling 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 windfirmness. Occasionally, entire trees or portions will be shattered, severely cracked, or split. On the other end of the spectrum, groups of trees may be synchronously killed by lightning without any apparent evidence of damage. 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.

Figure 36

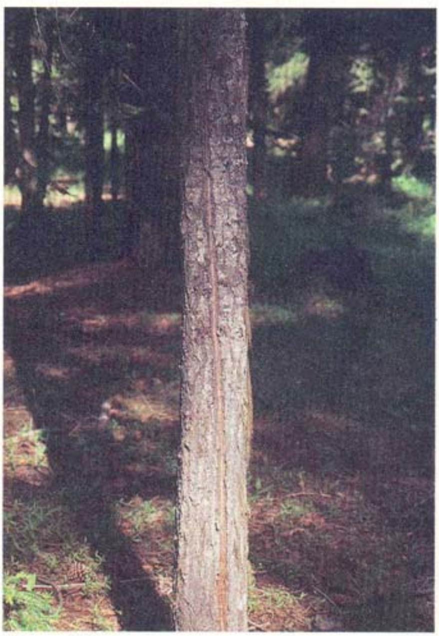


Figure 37

Figure 38

Cracks form **by wind shake** especially at higher elevations. High winds regularly impact conifer forests and winds are often turbulent, twisting trees this way and that. Under the influence of frequent high winds trees often develop shake in the bottommost 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 radially outward toward the bark **(Figure 36).** 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

Figure 39

Figure 40

associated with increasing butt rot. Wind shake cracks also incite dormant Indian Paint Fungus infections *(E. tinctorium)* to active decay.

Cracks form by the action of extreme cold. Frost cracks, also common at higher elevations, appear on bark as raised nearly vertical callus lines which extend to the ground where frosty air is coldest (Figure 37-38). 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 extracellular 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".

Dwarf mistletoe bole swellings are caused by systemic dwarf mistletoe infection of the bole. They are especially common on grand and white fir, western hemlock, and occasionally western larch (Figure 39). 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 by other opportunistic fungi begins to weaken the tree. Any of the fungi which 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.

Fungus cankers caused by Atropellis spp. frequently occur on the boles of

Figure 41

Figure 42

pine species, 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 from what would have been the normal circumference at that point (Figures 40-41). When the width of cankers approaches half the circumference of the stem, and the depressions are deep, failure potential is high.

Cankers caused by other fungal species, are occasionally found on conifers and should be probed to determine if decayed wood is present. Cankers also occur on hardwoods and are frequently associated with internal decay. These should also be drilled to determine their depth of sound rind.

Bole flattening is often caused when wood or steel cross-arms, attached to trees "temporarily" to support utility lines, buildings, or hang big game have been in place for many years. Wires or cables around boles also deform and weaken trees (Figure 42). As with cankers, if dead or rotten portions approach half the circumference of the bole and depressions are deep,

Figure 43

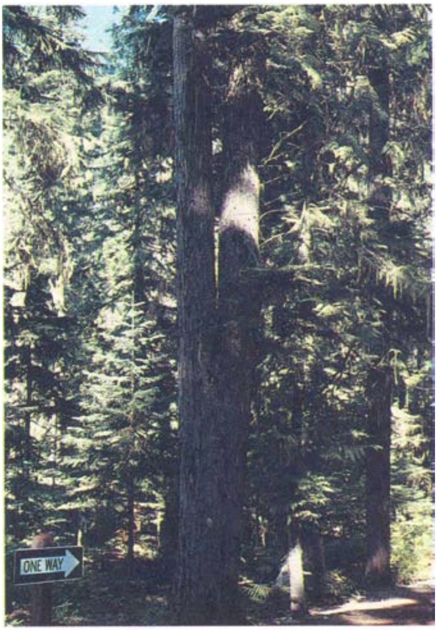



Figure 44

failure potential is high. A few reported tree failures *have* been attributed to bole flattening.

Crotches that are tightly V-shaped, can split and break from the green weight of foliage, *heavy* snow loads, or internal decay (Figure 43). Since a broad angled branch connection was not differentiated at the time the branch first formed, new radial growth at the point of branch *convergence* forces the acute angle further apart. Eventually, new radial growth will weaken the crotch to such a point that wind or snow load, or the added weight of new foliage causes a branch failure. This not only occurs in mature forked conifers, but also in conifers with *severe* ramicorn branching and hardwoods with large, spreading crowns. Tree crotches should be should be regularly examined (often with binoculars) for cracks, splits, and callus ridges which suggest weakening and predisposition to failure or infection by decay fungi. Mushrooms and/or conks associated with crotches indicate internal decay (Figure 44). Pitch streaming below crotches may indicate partial failure.

Defective Limbs

Hazards associated with *defective* limbs are often exaggerated (Figure 45). The incidence of failure in this category is lowest of any listed in Table 1. Table 1 does not indicate the magnitude of personal loss associated with

Figure 45

Figure 46

limb failures, but personal injury and property damage are usually less serious than that associated with trees that fail at the roots, butt, or bole. *Defective* limbs fall essentially straight down from the point of failure, and their impact area is considerably smaller than that of a tree failing at the roots, butt or bole. While failure probability is low for attached defective limbs, free-hanging limbs should be *removed* immediately if they hang *over* stationary or transitory targets (Figure 46).

Hardwoods especially poplars, maples, and alders, are more susceptible to limb failure than most conifers because their crotches are structurally weaker, the lignin content of the wood is low by comparison, and their long branches are heavily weighted at the extremities with green foliage and fruit. Additionally, heartrots of hardwoods often extend into major limbs creating higher 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.

Massive dwarf mistletoe brooms hanging directly *over* stationary targets of


Figure 47

value or over areas that are routinely exposed to heavy transitory traffic should be removed by pruning (Figure 47). In areas of normally high snow loading or violent winter storms, this hazard is often self-correcting. Brooms with a high failure probability will usually fail when sites are closed or visitor use is limited. Pruning of large brooms often temporarily improves the vigor of infected trees although it will not eliminate the infection. Candidates for pruning are those with dwarf mistletoe infection concentrated in brooms in the lower one-third to one-half of the live crown, and whose live crown ratios after pruning will continue to be 40 percent or more.

Each year, winter storms blow through developed site vegetation often causing failure of the most defective limbs. Severe storms have a sanitizing effect in an overstory that holds many defective limbs; few remain that are defective enough to fail during the next year under their own weight. This sanitation effect is especially common in the upper elevations. At lower elevations, severe storms may be less frequent, or different in kind or abundance, and heavy snow loads may be infrequent or may not occur at all. To illustrate, failure of a massive limb of a large maple at a developed site occurred one spring when newly unfurled leaves collected dew on a windless evening, and the combined weight of new leaves and dew was sufficient to cause failure. This tree had not been subjected to severe weather or snow loading, and failed with the first prompting. Other evidence suggests that failure can occur when water movement into branches associated with evapotranspiration, exceeds the strength threshold of weak branches.

Hazardous, defective limbs are usually treated by removal. Candidates for this treatment are dead, broken, or free hanging limbs (completely loose and lodged), or heavy dwarf mistletoe broomed limbs that are above permanent targets or heavily used areas. Trees in need of treatment are climbed and pruned as needed. Some success has been reported using another pruning technique which eliminates climbing. A line is shot over the distal end of defective limbs via a crossbow or compound bow, and both ends of the line are pulled downward in a sharp movement, thereby breaking off and removing that portion most prone to failure. If the limb does not break readily with pulling, it is unlikely to fail within the coming visitor use season. Smaller limbs have been removed with a high powered rifle slug by other site managers.

Pruning of live branches should be done with care to avoid excessive wounding and decay. At the junction of the main stem and branch, both coniferous and hardwood trees exhibit a folding of bark tissue that is called the branch collar. This collar is important in the production of a barrier zone of cells that wall-off tissues damaged by wounding and reduce the potential for decay. Pruning cuts should be made just outside this collar by one-half to one-inch. A longer stub is a more suitable entrance court for decay fungi and it is less readily overgrown by callus tissues in the healing process.

Wound dressings on pruning cuts or other wounds are not only unnecessary, but may even be detrimental. Dressings act as a moisture barrier, maintaining for longer periods, a suitable environment for decay. Pruning is best done in the late fall and winter when trees are fully dormant. In the intervening months before spring, wounds dry out or sublime, and trees are better able to wall off the point of attachment of the branch stub from the rest of the branch.

The following guidelines can be used to determine treatment needs for defective limbs. Treat dead limbs that meet all listed conditions.

Dead conifer limbs:

1) decay, cracks, splits, woodpecker holes, or insect activity are present;
2) limb is 3 inches or more in diameter one foot from the bole, and 6 feet or more in length;
3) limb is free hanging, 2 inches or more in diameter, and 2 feet or more in length;
4) there is a high probability that the limb will strike a valuable target.

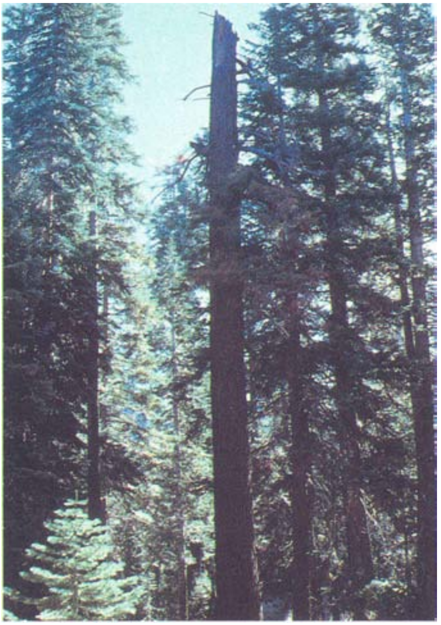
Dead hardwood limbs:

1) limb is 2 inches or more in diameter and 4 feet or more in length;
2) limb is free hanging, 2 inches or more in diameter, and 2 feet or more in length;
3) there is a high probability that the limb will strike a valuable target.

Dead Tops

Dead tops on live trees eventually break out and fall to the ground (Figure 48). See Table 3 in Appendix C for failure potentials of dead tops of Pacific Northwest conifers. Before tops break out they often rot in place and are held by little or no sound wood. A gentle bumping or jarring of a topkilled tree may send the top hurling to the ground. In developed sites, trees with dead, highly defective tops, are often jarred by people or their vehicles, and they and their property are in the impact zone immediately after the jarring. When dead tops are encountered in developed sites, hazard should be assessed immediately. Unacceptable hazards should be mitigated.

The failure potential of dead tops in incense cedar, western redcedar, ponderosa pines with comandra rust topkill, 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 a high hazard. 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



Broken Tops

Trees with old broken tops may have rot present below the break (Figure 49). 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, though trees with tops broken out should be monitored regularly. The potential that new tops arising from upturned lateral branches will fail, is also low unless indications of internal defect are evident.

Leaning Trees

Leaning trees result from root and butt decay, and from high winds that cause root wrenching. Tree leans are either recent or longstanding. All leaning trees should be examined for evidence of severe root and butt rot. Longstanding leaned trees are those that are leaned over and have subsequently grown a vertical top in the time since the lean occurred (Figure 50). 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.

Recently leaned trees are tilted over their entire length (Figure 51). Since there is no evidence of subsequent reinforcement of the root system,

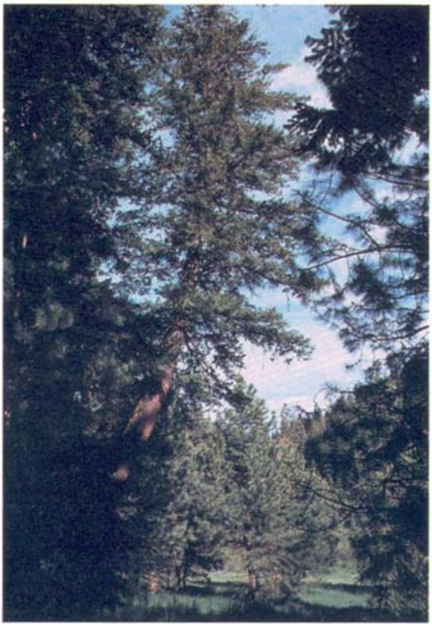


Figure 50

Figure 51

Figure 52

examiners must assume that such partially failed trees exhibit a high potential for failure. Hazard associated with recently leaned trees should be addressed immediately.

## Multiple Defects

Trees are often encountered with multiple defects. The potential for tree failure increases dramatically with the combined effects of multiple defects.

Some examples of multiple defects that indicate increased potential for failure are:

1) heart rot and cankers or stem injury;

2) root rot and lean;

3) split crotches and heart rot; or

4) wind shake and butt rot.

### Dead Trees

Dead trees are among those most likely to fail (Figure 52). While some dead trees remain standing for decades, it is virtually impossible to distinguish these from trees which will fail at any time. To verify, with high confidence, that a snag will remain standing, an examiner must excavate the root system to determine the extent of root and butt decay. The stem must also be evaluated with similar care to determine that adequate sapwood and heartwood exist to support the tree. Since saprot develops quickly and the outer rind of wood is most essential to withstand high winds, this stem evaluation would be required annually. When dead trees are encountered in developed sites they should be removed immediately. Snag management for cavity excavators and secondary cavity using birds and mammals is usually in conflict with maintaining an acceptable standard of safety for invited recreationists.

# Chapter 6

## Hazard Tree Management

Ideally, hazard tree management begins before there is a final decision on where to locate a proposed developed site. A thorough hazard evaluation of proposed sites prior to capital investment, reveals the prudence and feasibility of establishing the site, and it alerts managers to problems prior to the investment of scarce resources. Prior examination of old growth sites is particularly important because of the predictable decadence of these sites.

Old-growth stands, while more aesthetically appealing, are less well suited to developed site recreation. Not only is defect more abundant, but when old-growth stands are opened to establish access, parking, permanent camping spots, and structures, the probability of windthrow will likely increase, and continue increasing with each repeated salvage or hazard removal entry. Young thrifty stands are more windfirm, and they respond better and more rapidly to spacing entries. Trees readily re-establish windfirmness, and they resist repeated attacks of insects, diseases, and the damaged caused by visitors until they reach their pathological rotation age.

The best time to prepare a complete vegetation management plan is after an informed decision is made to develop a site. This plan should include a stem map and information on the condition of each tree within striking distance of proposed stationary or moving targets. With this information in hand, the landscape architect can finalize designs, taking advantage of openings where hazardous trees will be removed. If it is desirable that the stand be opened in certain areas to introduce more light, or increase variety or visibility, trees with varying degrees of hazard can be prioritized for removal, and treatment can occur during the construction phase.

## Hazard Tree Treatment

If a vegetation management plan has not been developed prior to establishing a developed site, hazard management will most likely be reactive rather than proactive. In these situations, creativity is important in treating hazardous trees. Removal is usually the least desirable option. If the component value (the character value, scenic value, historic value etc.) of a defective tree is high enough, moving a valuable target may be the preferred option. Topping to reduce the overall height (length of the moment arm), weight of the crown, and resistance to wind, may be enough to provide a manager the years needed to establish and grow replacement trees. Sometimes tree topping to leave only a relatively short stem bearing a few live branches to keep it alive, is sufficient to reduce hazard and maintain visual appeal. Even shortened trees like these disappear into the canopy and appear quite natural.

Some hazardous trees can be treated without their removal. Others must be removed. Trees affected by root diseases and standing dead trees fall into this latter category (see Table 5 in Appendix C for a matrix of treatment options by category of damage). Since resistance to failure is related to the amount of sound wood remaining in the butt and stem, many trees with butt defects do not require immediate treatment, but must be monitored if they are retained. Treatment will be required at some time in the future.

Defective trees that present an acceptable amount of hazard in the current year, should be monitored at regular intervals to track intensification of the hazards.

When it is recognized that a highly defective tree poses an unacceptable hazard, its value as a component of the whole site (component value) should be assessed before choosing a treatment alternative. A method for determining that aesthetic value is described below:

1 = NEGATIVE VALUE. The tree is unsightly and it detracts from visual quality; produces a spiny or smelly fruit in areas where visitors are prone to walk barefooted; produces copious sap

2 = MINOR VALUE. Adds marginally to aesthetic or visual quality

3 = ADDS TO COMPOSITE VALUE. Adds appreciable value when considered along with other trees, but does not make a significant individual contribution

4 = HIGH VALUE. Site loses significant value with loss of the individual tree; tree has historic value, scientific value

The higher the component value of a tree recommended for treatment, the more appropriate the selection of treatment alternatives to removal. Alternatives to removal that are worthy of consideration are topping, pruning, fencing off hazardous areas, tree guying, supporting (bracing or pinning), relocating targets, hazardous area or full site closure during hazardous weather conditions, and seasonal site closures. Since the goal of hazard management is risk reduction to acceptable levels, the least disruptive treatment method that will accomplish this goal while supporting the 10Ag range vegetation management goals, is the preferred method.

It is important to avoid creating new hazards while treating others. For example:

a) prune off defective limbs properly to avoid future stem decay;

b) when removing true firs, hemlocks, and ponderosa pine (on dry sites), be sure to treat the newly made stumps with borax to reduce the potential for HEAN colonization;

c) during construction and rehabilitation activities, avoid damaging tree boles and roots to prevent future decay and associated hazards.

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## Glossary

Algorithm - step-by-step computational procedure for *solving* a mathematical problem.

Azimuth - a compass reading in degrees going from $0^{o}$ (north) to $359^{o}$.

Basal wound - a wound to the base of a tree.

Bole - a tree stem once it has grown to a caliper sufficient to yield logs.

Broom - an abnormal clustering of branches associated with infection by dwarf mistletoes, conifer rust pathogens, genetic aberrations,and other insect and/or disease damages.

Butt log - the basal log of a tree extending up to 40 feet in length.

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

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, which may or may not *overgrow* an injured area.

Canker - a definitive 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 - the biotic or abiotic influence most highly correlated with the symptoms.

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

Chlorosis - an abnormal yellowing of foliage.

Climax forest - the last stage of natural forest succession.

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

Conk - a shelving reproductive structure of many wood decay fungi.

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.

Cull Tree - one that is so highly defective as to be lacking in commercial *value;* a tree that is decayed along most of the bole length.

DBH - the diameter of a tree at breast height; breast height is defined at 4 1/2 feet *above* the ground on the uphill side of any tree.

Decay - biodegradation or decomposition by fungi and other micro-organisms resulting in the progressive loss of integrity and strength of affected parts.

Defect - any feature, fault, or flaw that lowers the strength, integrity, or utility of an affected part; wood decay fungi cause defects.

Delaminate - to separate into sheets as with the pages of a book; wood delaminates at the growth rings.

Drip line - the maximum radial extension of the tree crown projected to the ground.

Ectotrophic mycelium - mycelium found on the outside of the bark.

Empirical data - data gathered from observation.

Exudate - matter that has oozed out.

Failure - partial or total collapse of a tree or tree part.

Frost ribs - parallel ridges of callus which form on either side of frost cracks which are repeatedly (often annually) aggravated by extreme cold.

Frost cracks - splitting of the outer bark and sapwood which occurs to the butts of trees subjected to extreme cold; such fissures follow the grain and are usually superficial.

Fruiting body - conk, mushroom, or other fungal reproductive structure.

Fungal thallus - the entire assimilative phase of the individual.

Gall - a pronounced swelling or tumor-like body produced on trees parasitized by certain fungi or bacteria, or infested by gall-forming insects. Galls are abnormal proliferations of tissues used by the parasite.

Hazard tree - any tree that is within striking distance of a permanent or transitory object of value.

Hazard - the real potential for tree failure; conditions conducive of failure.

Heartrot - Decay restricted to the heartwood.

Highly defective - trees or tree parts which possess such substantial decay or defect that they are likely to fail.

Hypha - a single, microscopic, thread-like filament made up of fungal cells.

Incipient stain/decay - early stages.

Inoculum - spores or tissue of a pathogen that serves to initiate disease.

Large tree parts - branches, tree tops, and portions of the main stem which are greater than 6 inches in diameter.

Medium tree parts - branches, tree tops, and portions of the main stem which are 2-6 inches in diameter.

Mesic - requiring a moderate amount of moisture.

Minor defect - defect that does not alter the structural integrity of a tree or tree part in any significant way.

Moderate defect - defect that certainly reduces the structural integrity of trees or tree parts but does not render them in immediate danger of failure. Trees with moderate defect should be monitored.

Modulus of rupture - a measure of resistance to bending under applied force; the force at which failure occurs under a static bending load.

Moment arm - the product of force and the distance to an axis or point.

Mycelial felt - a dense and expansive mycelium which takes the form of a thick sheet.

Mycelium - a mass of hyphae or fungal filaments.

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

Parenchyma - the soft tissue of higher plants commonly used for food storage.

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

Plant association - a system of classifying plant communities to reveal site potentials.

Pores - small holes in the undersurface of conks and some mushrooms from which spores (microscopic reproductive propagules of fungi) emanate.

Prophylactic treatment - treatment to reduce potential of infection or infestation.

Punk knots - a protruding and unhealed (bark may not encase the knot) knot of a tree with heartrot; the knot interior contains highly decayed wood which resembles the interior of the conk of the causal agent.

Ramicorn - acute branch angle.

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

Rhizomorph - a thread-like or cord-like fungal structure made up strands of hyphae that are covered with a protective rind; rhizomorphs look like roots but they are an extension of a fungus in search of live or dead host parts (usually roots or wood).

Rind - the shell of solid wood surrounding a decay column in a tree.

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

Root crown - the region where the root system joins the bole.

Setal hypha - a thick-walled reddish-brown hypha that tapers to a point; they are microscopic and are found in the interior of, and projecting into the pores of certain conks; only found in laminated advanced decay associated with laminated root rot.

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

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

Slime flux - the fermented exudates of bacteria and/or yeasts which have colonized the sapwood adjacent to an older wound or scar; these exudates indicate the location of an old injury and a prior entrance court for decay fungi.

Small tree parts - branches, tree tops, and portions of the main stem which are less than 2 inches in diameter.

Snag - a standing dead tree which is more than 20 feet tall.

Spores - microscopic reproductive propagules of fungi (and other cryptogams).

Stem - the main trunk or central stalk of a plant (tree).

Stromatal flecks - a dense mass of vegetative hyphae often covered by a dark rind.

Stub - a snag that is less than 20 feet tall.

Symptoms - the outward manifestations of disease in a host.

Target - person or object within striking distance of a tree.

Tensile strength - a measure of resistance of a body to tensile loading; the force at which failure occurs under a tensile load.

Topping - removal of some of the upper crown of a tree.

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

Very small tree parts - tree leaves, small twigs, and fruit.

Xylem - water conducting tissue.

# Appendix A

## Beaufort's Description of Wind Effects

| | mph | knots | |
|---|---|---|---|
| | 200 | 174 | Tornadoes; complete destruction of structures |
| | 100 | 87 | |
| | 90 | 78 | |
| Hurricane | 80 | 70 | Very rarely experienced; accompanied by great damage |
| Storm | 70 | 61 | |
| Whole gale | 60 | 52 | Seldom experienced inland; trees uprooted; considerable structural damage |
| Strong gale | 50 | 43 | Slight structural damage (chimney pots and slate removed) |
| Fresh gale | 40 | 35 | Twigs broken off trees; impedes progress Whole trees in motion; inconvenience felt when walking against the wind. |
| Moderate gale | 30 | 26 | Needles and small branches (2-6 in. long) fly in the air |
| Strong breeze | | | Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty |
| Fresh breeze | 20 | 17 | Small trees in leaf begin to sway; crested wavelets form on inland waters |
| Moderate breeze | | | Dust and loose paper raised; small branches move |
| Gentle breeze | 10 | 9 | Lvs. and sm. twigs in const. motion; lt. flag extended. |
| | | | Wind felt on face; lvs. rustle; ordinary vane moved |
| Light breeze | | | Direction shown by smoke drift but not by wind vanes |
| Light air | | | |
| Calm | 0 | 0 | Calm; smoke rises vertically |

# Tree Record Form (TRF1-91)

Recreation site ______________________________

Tree number ________ Tree species ________ Date first recorded ________

Reference point ________ Distance ________ ft. Azimuth ________ degrees true

| Date | DBH in. | Ht ft | Root1/ sympt | Root2/ cause | Butt3/ cause | Rind in. | Stem4/ defct | Stem5/ fungs | RiskRate6/ PF | PI | CV | Recom7/ treat | Treat date | Next exam | Exam init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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1/ REGR-reduced top growth; DETO-dead top; DEBR-dead branches; THCR-thinning crown; CHFO-chlorotic foliage.

2/ PHWE-laminated root rot; AROS-Armillaria root disease; HEAN-Annosus root disease; PHSC-brown cubical butt rot; MECH-mechanical injury; COMP-compaction; UNRO-undermined roots; briefly describe other.

3/ PHSC-brown cubical butt rot; HEAN-Annosus root disease; MECH-mechanical injury; ARSP-dwarf mistletoe canker; PEHA-western gall rust canker; WIND-wind caused cracking; briefly describe other.

4/ MECH-mechanical injury; LIST-lightening strike; FRCR-frost crack; FORK-forked stem; CROK-crook in stem; STCR-stress crack; SLFL-slime flux; ARSP-dwarf mistletoe canker; briefly describe other.

5/ PHPI-red ring rot; ECTI-rust red stringy rot; CANK-unknown canker; other.

6/ PF-probability of failure(1-4); PI-potential for target impact(1-4); CV-component value(1-4).

7/ TOPx-top tree (where x=height of remaining stem); PRUN-prune branches; MOTA-move target; EXVI-exclude visitors from target area; FELL-remove tree; GUYI-guying; SUPP-supporting; briefly describe other.

REMARKS: ______________________________

# Appendix B

Scoping and Analysis Phases of Expanded

In this section, we expand our discussion of Steps 1 to 8, the scoping and analysis phases of the NEPA process, initiated in Chapter 2.

STEP #1 - Reviewing the Forest Plan. The objective of this first step is to assess the contribution this vegetation management project makes to the accomplishment of Forest Plan and recreation program goals and objectives.

The District Ranger and District Recreation Staff review the Forest Plan and recreation program planning documents, paying special attention to Forest-wide and Management Area Standards and Guidelines and other direction applicable to the project area. District personnel assess how the project might be designed to conform to those Standards and Guidelines, constraints, and requirements of the law. They develop an initial list of potential project issues, opportunities, and public involvement needs (who is going to be concerned, who should participate, and to what degree), and assess the land area influenced by the proposed project. The influence area of the project should be well defined so that meaningful estimates of direct, indirect, and cumulative environmental effects can be made. The District Ranger provides input to the project by molding guidance from the Forest Plan into the form of a developing project concept. All of these elements need not take on any special formality, but each element should be addressed to avoid later redirection and wasted effort.

The products of Step 1 are:

1) a set of notes on emphasis items for the project; and
2) a set of notes on the project's potential contribution to attaining Forest Plan goals and objectives.

STEP #2 - Developing the Project Concept The objective of this step is to determine precisely what this project will be designed to accomplish and why.

Specific project goals are expressed in broad, general terms and are not intended to be quantifiable; the goals capture and identify the vision. In this step the Ranger and Staff work together to develop a clear concept of what the project should accomplish. They will identify the specific issues, interested and affected publics, and resource skills needed for the analysis. Once some of the major project issues have been identified, quantifiable project objectives (they should be measurable) can be developed to address the issues and achieve the project goals, and the public involvement process can be outlined and initiated. The need for quantifiable objectives cannot be overstated. Objectives are the way in which a vision is realized, and when not realized they constitute the diagnostic tools for understanding non-attainment and constructively redirecting efforts.

If Rangers identify a skill needed and not represented on their staff, they request the assistance of a specialist who can provide that skill.

The products of Step 2 are:

1) a list of project goals;

2) a list of issues;

3) a list of resource and subject matter skills needed;

4) a list of interested and affected publics;

5) a list of quantifiable objectives unique to this project; and

6) establishment of a project file.

**STEP** #3 - Conducting an Extensive Field Reconnaissance. The objective of this step is to visit the project area to determine whether the project concept will work. Several questions should be addressed in the field:

1) Is the list of issues complete?

2) Are other skills needed?

3) Have all interested and affected publics been identified?

4) Can project objectives be met?

5) rs the project a strong Forest Plan implementation action?

6) Can Forest Plan objectives be met, constraints, laws, and regulations conformed to, Management Area Standards upheld, and Management Guidelines incorporated?

7) Should the interdisciplinary team proceed to the next step?

Each resource and subject matter specialist identified in Step #2 has an important role to play in the extensive reconnaissance effort. It is also in this step where the real work of hazard tree evaluation and pest management begins. The silviculture, pathology, and entomology representatives on the project 10 team need to reconnoiter each of the stands in the project area by walk-through examination. Before going to the field, it is useful for them to review appropriate aerial photos, contour maps, transportation plans, stand exam printouts (if available), and other resource surveys. The product of the walk-through exam is a composite silviculture and pest management diagnosis for each site with the following components:

1) characterization of current site condition including species composition, stand age, structure, and size class distribution, successional position, fire and timber management history, and notes on desirable future condition;

2) characterization of current stand health and vigor including an assessment of current insect and disease impacts to each conifer and hardwood host and a relative damage severity ranking;

3) a silviculture diagnosis that incorporates all pest (insect, disease, animal, noxious weed, and human) management considerations that can exert a limiting influence on the management of that site; and

4) separate treatment priorities for pest management and silviculture, and a composite score for the site that answers the question of how important it is that we modify current vegetation conditions right now.

The products of Step 3 are:

1) notes on the field verification, additions, and deletions to the lists of critical issues, interested and affected publics, and project objectives;

2) recommendations for or against proceeding with the project analysis;

3) an appropriately scaled base map of the project planning area on a contour map, orthophoto, or GIS base showing known resource information, stand boundaries, archaeologic sites, critical soil and hydrologic areas;

4) notes on physical features, road locations and conditions, levels of defect, other resource needs or special information;

5) a preliminary transportation plan, including roads to be eliminated or closed temporarily, the existing road system, and locations of important views or special site features identified on the base map;

6) preliminary logging plan (if the vegetation management will be accomplished with some amount of logging) with notes on preferred logging system(s) and layout, whether the logging should be accomplished in a separate small sale or in the context of a larger sale, K-V opportunities; and

7) recommendation for completion of this project within an identified time frame.

**STEP** #4 - Preparing a Feasibility Report. The objective of this step is to prepare a brief report documenting the technical and economic feasibility of the project.

The feasibility report should record the results of the scoping effort that occurred In the previous steps and serve as a decision aid for making further project investments.

The product of Step 4 is:

1) an approved feasibility report containing the following elements:

   a) a project area location;

   b) pertinent information on lands adjacent to and within the project area;

   c) a list of potential project outputs;

   d) a list of critical project issues;

   e) a list of special skills needed;

   f) a statement of resource management objectives for the project;

   g) a brief economic assessment of project feasibility;

   h) a project development schedule;

   i) a project base map; and

   j) a statement documenting project consistency with Forest Plan and recreation program management objectives.

**STEP** #5 - Verifying that the Project is Appropriately Scheduled. The objective of this step is simply to verify that the project is on the Forest's schedule of things to accomplish.

The project should be listed on appropriate schedules such as the 5-year timber sale action plan, project work plan, and/or capital investment plans.

These schedules should then be incorporated into the 10-year implementation schedule.

The products of Step 5 are:

1) updated project action plans; and
2) an updated Forest Plan 10-year implementation schedule.

STEP #6 - Conducting an Intensive Reconnaissance. The objective of this step is to acquire all of the on-the-ground knowledge of the project planning area and its resources to design a project that fully addresses the issues, project objectives and other appropriate resource management objectives.

A thorough, intensive reconnaissance is essential to the development of plans with adequate depth and long-range aspect, and it is the most critical step in project development. In this step, sufficient on-the-ground knowledge is gained to design a project to its unique location and *objectives.* All of the site specific information needed for the project plan is collected during this step. Examples are:

1) a survey of visual resources (existing and potential), viewpoints, viewing angles, character trees, desired variety in vegetation texture and composition, spring and fall color opportunities with ground covers, shrubs, and trees;
2) relationship to identified wildlife habitats for viewing opportunities (existing or emerging);
3) location of roads, trails, railroad grades, and other rights-of-way;
4) location of streams, their classification and management standards, the location of ephemeral watercourses and periodic floodplains;
5) location of habitat elements for people such as edges, hiding or privacy screening, shade, windscreening, proximity to water, flat areas to camp, picnic, and congregate for social functions, openings for sunlight;
6) relationship of adjacent management allocations, and ownerships;
7) location of historic structures, and cultural resources;
8) survey of individual tree hazards including damaging agents, extent of damage, and recommended treatment or disposition.
9) survey of local plant or animal populations whose abundance or scarcity may exert a limiting or shaping influence on management of the site; and
10) survey of environmental and edaphic factors in and around the site that may exert a limiting or shaping influence on management of the site.

When ID team leaders or project initiators recognize that there is a resource problem that exceeds the team's skill level, they should request the assistance of appropriate resource or subject matter specialists. The project initiator should direct the specialists to the specific problem areas for which their input is needed. When there is conflicting input from various resource specialists, it is best to travel to the site or stand in dispute and resolve differences on the spot. This clarifies, for everyone, the specific conflicts, and allows the specialists to work with each other to arrive at acceptable trade-off recommendations or more reasonable *alternatives.* A single, integrated recommendation should be developed with the concurrence of all specialists *involved.* If *alternative* recommendations are offered, they should be team recommendations as well.

If concerned publics *have* specific problems with some elements of a project plan, one option would be to take them to the field to visit the problem area. There, team members can more readily come to an understanding of the specific concerns and work towards a solution.

The products of Step 6 are:

1) a nearly complete set of integrated *vegetation* management prescriptions with pest management and all other resource considerations which are limiting and are quite susceptible to alteration; activity unit or treatment unit boundaries are delimited on the ground incorporating all the important relationships to topographic features, roads, streams, and habitats in the layout; boundaries are actually flagged lines that are easily relocated;

2) designated ROS class including level of access, facilities, naturalness, management of the visitor, social encounters, visual impacts, and description of opportunities to be provided;

3) a transportation plan sufficient to access the site to the level of designed accessibility;

4) a nearly complete set of road management objectives for all roads including eliminations and closures, and design and maintenance *levels* to provide the appropriate experience; all new roads needed to provide access to the site should be clearly flagged with control points and critical points clearly identified and easily relocated;

5) land lines needing survey and posting, if any; and

6) cultural resources survey completed with sites identified on the ground.

STEP #7 - Generating and Comparing Alternatives. The objective of this step is to *develop* a reasonable range of alternatives including a "No Action" *alternative.*

Alternatives for projects tiered to completed Forest Plans will represent a narrower range than pre-Plan alternative sets. The "No Action" alternative should always be considered because action is not always required or justifiable. At this point alternatives can be modified or tossed out altogether, and new alternatives can be *developed.* Alternatives should specify resource management activities that fully address the critical issues, project and Forest Plan objectives, Forest Plan management requirements, mitigation measures, and monitoring requirements for environmental effects. Each alternative should have a simple economic analysis to illustrate the relative costs of implementation.

Once a reasonable range of alternatives has been developed:

1) the significant effects on resources of each *alternative* (including the No Action alternative) should be estimated;

2) each alternative should be evaluated against the project objectives on its own merit;

3) the effects and output of each should be compared and contrasted; and

4) the ID team should identify a recommended or best alternative.

No formal environmental documentation should be prepared unless the responsible line officer decides that it is needed. It is highly desirable that this need is evaluated by the deciding official in Step #1 whenever possible.

The products of Step 7 are:

1) notes on the vegetation management analysis including each alternative generated and how well each one addresses the issues, the interested and affected publics, and the resource management objectives relevant to the project;

2) notes on the comparison of effects of each alternative on resources with criteria for evaluation and comparison; and

3) notes on the recommended course of action (may include a recommendation for formal environmental documentation).

STEP #8 - Selecting an Alternative. The objective of this step is for the deciding official to select the best alternative for implementation.

This step marks the completion of the analysis portion of the vegetation management planning process. An alternative is either selected or revisions are requested by the responsible official and the process cycles back to an earlier step. The second part of this step pertains to the level of documentation appropriate to document scoping, analysis and decision phases of the process.

The products of Step 8 are:

1) a selected management alternative that will be implemented, and

2) an assessment of, and decision on added documentation needs.

This completes the section on vegetation management plan development. By following the above outline, a complete, quality vegetation management plan can be produced.

# Appendix C

## Guide to Important Indicators of Damage and Defect

**Laminated root rot** has been identified on all conifer species in the Pacific northwest, with susceptibility *varying* from extreme to highly resistant. This root disease is characterized by ectotrophic mycelia, i.e., mycelium growing on the surface of roots (Figure 1), setal hyphae (sterile hairs) in decayed wood that look like tiny reddish whiskers (Figure 2), and laminated decay (Figure 3) with pitting apparent on both sides of resultant laminae (Figure 4). Setal hyphae are usually found within the *advanced* decay. *Live* infected trees are frequently windthrown (Figure 5). Trees identified as infected *have* a high probability of failure.

Figure 1

Figure 2

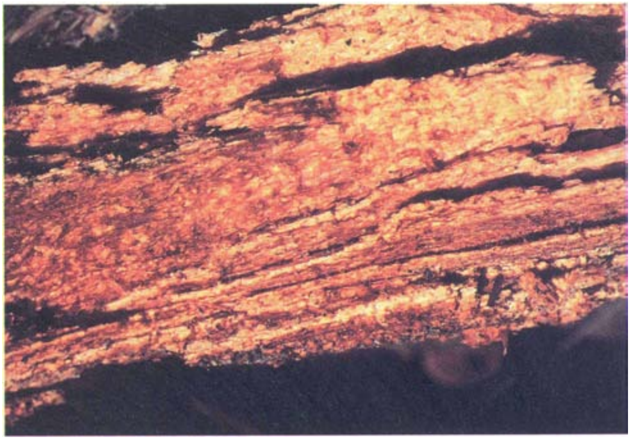

Figure 3

Figure 4

Figure 5

Crown symptoms of trees damaged by Armillaria root disease are similar to those of laminated root rot. Many other signs and symptoms are unique to this disease. Infected trees exhibit a copious resin flow (Figure 1), or resin-soaking of the butt (Figure 2). In the fall, honey-colored mushrooms may be found fruiting at the base of infected trees (Figure 3). Examination of the roots and root collars of symptomatic trees with advanced infection reveals a fan of mycelium under the bark (Figure 4). Rhizomorphs (black, root-like fungal structures) are often found under the bark, or in the soil adjacent to infected roots (Figure 5). The advanced decay is a yellow stringy rot which appears water- or resin-soaked with small straw-colored flecks interspersed. Unlike laminated root rot, Armillaria root disease-killed trees most often die standing (Figure 6). Trees identified as infected have a high probability of failure.

Figure 2

Figure 3

Figure 4

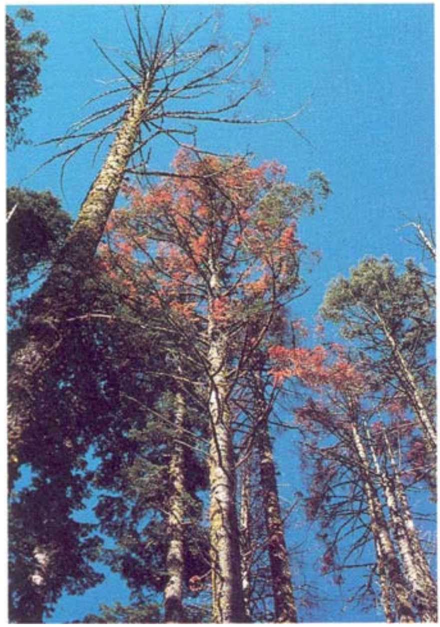

Figure 6

Figure 5

Annosus root diseased trees may exhibit generic symptoms of root disease or they may appear symptomless if the decay is confined to the butt and lower bole. The advanced decay of Annosus root disease is either laminated, with pitting apparent on only one side of laminae (Figure 1), or it appears as a white spongy rot often interspersed with black stromatal flecks (Figure 2). Conks can 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. They may appear as small pustules on roots (Figure 3) or shelving perennial conks, creamy-white on the undersurface with a poreless margin, and dark chestnut brown on the upper surface with concentric furrows (Figure 4). Butt decay predisposes trees to windthrow and breakage (Figure 5). Trees identified as being infected should be examined for decay in the roots. Trees with infected roots have a high probability for failure.

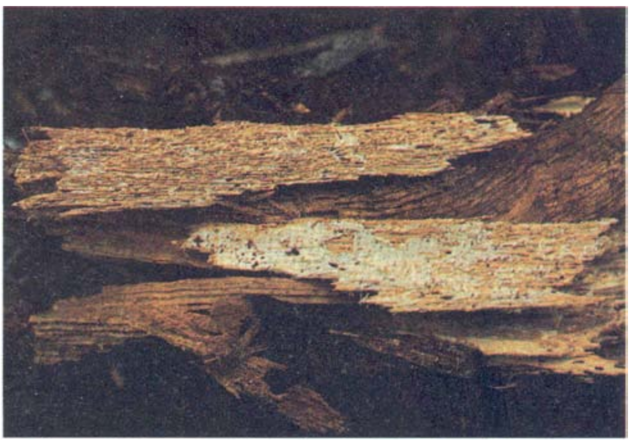

Figure 1

Figure 2


Figure 3


Figure 4


Figure 5

**Tomentosus root rot** may be completely hidden on trees with extensive butt rot. In developed sites, Engelmann spruce is the principal host (Figure 1). Fruiting bodies are small, cinnamon colored, leathery, poroid mushrooms which appear in the fall on the ground near the base of defective trees (Figure 2). The advanced decay is a rather nondescript white pocket rot (Figure 3). The margins of the white pockets are often quite discrete (Figure 4). When hosts are mature they are more apt to be severely rotted in the roots and butt. Trees identified with infection in the roots and butt pose a high failure potential.

Photo by Kathy Lewis

Figure 1

Photo by Richard Reich

Figure 2

Photo by Kathy Lewis

Figure 3

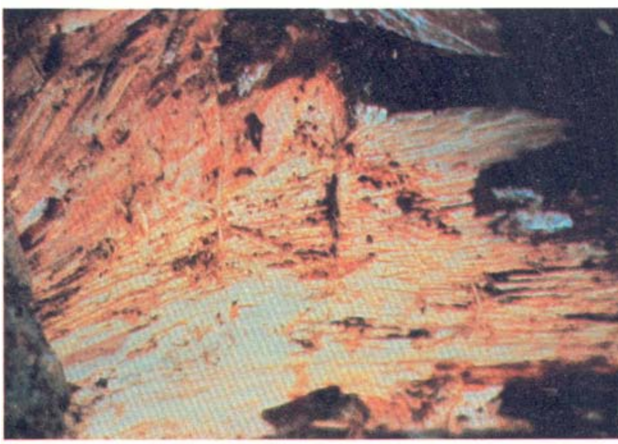

Photo by Kathy Lewis

Figure 4

**Brown cubical butt rot** is a common defect of old growth Douglas-fir, pines, spruces, and western larch. Butt swelling is one symptom of significant defect (Figure 1). The fungus causing brown cubical butt rot has an annual fruiting body that can be found on the ground at the base of infected trees (Figure 2). Produced in the fall, the fruiting body is readily identifiable for at least a year after its emergence. Trees with severe butt defect may have fruiting bodies growing from the butt (Figure 3). This often is indicative of a tree with a high failure potential. Fresh fruiting bodies are velvety to the touch and have a brightly colored yellow margin (Figure 4). Trees identified with decay in major lateral roots pose a high failure potential.

Figure 1

Figure 2

Figure 3

Figure 4

The more common signs of **saprot** include fleshy globose mushrooms with a covered pore surface, that are tan to golden brown when fresh (Figure 1), and fade to a chalky white with age (Figure 2), or numerous small, thin, shelving purplish conks (Figure 3). Sap rotting fungi only affect dead sapwood (Figure 4). There are dozens of minor sap rotting species in conifers. Failure potential increases directly with circumference of dead tissue and depth of saprot.

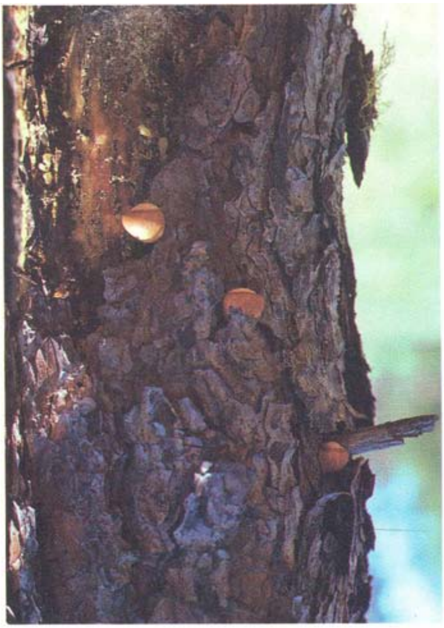

Figure 1

Figure 2

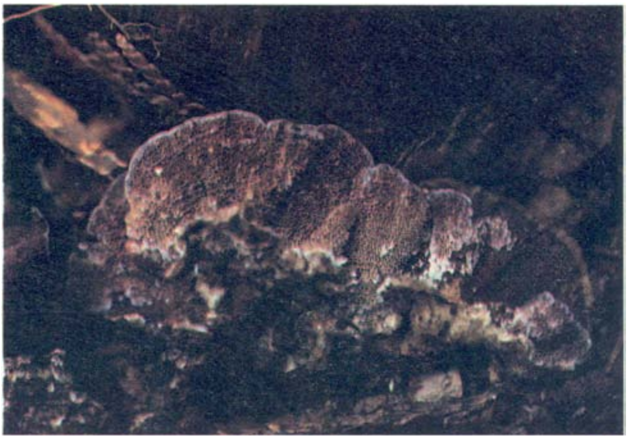

Figure 3

Figure 4

**Rust-red stringy rot** is common in older true firs and hemlocks. Since this defect is often well above reach in the bole, the extent of damage is determined based on external indicators. Hoof-shaped conks are the best indicator of defect (Figure 1). Occasionally, conks are found on the ground at the base of an infected tree; their shape and spiny underside are helpful clues (Figure 2). Inside the conk, the obvious brick red interior is indicative of this fungus only (Figure 3). The advanced decay associated with conks is a rusty red stringy rot (Figure 4). A large single conk indicates extensive decay and a high potential for failure.

Figure 1

Figure 2


Figure 3


Figure 4

Trees with red **ring rot** produce characteristic hoof-shaped conks with a cinnamon-brown pore surface, which are formed at branch stubs or knots (Figure 1). Hosts include Douglas-fir, spruces, pines, larch, true firs, and hemlocks. While a single conk indicates decay, the decay indicated by one conk is not nearly as extensive as that associated with a single conk of rust red stringy rot (Figure 2). Consequently, a single conk with no evidence of any others, suggests monitoring rather than mitigation. Several conks in close proximity or numerous conks throughout the bole indicate significant decay (Figure 3). Punk knots are commonly associated with damage caused by this fungus (Figure 4). Failure potential increases directly with the number of conks and/or punk knots.

Figure 1

Figure 2

Figure 3

Figure 4

**Brown trunk rotted trees** bear hoof-shaped to pendulous perennial conks that *have* a chalky white upper surface and a white pore surface (Figure 1). Hosts include Douglas-fir, pines, and western larch. The advanced decay is brown and cubical with white mycelial felts filling the shrinkage cracks (Figure 2). A single conk indicates *severe* stem decay and immediate mitigation when valuable targets are nearby (Figure 3).

Figure 1

Figure 2

Figure 3

**Redcedar pencil rot** is best indicated by the conspicuous dry side that is evident adjacent to areas of the bole with *extensive* decay (Figure 1). Conks rarely occur. The principal host of this defect is western redcedar. The advanced decay is a dark brown cubical rot which occurs initially in discrete pencil-shaped pockets (Figure 2), which later coalesce into larger rot columns (Figure 3-4).

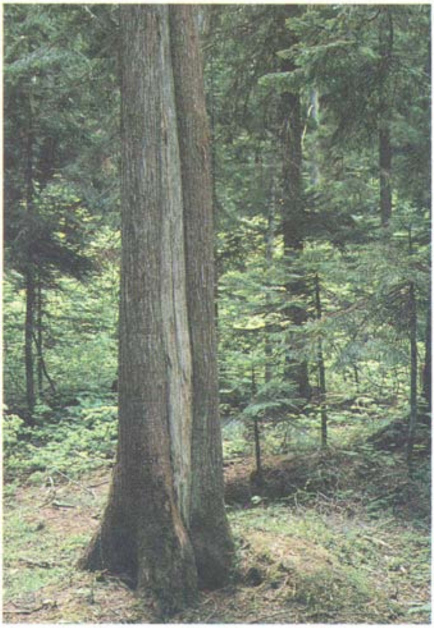

Figure 1

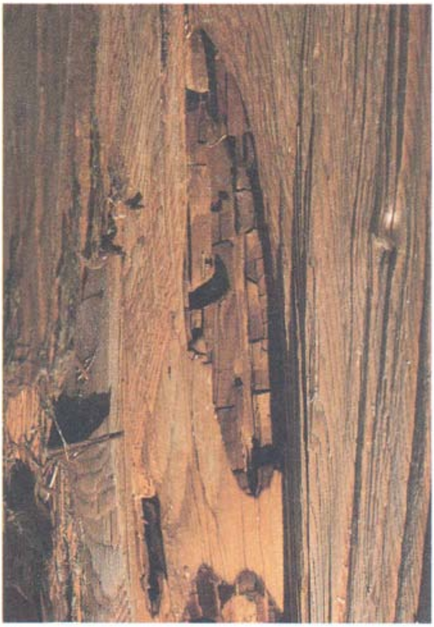

Figure 2

Figure 3

Figure 4

**Pecky rot of incense cedar** is quite similar to the pencil rot of western redcedar though fleshy conks may be apparent (Figure 1). The primary host is incense cedar. A single conk indicates a highly defective tree. The advanced decay is a dark brown cubical rot which occurs initially in discrete pencil-shaped pockets (Figure 2), which later coalesce into larger rot columns (Figure 3). Shot-hole cups may be evident on defective trees which also indicate that a tree is cull.

Figure 1

Figure 2

Figure 3

Table 1 - Distribution of failures by position of defect and tree species on Pacific Northwest recreation sites.

| Tree species | Up bole (%) | Low bole (%) | Butt (%) | Limb (%) | Root (%) | Total Number |
|---|---|---|---|---|---|---|
| Alder | 23 | 11 | 30 | 1 | 35 | 154 |
| Douglas-fir | 17 | 11 | 15 | 3 | 54 | 404 |
| Engelmann spruce | 0 | 3 | 34 | 0 | 63 | 38 |
| Grand fir | 12 | 18 | 18 | 0 | 53 | 34 |
| Incense cedar | 14 | 29 | 8 | 4 | 44 | 111 |
| Larch | 8 | 26 | 4 | 4 | 58 | 26 |
| Lodgepole pine | 13 | 8 | 7 | 3 | 69 | 637 |
| Madrone | 10 | 2 | 28 | 42 | 18 | 321 |
| Maple | 13 | 4 | 30 | 9 | 47 | 47 |
| Mountain hemlock | 12 | 77 | 0 | 0 | 12 | 43 |
| Noble fir | 37 | 11 | 0 | 0 | 53 | 19 |
| Pacific silver fir | 5 | 48 | 5 | 0 | 43 | 21 |
| Ponderosa pine | 42 | 6 | 5 | 0 | 47 | 280 |
| Poplar | 15 | 12 | 19 | 31 | 23 | 26 |
| Red fir | 16 | 30 | 13 | 1 | 40 | 87 |
| Sitka spruce | 18 | 27 | 18 | 0 | 36 | 11 |
| Spruce, unident. | 0 | 53 | 0 | 0 | 47 | 297 |
| Subalpine fir | 55 | 3 | 24 | 0 | 17 | 29 |
| Sugar pine | 14 | 25 | 17 | 8 | 36 | 36 |
| Tanoak | 13 | 24 | 18 | 16 | 28 | 1614 |
| Western hemlock | 4 | 18 | 19 | 1 | 58 | 113 |
| Western red cedar | 0 | 15 | 12 | 10 | 63 | 41 |
| White fir | 6 | 53 | 15 | 0 | 26 | 34 |
| Average | 15% | 22% | 15% | 6% | 42% | 4423 |

Table 2 - Minimum safe-tree shell thickness at various DBH's[1].

| Tree DBH (in.) | Minimum Shell ThicknesS-Y (in.) | Tree DBH (in.) | Minimum Shell Thickness (in.) |
|---|---|---|---|
| 4 | 1.0 | 40 | 6.0 |
| 8 | 1.5 | 44 | 6.5 |
| 12 | 2.0 | 48 | 7.0 |
| 16 | 2.5 | 52 | 8.0 |
| 20 | 3.0 | 56 | 8.5 |
| 24 | 3.5 | 60 | 9.0 |
| 28 | 4.0 | 64 | 9.5 |
| 32 | 4.5 | 68 | 10.0 |
| 36 | 5.5 | | |

1/Modified from Wagener, 1963 by expanding the range of diameters covered.
2/Minimum shell thickness for trees with open wounds is 25 percent greater than indicated in Table 2.

Table 3 - Damaging Agent - Host Susceptibility Matrix

| Agent | PSME | ABLA | ABAM | ABGR | ABCO | ABMA | ABPR | TSME | TSHE | THPL | LIDE | CHNO | CHLA | LAOC | PIPO | PICO | PILA | PIMO | PIEN | PISI | HARD-WOODS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PWHE | H | I | I | H | H | I | I | H | I | R | R | R | R | T | T | T | T | T | I | I | ■ |
| AROS | H◆ | I | I | H | H | I | I | I | I | T♠ | T | T | T | T | I | I | I | I | I | I | R♣ |
| HEAN | R★ | H | I | H | H | I | I | I | I | R | R | R | R | R | I● | I | T | T | I | I | R |
| INTO | T | I• | I• | T• | T• | I• | I• | I• | I• | R• | ■ | ■ | ■ | T• | I• | H• | T• | T• | H• | H• | R |
| PHSC | H• | T | T | T | T | T | T | T | T | R | R | R | R | H• | H• | H• | I• | I• | H• | I• | R§ |
| ECTI | R | H▪ | H▪ | H▪ | H▪ | H▪ | H▪ | H▪ | H▪ | R | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | R | R | ■ |
| PHPI | H♥ | I♥ | I♥ | H♥ | H♥ | I♥ | I♥ | H♥ | H♥ | R♥ | R♥ | R♥ | R♥ | I♥ | H♥ | I♥ | H♥ | H♥ | H♥ | H♥ | R |
| FOOF | H• | R | R | R | R | R | R | R | R | ■ | ■ | ■ | ■ | H• | H• | H• | I• | I• | T• | T• | ■ |
| OLSE | R | I• | T• | T• | T• | T• | T• | R | R | H• | ■ | R• | ■ | R | R | R | R | R | R• | R• | ■ |
| OLAM | ■ | R• | R• | R• | R• | ■ | ■ | ■ | ■ | ■ | H• | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Dead Top♣ | | X | X | X | X | X | X | X | X | | | | | | X◇ | X | X | X | X | X | X |

Susceptibility:
H = High  T = Tolerant
I = Intermediate  R = Resistant

- ♣ High potential for failure.
- ◆ Westside PSME is susceptible to age 30 years then tolerant. Eastside PSME is susceptible all ages with a few exceptions.
- ♠ Intermediately susceptible on CNEW, CSUL on the COL NF.
- ♣ Hardwoods are quite susceptible to *Armillaria mellea* and other North American *Armillaria* spp.
- ★ PSME is tolerant on the OKA NFs and COL NFs.
- ● PIPO is susceptible on dry climax PIPO sites.
- • Infection occurs at apparently any age, extensive butt rot develops beyond pathological rotation age.
- § Most hardwoods resistant or immune, *Betula* and *Quercus* spp. are reported hosts in the literature; we are unsure of the accuracy of those reports.
- ▪ Hosts are infected at any age; infections are dormant until encased in heartwood and injured closeby.
- ■ Host is immune, there is no report of successful infection.
- ♥ Infections occur at apparently any age, extensive heartrot is develops beyond pathological rotation age.
- ◇ Tops break out easily unless they have been killed by Comandra blister rust; these are stable and slowly weather.

## Table 4 - Damaging Agent - Sign/Symptom Matrix

x indicates the sign/symptom is routinely evident;
O indicates the sign/symptom is occasionally evident.

| SIGN OR SYMPTOM | PHWE | AROS | HEAN | PHSC | ECTI | INTO | FOOF | OLSE | OLAM | PHPI | BBEETLES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Reduced height growth | X | X | X | | | O | | | | | |
| Yellow foliage | X | X | X | | | O | | | | | |
| Slow loss of foliage | X | X | X | | | O | | | | | |
| Distress cones | X | X | X | | | O | | | | | |
| Slow crown decline | X | X | X | | | O | | | | | |
| Rapid tree death | O | X | | | | | | | | | X |
| Dead, no foliage loss | | X | | | | | | | | | X |
| Abundant basal resinosis | | X | | | | | | | | | |
| Roots rotted | X | X | X | X | | X | | | | | |
| Windthrown live trees | X | | X | | | | | | | | |
| Stem Breakage | X | | X | X | X | X | X | X | X | X | |
| Insect galleries | X | X | X | | | O | | | | | X |
| Annual mushrooms | | X | | | | X | | | | | |
| Mycelial fans under bark | | X | | | | | | | | | |
| Mycelia obvious in decay | O | | O | X | | O | X | | | | |
| Rhizomorphs | | X | | | | | | | | | |
| Perennial conks | O | | X | | X | | X | | | X | |
| Annual conks | | | | X | | | | X | X | | |
| Conk w/rust-red interior | | | | | X | | | | | | |
| Setal hyphae | X | | | | | | | | | | |
| Ectotrophic mycelium | X | | X | | | X | | | | | |
| Pustules on roots | | | X | | | | | | | | |
| Delamination pits 1-side | | | X | | | | | | | | |
| Delamination pits 2-side | X | | | | | | | | | | |
| Yellow stringy decay | | X | | | | | | | | | |
| White spongy decay | | | X | | | | | | | | |
| Rust-red stringy decay | | | | | X | | | | | | |
| Red-brown cubical decay | | | | X | | | | | | | |
| White pocket rot | O | | O | | | O | | | | X | |
| Honeycomb decay | | | | | | X | | | | | |
| Brn. cubical pocket rot | | | | | | | | X | X | | |
| Conk w/cinnamon brn. interior | X | | | | | X | | | | X | |
| Brown cubical decay | | | | | | | X | | | | |
| Found in overcrowded trees | | X | | | | | | | | | X |
| Found in low vigor trees | | X | O | | | | | | | | X |
| Found w/ other root diseases | X | X | X | X | | X | | | | | X |
| Found w/ severe mistletoe | | X | O | | | | | | | | X |
| Conk looks like cow flop | | | | X | | | | | | | |
| Conk w/dark brown interior | | | | X | | | | | | | |
| Conk w/spiny pores | | | | | X | | | | | | |
| Conk produced at branch stubs | | | | | X | | X | | X | X | |

Table 5 - Tree Damage - Treatment Options Matrix

| Agent | PRUNING | TOPPING | GUYING | SUPPORTING | REMOVAL |
|---|---|---|---|---|---|
| Root Rots | | ♥ | | | X |
| Undermined Roots | | X♦ | X♦ | X♦ | |
| Severed Roots | | X♦ | X♦ | X♦ | |
| Wrenched, Broken Roots | | X♦ | X♦ | X♦ | |
| Heartrots | | X | | | |
| Saprots | | X♣ | | | |
| Cracked/Split Bole | | X | X♦ | X♦ | |
| Dwarf Mistletoe Cankers | X | X | | | |
| Fungus Cankers | | X | | | |
| Bole Flattening | | X | X♦ | X♦ | |
| Crotches | X♦ | X | X♦ | X♦ | |
| Defective Limbs | X | | X♦ | | |
| Dead Tops | | X | | | |
| Broken Tops | | X | | | |
| Leaning Trees (old lean) | | X | X♦ | X♦ | |
| Dead Trees | | | | | X♠ |

♥ Topping is only a practical consideration with moderately hazardous PHSC

♦ Hazardous tree should be treated with these methods when it has a conspicuous lean away from any target

♣ An acceptable treatment if saprot is the result of nonlethal injury or bark beetle topkill or strip attack

♠ Dead trees should always be removed where targets of consequence are nearby; developed sites are a poor place to maintain snags for cavity nesting birds; they may be left for this purpose well outside the impact zone.

In all cases, site closure, target removal or relocation, and/or exclusion of visitors from the impact zone are treatment options either alone or in combination, so they are not listed above. Removal is indicated as an option when it is the only acceptable alternative, other than the above three, for eliminating an unacceptable hazard.

Table 6. Estimated pathological rotation ages for Pacific Northwest conifers intermediately susceptible, tolerant, or resistant to laminated root rot.

Intermediately Susceptible
Pacific silver fir - 120 years
Noble fir - 140 years
subalpine fir - 120 years
Shasta red fir - 140 years
Engelmann spruce - 140 years
Sitka spruce - 140 years
western hemlock - 140 years

Tolerant
ponderosa pine - 150 years •
lodgepole pine - 100 years •
western white pine - 140 years •
sugar pine - 150 years •
western larch - 150 years •

Resistant
western redcedar - 200 years •
Incense cedar - 150 years •
Port-Orford Cedar - 200 years •
Alaska yellow cedar - 200 years •

• Other pathogens and/or insects become limiting at this age

Table 7. Estimated pathological rotation ages for Pacific Northwest conifers intermediately susceptible, tolerant, or resistant to annosus root disease.

**Intermediately Susceptible**

Pacific silver fir - 120 years
Noble fir - 140 years
Shasta red fir - 140 years
Engelmann spruce - 140 years
Sitka spruce - 140 years
western hemlock - 140 years

**Tolerant**

● ponderosa pine - 150 years ✦
lodgepole pine - 100 years ✦
western white pine - 140 years ✦
sugar pine - 150 years ✦
western larch - 150 years✦

**Resistant**

western redcedar - 200 years ✦
Incense cedar - 150 years ✦
Port-Orford Cedar - 200 years ✦
Alaska yellow cedar - 200 years ✦

● Ponderosa pine in dry climax pine sites is very susceptible. That growing on more mesic Douglas-fir and grand or white fir climax sites is much more tolerant to this root disease.

✦ Other pathogens and/or insects become limiting at this age

Table 8. List of acronyms used in the text, their Latin binomial and common name.

| | Acronym | | Latin binomial | | Common name |
|---|---|---|---|---|---|
| **TREES** | ABAM | = | *Abies amabilis* | = | Pacific silver fir |
| | ABCO | = | A. *concolor* | = | white fir |
| | ABGR | = | A. *grandis* | = | grand fir |
| | ABLA | = | A. */asiocarpa* | = | subalpine fir |
| | ABMA | = | A. *magnifica* | = | California red fir |
| | ABPR | = | A. *procera* | = | noble fir |
| | CHLA | = | *Chamaecyparis /awsoniana* | = | Port-Orford-cedar |
| | CHNO | = | C. *nootkatensis* | = | Alaska yellow cedar |
| | LAOC | = | *Larix occidentalis* | = | western larch |
| | L1DE | = | *Libocedrus decurrens* | = | incense cedar |
| | PICO | = | *Pinus contorta* | = | lodgepole/shore pine |
| | PIEN | = | *Picea enge/mannii* | = | Engelmann spruce |
| | PILA | = | *Pinus /ambertiana* | = | sugar pine |
| | PIMO | = | *P. montico/a* | = | western white pine |
| | PIPO | = | *P. ponderosa* | = | ponderosa pine |
| | PISI | = | *Picea sitchensis* | = | Sitka spruce |
| | PSME | = | *Pseudotsuga menziesii* | = | Douglas-fir |
| | THPL | = | *Thuja p/icata* | = | western redcedar |
| | TSHE | = | *Tsuga heterophylla* | = | western hemlock |
| | TSME | = | *T. mertensiana* | = | mountain hemlock |
| **DISEASES** | AROS | = | *Armillaria ostoyae* | = | Armillaria root disease |
| | CRVO | = | *Cryptoporus vo/vatus* | = | gray-brown sap rot |
| | ECTI | = | *Echinodontium tinctorium* | = | rust-red stringy rot |
| | FOOF | = | *Fomitopsis officinalis* | = | brown trunk rot |
| | HEAN | = | *Heterobasidion annosum* | = | annosus root disease |
| | INTO | = | *Inonotus tomentosus* | = | tomentosus root rot |
| | OLAM | = | *O/igoporus amarus* | = | incense cedar pecky rot |
| | OLSE | = | 0. *sericeomollis* | = | redcedar pencil rot |
| | PHPI | = | *Phellinus pini* | = | red ring rot |
| | PHSC | = | *Phaeo/us schweinitzii* | = | brown cubical butt rot |
| | PHWE | = | *Phellinus weirii* | = | laminated root rot |

Table 9 - A Standard for Rating.

POTENTIAL FOR FAILURE

1 = VERY LOW FAILURE POTENTIAL

Sound trees that will not likely be exposed to extremes of weather.

2 = LOW FAILURE POTENTIAL.

Trees with only minor defects (stem decay with more than an acceptable rind of sound wood), in areas sheltered from weather extremes, or sound trees that will likely be exposed to weather extremes (wind, snow loads).

3 = MEDIUM FAILURE POTENTIAL.

Trees with moderate defects (at or near the threshold of acceptable rind thickness) or that are growing in shallow soil, are shallow-rooted, or are exposed to a high water table, and that will likely to be exposed to strong winds and snow (extent of defect alone does not justify removal or hazard mitigation); or highly defective trees in areas well-sheltered from weather extremes; or highly defective trees exposed to weather extremes which occur only in the off season.

4 = HIGH FAILURE POTENTIAL.

Highly defective trees in unsheltered areas, or trees with root anchorage limited by erosion, excavation, undermining, or adverse soil conditions; dead trees, or those with root disease.

POTENTIAL FOR DAMAGE

1 = NO DAMAGE.

Target impact will involve only very small tree parts, or there is no chance that failed parts will cause damage when they impact a target.

2 = MINOR DAMAGE.

Failure of only small tree parts, and impacts in occupied areas are indirect; or failures will likely occur when area is unoccupied; damage when it occurs, is to low value target( s).

3 = MEDIUM DAMAGE.

Failure involves small trees or medium-sized tree parts, and impacts will likely occur in areas with targets; impacts will be direct, damage will likely be moderate, target value is moderate.

4 = EXTENSIVE DAMAGE.

Failure involves medium to large tree parts or entire trees, and impacts will be direct in areas with targets; target value is high, and damage to property will likely be severe; or serious personal injury or death is the likely result.

The hazard classification for each individual tree is determined by combining the values from the two parts of the rating system. Seven risk classes ranging from 2 to 8 are possible. Treatment priorities by risk class are as follows:

| Risk Class | Treatment Priority |
|---|---|
| 8 | very high |
| 7 | high |
| 6 | moderate |
| 2-5 | low |

Table 10 - Relative Value of Individual Trees

1 = NEGATIVE VALUE. The tree is unsightly and it detracts from visual quality; produces a spiny or smelly fruit in areas where visitors are prone to walk barefooted; produces copious sap

2 = MINOR VALUE. Adds marginally to aesthetic or visual quality

3 = ADDS TO COMPOSITE VALUE. Adds appreciable value when considered along with other trees, but does not make a significant individual contribution

4 = HIGH VALUE. Site loses significant value with loss of the individual tree; tree has historic value, scientific value

# Tree Record Form (TRF1-91E) Example

Recreation site LEISURE HAVEN
Tree number 107 Tree species ABGR Date first recorded 4/86
Reference point 3 Distance 27 ft. Azimuth 105 degrees true

| Date | DBH in. | Ht ft | Root1/ sympt | Root2/ cause | Butt3/ cause | Rind in. | Stem4/ defct | Stem5/ fungs | Risk Rate6/ PF PI CV | Recom7/ treat | Treat date | Next exam | Exam init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/86 | 10 | 70 | - | - | - | 5 | MECH | - | 1 3 2 | - | - | 88 | RDH |
| 5/88 | - | - | - | - | - | - | MECH | ECTI | 4 3 2 | TOP 30 | 88 | 91 | PFH* |
| 4/91 | 10 | 30 | - | - | SAP ROT | - | - | ECTI | 1 1 3 | - | - | 94 | RDH** |
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1/ REGR-reduces top growth; DETO-dead top; DEBR-dead branches; THCR-thinning crown; CHFO-chlorotic foliage.
2/ PHWE-laminated root rot; AROS-Armillaria root disease; HEAN-Annosus root disease; PHSC-brown cubical butt rot; MECH-mechanical injury; COMP-compaction; UNRO-undermined roots; briefly describe other.
3/ PHSC-brown cubical butt rot; HEAN-Annosus root disease; MECH-mechanical injury; ARSP-dwarf mistletoe canker; PEHA-western gall rust canker; WIND-wind caused cracking; breifly describe other.
4/ MECH-mechanical injury; LIST-lightening strike; FRCR-frost crack; FORK-forked stem; CROK-crook in stem; STCR- stress crack; SLFL-slime flux; ARSP-dwarf mistletoe canker; briefly describe other.
5/ PHPI-red ring rot; ECTI-rust red stringy rot; CANK-unknown canker; other.
6/ PF-probability of failure(1-4); Pi-potential for target impact(1-4); CV-component value(1-4).
7/ TOPx-top tree (where x= height of remaining stem); PRUN-prune branches; MOTA-move target; EXVi-exclude visitors from target area; FELL-remove tree; GUYI-guying; SUPP-supporting; briefly describe other.

REMARKS: *Tree topped '88; snag retained for cavity dwellers. **Should have 6-10 years of life at current rate of deterioration.

# Appendix E

Defect Rules for Determining the Extent of Decay Associated With Visible Indicators of the Most Common Root/Butt and Stem Decays

*Annosus Root Disease:*

For hemlocks, spruces, true firs:

When a conk is visible near the root collar, the lower 16-feet of the butt log are defective; or

Defect extends 4-feet above the top of an infected basal scar when annosum decay is verified, whichever is greater;

Defect extends 4-feet above and below infected stem wounds when annosum decay is verified;

Defect rules apply to wounds that are at least 10 years old; date wounds and scars with a cruiser's axe; for wounds less than 10 years old, expect internal defect to run the length of the wound or scar.

*Brown Cubical Butt Rot:*

For pines, Douglas-fir, western larch, spruces, others:

With conk(s) on the ground near the base of a tree, or on the tree at the base (old growth and older second growth, no scars or cracks), expect 8-feet of defect in the butt log;

With conk(s) on scars or cracks at the base of old growth Douglas-fir, or western hemlock, or with conks on the ground near a tree base that is scarred or cracked, expect 16-feet of defect in the butt log; (expect 8-feet of defect only on the UMP);

With conk(s) on scars or cracks at the base of young growth Douglas-fir or western hemlock, or conks on the ground near a tree base with scars or cracks, expect 8-feet of defect in the butt log;

32-feet of the butt are defective when conk(s) occur on scars 8-feet or more above the ground:

For dead tree defect rules, add 4-feet to the preceding rules.

*Rust-Red Stringy Rot:*

Rules used to determine the extent of defect on the OLY, MBS, MTH, SIU, WIL, and the eastside NF's of Oregon and Washington:

For hemlocks, and true firs:

DBH < 19 inches; 18 feet above, below conks;
DBH = 19 inches to 26.9 inches; 20 feet above, 18 feet below conks;
DBH = 27 inches to 34.9 inches; 20 feet above, 21 feet below conks;
DBH >34.9 inches; 20 feet above, 22 feet below conks.

Rules used to determine the extent of defect on the ROR, UMP, and SIS NFs:

Single small conk, young tree, defect is 8 feet above/below conk;

Lowest conk 0 to 32 feet from the ground, defect is 12 feet below the lowest conk, 21 feet above the highest conk;

Lowest conk> 32 feet above the ground, defect is 20 feet below the lowest conk, 21 feet above the highest conk;

Conks in the bottom one-third of the merchantable length, defect runs throughout the bottom and middle thirds;

Conks in the top one-third of the merchantable length, defect runs throughout the top and middle thirds;

Where two conks are separated by more than 25 feet, the entire tree is defective.

*Red Ring Rot:*

Rules used to determine the extent of defect on the OLY, MBS, GIP, MTH, SIU, WIL, ROR, UMP, SIS NFs:

For Douglas-fir (west of the Cascade crest):

Trees < 125-years-old: with conks, defect warrants periodic evaluation;

Trees 125- to 150-years-old: defect extends 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;

Trees 151- to 200-years-old: defect extends 10-feet above/below conks (punk knots), 5-feet above/below swollen knots;

Trees 201- to 250-years-old: defect extends 13-feet above/below conks (punk knots), 7-feet above/below swollen knots;

Trees 251- to 300-years-old: defect extends 18-feet above/below conks (punk knots), 9-feet above/below swollen knots;

Trees 301- to 350-years-old: defect extends 22-feet above/below conks (punk knots), 11-feet above/below swollen knots.

For old growth western hemlock and true firs (> 125-years):

Trees with single conk: defect extends 8-feet above/below; 4-feet above/below swollen knots when accompanying conks;

Trees with multiple conks: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots.

Rules used to determine the extent of defect on the OKA, WEN, COL, DES, OCH, FRE, WIN, WAW, UMA, MAL NFs:

For ponderosa pine, western larch, Douglas-fir (eastside):

Trees < 125-years-old: defect extends 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;

Trees 125- to 200-years-old: defect extends 8-feet above/below conks (punk knots), 4-feet above/below swollen knots;

*Red Ring Rot continued:*

Trees 201- to 250-years-old: defect extends 12-feet above/below conks (punk knots), 6-feet above/below swollen knots;

Trees 251- to 300-years-old: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots;

Trees 301- to 350-years-old: defect extends 20-feet above/below conks (punk knots), 10-feet above/below swollen knots;

Trees> 350-years-old: defect extends 24-feet above/below conks (punk knots), 12-feet above/below swollen knots.



Rules used to identify the extent of defect on the OKA, WEN, COL, DES, OCH, FRE, WIN, WAW, UMA, MAL NFs:

For true firs, hemlocks. and spruces:

Trees < 200-years-old: defect extends 8-feet above/below conks (punk knots), 4-feet above/below swollen knots;

Trees 200-years and older: defect extends 16-feet above/below conks (punk knots), 8-feet above/below swollen knots.

For western white pine and sugar pine:

Trees < 200-years-old: defect externds 4-feet above/below conks (punk knots), 2-feet above/below swollen knots;

Trees 200-years and older: defect extends 8~feet above/below conks (punk knots), 4-feet above/below swollen knots.

*Brown Trunk Rot:*

Rules used to identify the extent of defect on all NFs:

Live trees with conk(s) above 50-feet: the top half (length not volume) of the existing tree is defective;

Live trees with conk(s) below 50-feet: the entire tree should be considered highly defective.*



U.S. GOVERNMENT PRINTING OFFICE: 1992 - 694-861

| | |
|---|---|
| **From:** | Dennis Triglia |
| **To:** | Teri Davis |
| **Subject:** | My Comment for inclusion in Council Workshop Packet (9/18/17) |
| **Date:** | Monday, September 11, 2017 1:40:46 PM |
| **Attachments:** | Snags for Wildlife.pdf |

Hi Teri,

Brian French from Arboriculture International gave an excellent seminar at the recent International Master Gardeners' Conference in Portland. During his seminar, he spoke about keeping a few trees as "snags" ("Habitat Trees") for utilization by various wildlife species. One or two owls have been observed in one of the trees near the Capella By The Sea. Owls are a secondary species meaning that they will use nests or holes, *etc*. left by the primary species. The owls most commonly use nests built by other species in whatever tree is available, but also use cavities in trees and snags, cliffs, deserted buildings, artificial platforms, ledges and pipes.

I will propose to the City Council that the City of Brookings allow two of the felled trees to remain as "snags" and that we purchase from Arboriculture International two "Habitat In Progress" signs @ $30 apiece (see attached pdf) to demonstrate the value of "snags" to wildlife in the park as an informational item for the public.

I have attached a pdf of material on Mr. French's company website and would appreciate the inclusion of both this email and the pdf in the Workshop Packet materials.

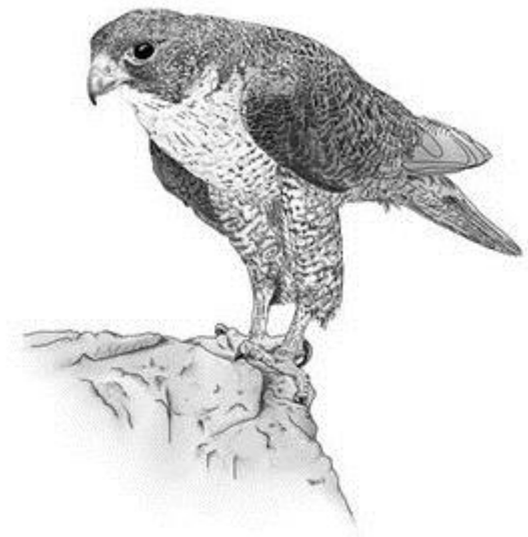
Thanks again for your help,
Dennis

**Dennis Triglia**
Councilor

City of Brookings
898 Elk Drive
Brookings, OR 97415

dtriglia@brookings.or.us

# Wildlife Work



Arboriculture International is constantly engaged in environmental projects that require professional climbing for rigging and access. Works include wildlife surveys, restoration projects, habitat projects and seed/cone collection. Additionally, AI accompanies and assists scientists in a myriad of research projects.

**"One of my ongoing missions is to match my skills and knowledge as an arborist who works and lives in the urban environment with my other half... the one who works, lives and recreates among our primitive forests. I want my focus to be on what I appreciate the most... preserving our oldest trees, enhancing our natural environment and protecting our wildlife."**

**Brian French**

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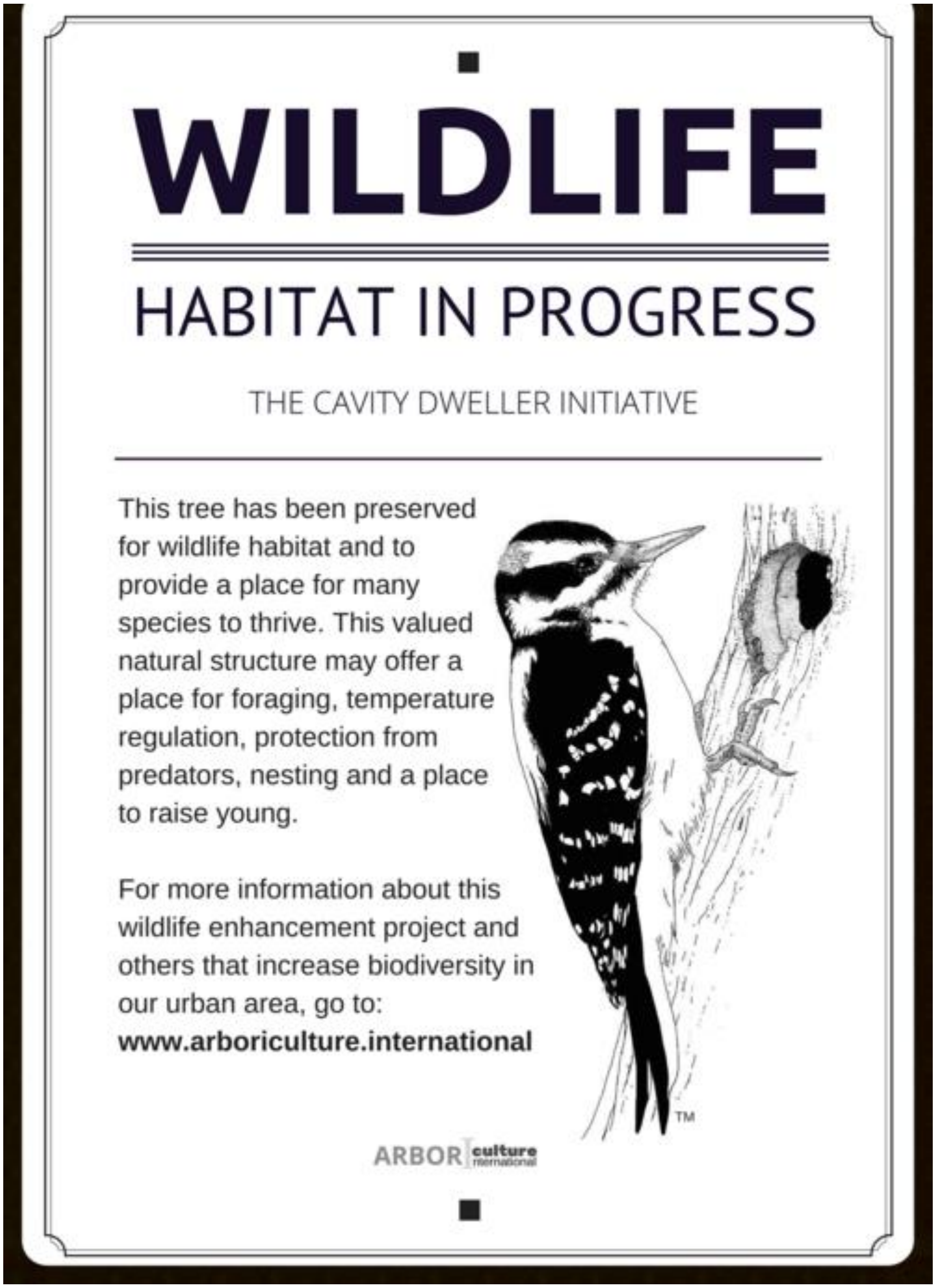
## WILDLIFE PROGRAM




**Habitat sign for ongoing urban habitat enhance projects. Aluminum printed signs with or without Arboriculture International logo available at $30. Pre-drilled signs and screws included.**

Arboriculture International has started an initiative to enhance our urban forests with tree material for cavity dwellers. This means that rather than removing trees entirely to the ground, we aim to find viable structures for wildlife species to live and reproduce in.

This initiative is in response to both the history of habitat loss and the continued removal of habitat. Habitat loss is due to destruction, fragmentation and/or degradation of habitat. This is the primary threat to the survival of wildlife in North America and around the world.

There are over 130 cavity dwelling species in the Pacific Northwest and all have been effected by the removal of trees and loss of habitat.

### WHAT CAN WE DO?

Before removing a tree on a property we may consider:

- What wildlife exists in or around the tree?
- When is the best timing to not effect nesting season?
- How many trees are around the tree to be removed?
- Can parts of the tree remain as a wildlife snag?
- Can parts of the tree be used for wildlife species on the ground?

**Contact Arboriculture International:**

For questions concerning cavity dwelling species on your property, trees or options to enhance your wildlife habitat please contact us at **(503) 709-0439**.

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# A Snag in the Plan

### by Tom Costello, Sanctuaries Director

This past month I attended a natural resources workshop at Silver Falls State Park that explored a recently completed forest thinning project in the 55 acres closest to the main offices, visitor center, and day use areas. The park managers had the difficult task of dealing with a dense second-growth forest ripe with many hazard trees growing above park structures, parking areas, and picnic areas. While from an ecological perspective it would be best to let these trees fall naturally or remain standing as snags, from the risk-management perspective these trees needed to be removed to protect the historic structures of the park and the one million visitors that pass through this area every year.

This classic snag is a wildlife condominium: its broken top and cavities can be used by birds, raccoons, squirrels, salamanders, and more; bare branches provide excellent perches; dead wood harbors a variety of insects, perfect food for Pileated Woodpeckers and many other species.
© Brian French

The project was completed this winter, and despite the fact that felling trees in a natural area is rarely a popular undertaking, the project was completed without any significant debate or controversy. There was some interesting discussion at the workshop about the project, particularly in regard to the idea of leaving standing snags in lieu of felling some trees. This is a concept I have embraced, as standing snags and downed trees both provide significant ecological function and habitat value.

In this particular project only two trees were left as standing snags. According to the forester in charge of the project, there are enough snags in the surrounding 9,000 acres of park providing habitat that it would not be worth the additional cost to create snags in the relatively small project area. Two snags were left in highly visible areas, as there can be significant value in raising awareness of the value of dead wood in natural ecosystems. However, the ecological benefit of standing snags was not considered in the overall context of this project, and the snags that were left in place were not cut in a way that would be specifically conducive to wildlife habitat or educational purposes.

With 9,000 acres of adjoining forest, budget limitations, and a short project window, this was a reasonable approach to the project. But the considerations change when we consider the value of leaving wildlife snags in parks, natural areas, and even residential settings in the urban landscape. For too long, tree removal was considered the only option for dealing with problem trees in the urban and suburban landscape. As with many other elements of a functional ecosystem, dead wood is severely lacking in our cities, parks, and suburban areas.

A State of Washington publication, *Snags – The Wildlife Tree*, states that "trees can actually provide more habitats for wildlife dead than when they were alive." Snags provide broken tops and hollows that can be used as nest sites and shelter by birds, raccoons, salamanders, and squirrels. Hollows in the bark and rotten wood inside the snag contain insects which provide food for many species of birds as well as providing the service of converting the biomass of the tree into nutrients that can be used by other nearby plants.

Brian French explains the process of creating wildlife snags that look natural and benefit wildlife. The photo at right shows the finished cover of the cavity nester version of a manufactured home. Photos © Ron Dyer

Professional arborist Brian French, co-founder of Ascending the Giants and fellow organizer of this summer's Tall Tree Tour at Portland Audubon, has been busy researching best practices for creating wildlife snags and putting these practices to use for clients. "There's no question that there has been a great loss of wildlife habitat in our urban communities — the question is how do we create it again," says French. "The natural process can take hundreds of years; however, recognizing the potential that 'trees to be removed' offer gives us a unique opportunity to explore methods to speed up that process. I imagine the day when 'Wildlife Habitat Creation' is a common service advertised by practicing arboriculture companies nationwide."

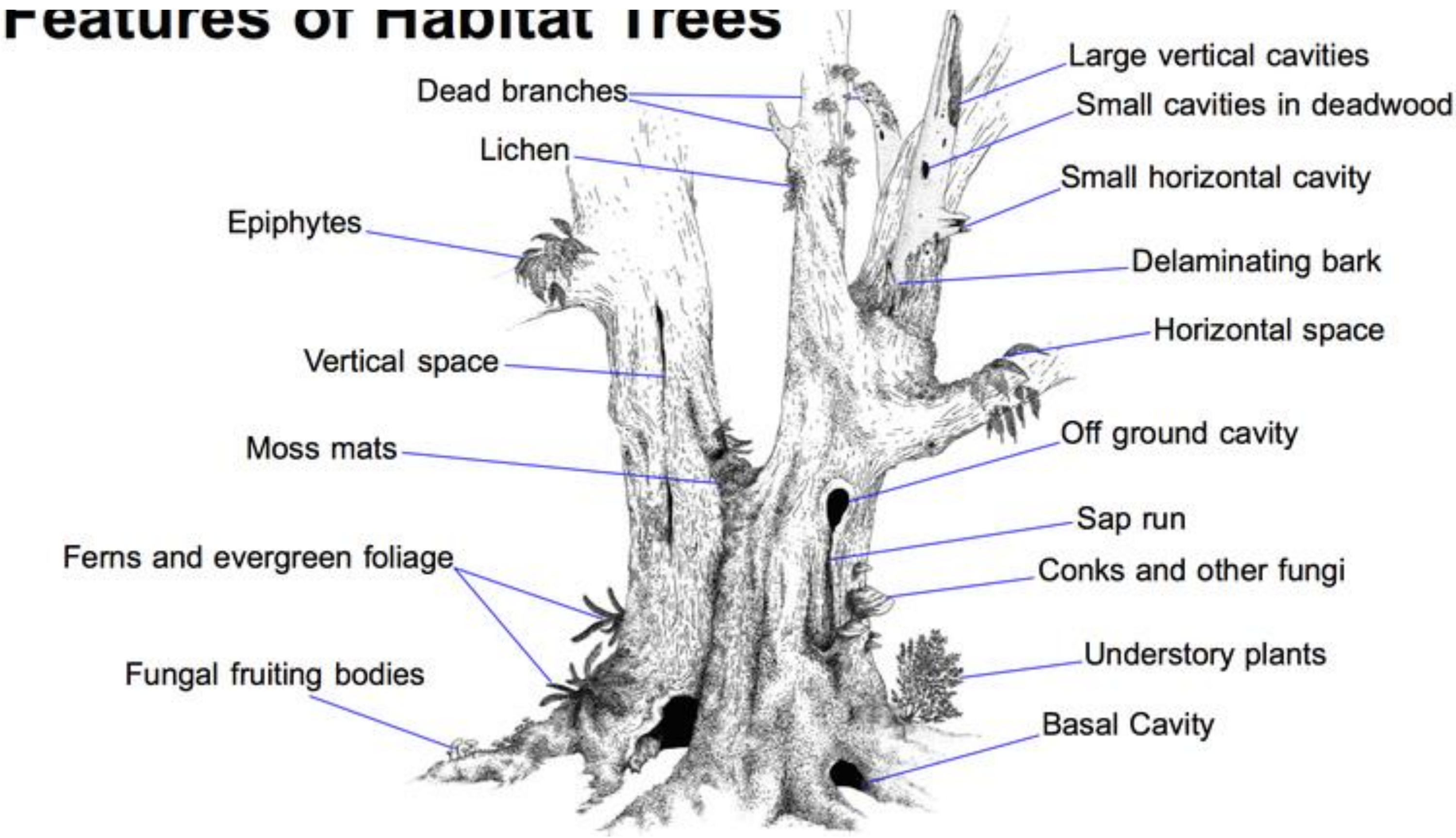
The creation of wildlife snags is a currently underutilized option for creating and enhancing wildlife habitat in our cities. Of course we love all of our lovely, living trees — but snag creation is a viable alternative to tree removal in the case of dead, dying, or hazard trees in the urban landscape. If you are interested in learning more about the creation and benefits of wildlife snags, contact Brian French at Arboriculture International: **ai.brianfrench@gmail.com**.

# Wildlife Snag Gallery








Often, trees or parts of trees that offer the most habitat are condemned as 'Defects'. Trees offer a diversity of habitat features that can only be found in and among 'Old Trees'. The illustration above shows some such features. **Illustration: Brian French**

## WILDLIFE HABITAT

Homeowners, city managers and arborists alike have an unique opportunity to contribute to wildlife retention in our community.

It all begins with recognizing the place in which wildlife species live, forage, hunt and reproduce. In many cases, It all begins with preserving and restoring such places in trees.

Many species rely entirely on features that only old trees can provide. It may take a tree 100 years to become large, but another 100 years to develop adequate space for dwelling.

---

AZALEA PARK TREES

Darlene Ashdown

16974 Pacific View Dr

Brookings, OR 97415

Re: Questions for Bryan French, Aborist

Mr French - As the trees in Azalea park are questionably infected and removal is advised, will the surrounding, healther trees be treated with a systemic fungicide(Aqui Foss) and /or susfactout(Pentra Bark) in and around trees?

According to "The Suden Oak Death Guidelines for Forestry", The County Agricultural Commissioner must issue a permit for the removal of the trees. There is a number of other steps that must be made for the authorization of the removal. How long will this take?

Under these guidelines, removal of these trees is recommended when moisture is not present. Moisture spreads the pathogen.

Thank you for your information.

Darlene Ashdown