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

The Context of Hazard Tree Management

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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
do = diameter outside bark at root col!ar
d, = 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).

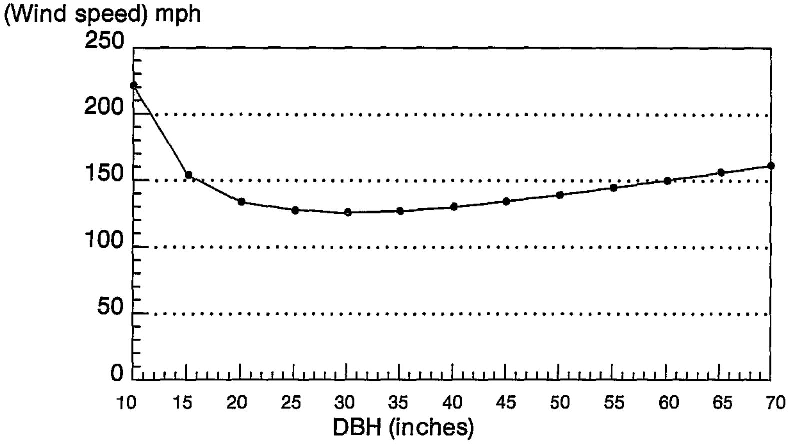
One method that may be used to determine wind speeds that have occurred in an area would be to locate trees that have failed and are on the ground. In most cases, the remnant base of a tree may be sufficient. Tree species, DBH, base diameter, and rind can be measured from the down tree or tree portion. 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.

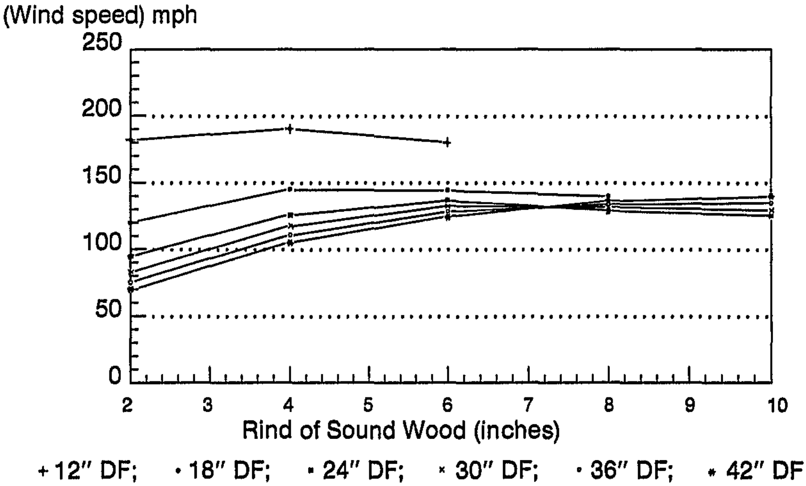


diameter growth over time. As trees age, height growth tapers off, yet diameter growth may steadily increase for many decades improving resistance to collapse. When trees are young, their live crowns are relatively long, dense, and broad, providing a large surface for wind interception. Site managers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

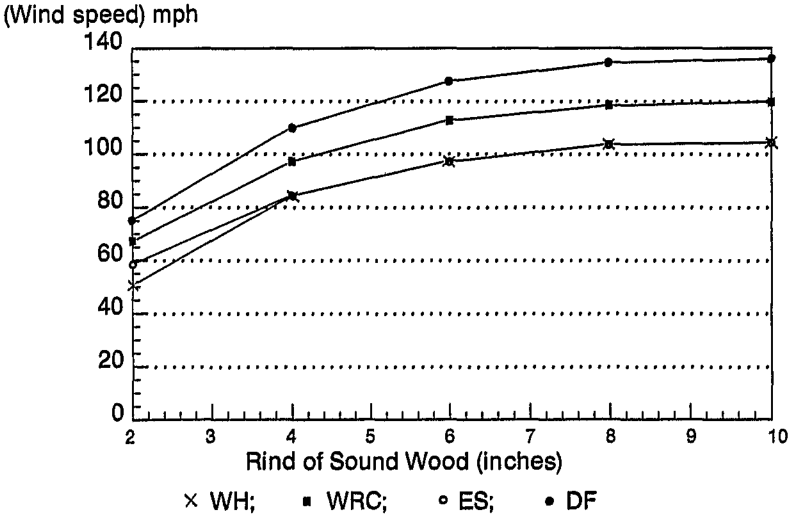
Figure 14. Relationship of minimum wind speed to cause tree failure for 12-42 in. Douglas-fir with varying widths of sound rind.



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, OF, ES
Armillaria Root Disease	*Armillaria ostoyae* (AROS)	true firs, OF PP,LP
Annosus Root Disease	*Heterobasidion annosum* (HEAN)	PP, true firs hemlocks, spruces
Tomentosus Root Rot	*Inonotus tomentosus* (INTO)	ES, true firs PP, LP
Brown Cubical Butt Rot	*Phaeolus schweinitzii* (PHSC)	pines, OF, WL 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

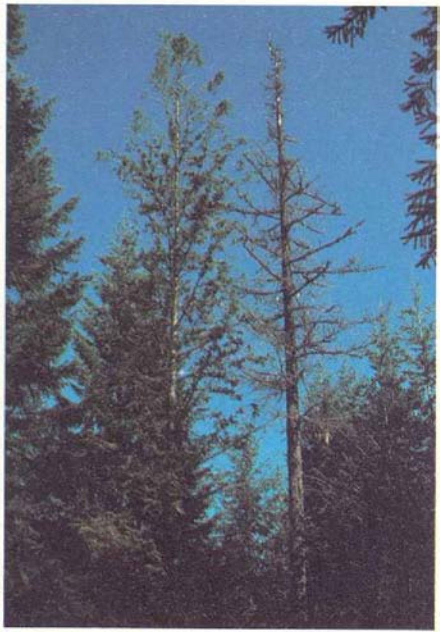


Figure 17

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.

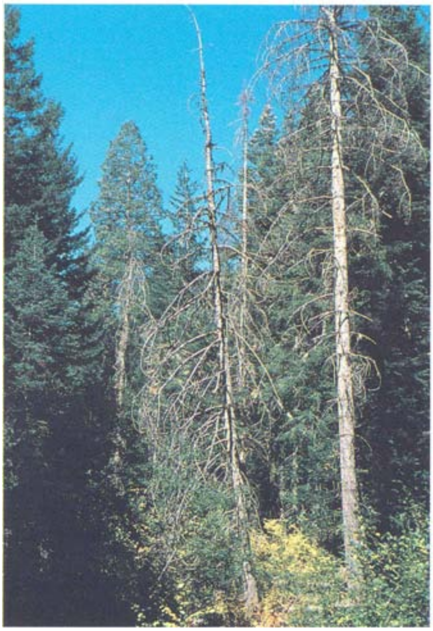


Figure 23

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, WAlAl, 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, WAlAl, 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, saprots 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

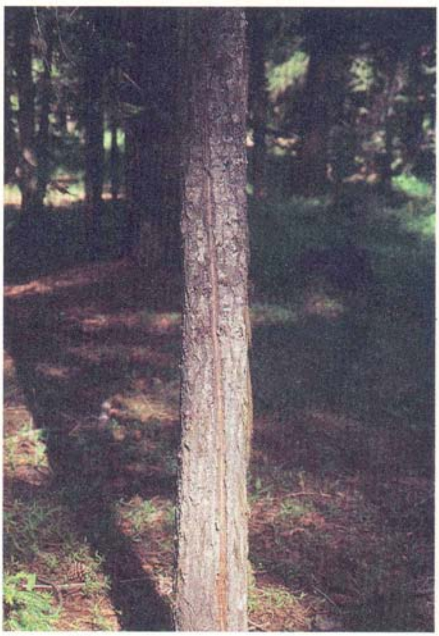


Figure 37

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

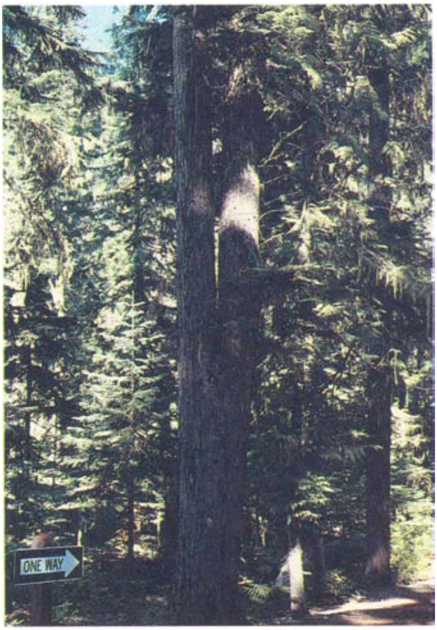


Figure 44

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.

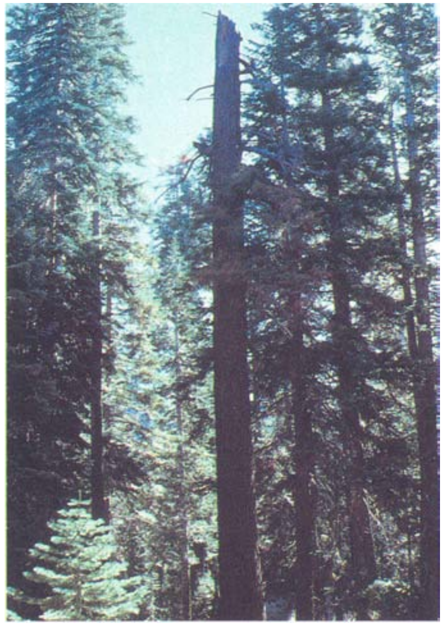
Dead hardwood limbs:

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,

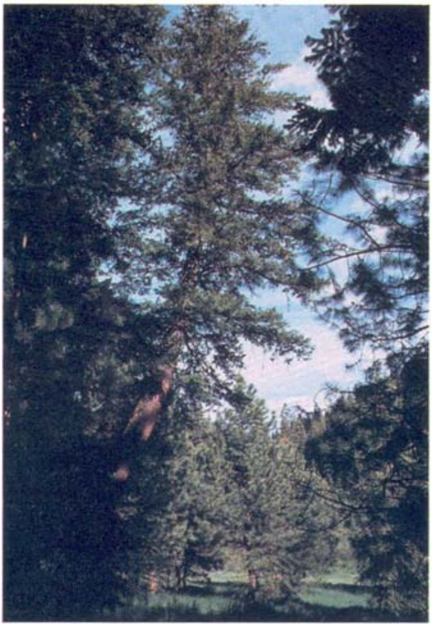


Figure 50

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	Root 1/ sympt	Root 2/ cause	Butt 3/ cause	Rind in.	Stem 4/ defct	Stem 5/ fungs	RiskRate 6/ PF	PI	CV	Recom 7/ treat	Treat date	Next exam	Exam init

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

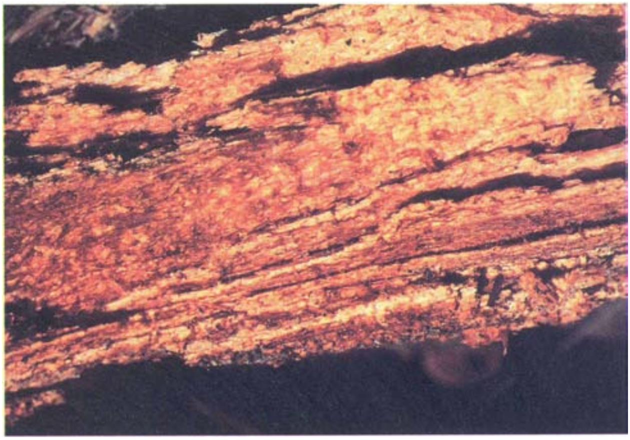

Figure 3

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

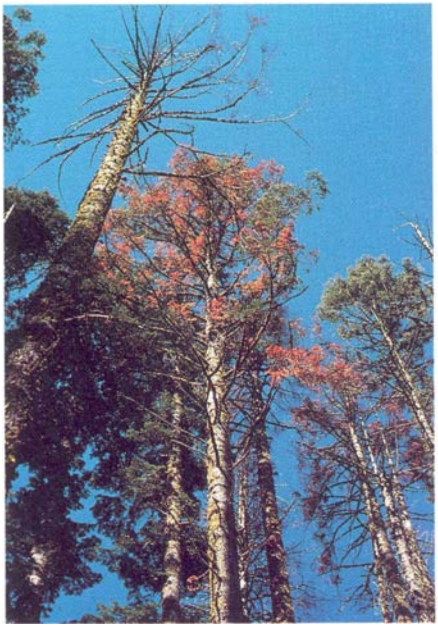
Figure 6


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.

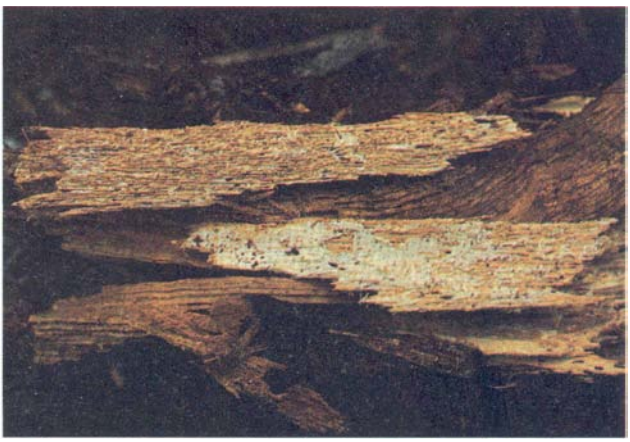

Figure 1

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.

Figure 1

Figure 2

Photo by Kathy Lewis

Figure 3

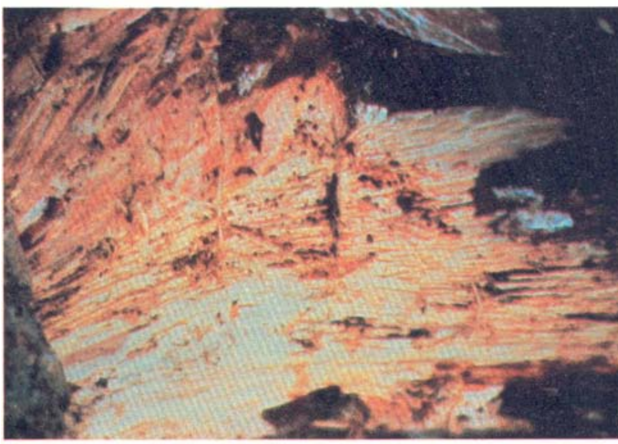

Photo by Kathy Lewis

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.

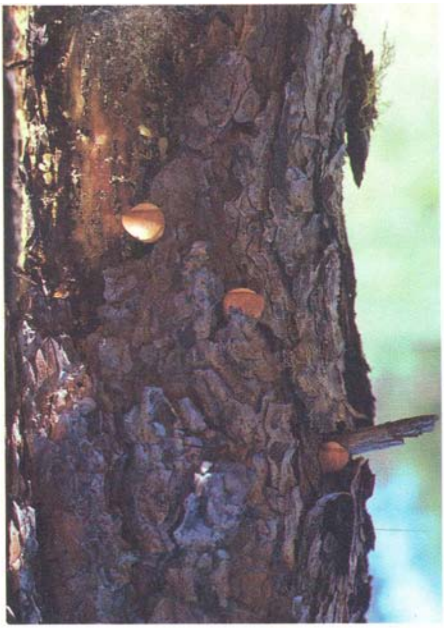

Figure 1

Figure 2

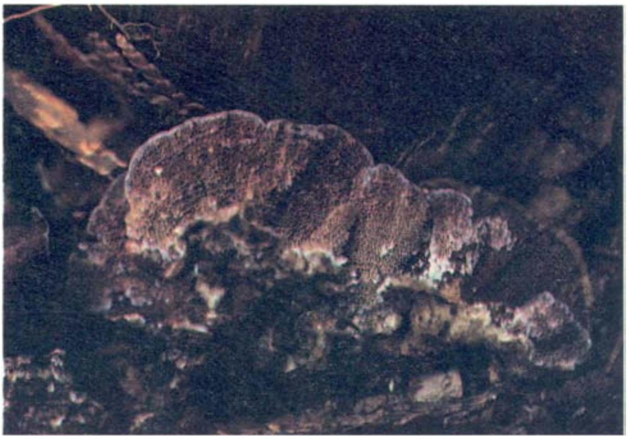

Figure 3

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).

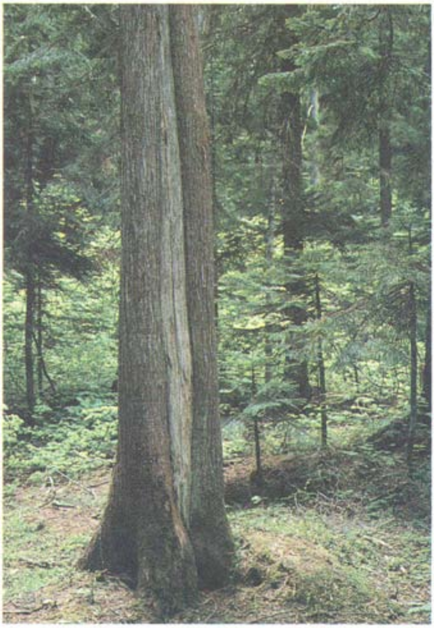

Figure 1

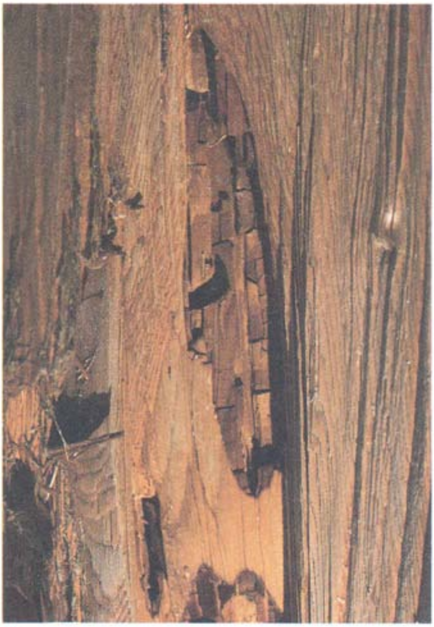

Figure 2

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[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.

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
- I = Intermediate
- T = Tolerant
- 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	=	*|nonotus 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**

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.*

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