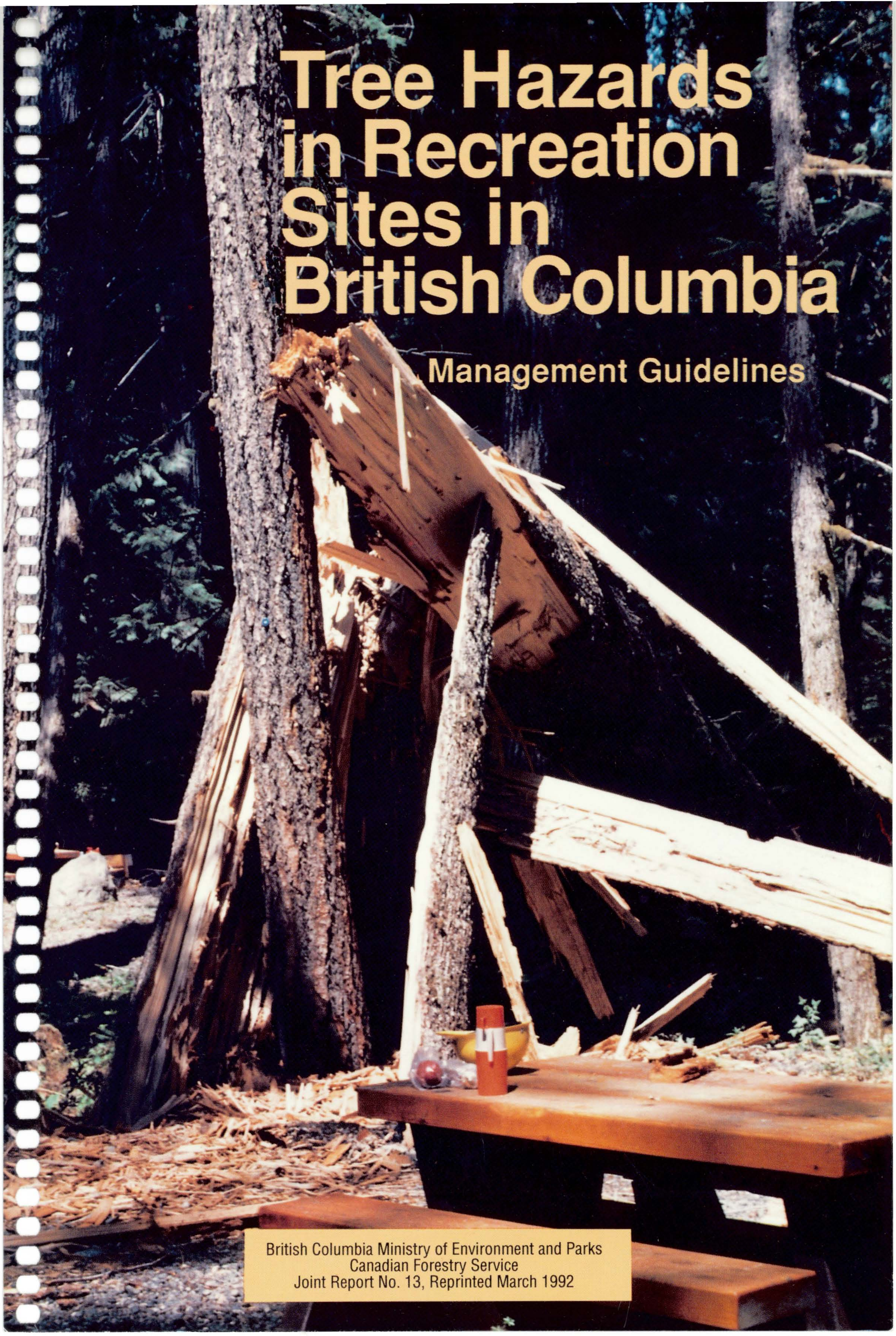
Tree Hazards in Recreation Sites in British Columbia

Management Guidelines



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TREE HAZARDS IN RECREATION SITES IN BRITISH COLUMBIA

Management Guidelines

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PREFACE

This publication, prepared primarily for the Provincial Park System, introduces the concept of tree hazard and provides a uniform system by which potentially hazardous trees may be rated. Procedures for conducting tree-hazard control inspections and surveys are described and measures to reduce or abate hazards are suggested. Indicators of some common tree defects are described and illustrated.

The information on tree defects and forest pathology is consistent with known conditions in British Columbia. Procedural methodology may be suitable to other agencies concerned with the operation and management of forested recreation sites. However, prior to other agencies use of information contained in this publication on a program scale, consideration on a policy basis of such topics as areas of application, funding, liability, etc., would be advisable.

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CONTENTS

INTRODUCTION

Trees are a prime environmental feature in most recreation sites. Like all living organisms, they develop defects (faults or areas of weakness) with age. This is an ongoing natural process which ultimately leads to the structural failure of portions of a tree or the entire tree.

On treed recreational sites, failures can result in property damage (Fig. 1), personal injury, or sometime death. Tree hazard control programs attempt to identify defective trees, assess the hazard posed by such trees, and implement measures designed to prevent accidents caused by their failures.

Fig. 1
Extensive decay in the roots caused this tree to fail without warning.

WHAT IS TREE HAZARD

A tree can be considered potentially hazardous if it is situated in an area frequented by people or is located adjacent to valuable facilities and has defects in roots, stem or branches **that may cause a failure resulting in property damage, personal injury or death.** The degree of hazard will vary with size of the tree, type and location of the defect, tree species and the nature of the target.

Recreational site managers must be aware of tree hazards and know how to recognize, evaluate and correct them. Conscientious and systematic hazard assessment and abatement will make recreation sites safer for the increasing number of visitors enjoying them each year and will minimize damage to park facilities and blockage of trails and roads.

Fig. 2
Extensive heart rot caused this Douglas-fir to collapse.

RATING THE HAZARD

The objectives of tree hazard control are to provide a high level of public safety while retaining aesthetically pleasing surroundings and remaining within reasonable budgetary limits.

Any defective tree has the potential to fail at any time and, depending on its location, may cause damage. **However, by careful inspection of all developed areas, it should be possible to detect most defects and rate the likelihood of failure during normal site usage and weather conditions.** In some instances, defects are difficult to detect. Apparently sound trees growing adjacent to root rot centers must be critically examined below ground for evidence of the fungus (see descriptions of root rots). The extent of decay in the heartwood of some trees may become evident only after the stems are drilled.

When conducting an inspection, **all trees within a target area must be examined. However, only those trees with detectable defects are to be formally rated.** Failures in sound trees are rare and must be accepted as occurrences over which one has no control.

RATING SYSTEM

A standardized tree rating system is a fundamental requirement of any tree hazard control program. The Provincial Parks tree hazard rating system requires the evaluation of defective trees based on two elements: **failure potential and failure impact.** Each element is quantified on a scale of 1 to 3; their total gives a numerical value of the degree of hazard. The objective of this rating is to evaluate trees with defects and decide whether there is a degree of hazard that requires abatement. Adherence to this system will provide a uniform level of tree hazard evaluation and a basis on which expenditure of hazard abatement funds can be priorized. The system, because of the extreme variation in hazards, must be of a general nature. Knowledge, common sense and intuition are fundamental requirements for inspectors if this system is to be effective.

I. FAILURE POTENTIAL

This element considers the likelihood of failure under conditions prevailing during site usage. It is based primarily on an evaluation of the type of defect or defects and the tree species. The rating scale, 1 to 3, is as follows:

Value 1 - low potential for failure, some minor defects present

Value 2 - medium potential for failure

Value 3 - high potential for failure; dead trees, trees with serious defects, and those with multiple defects

Guidelines for evaluating **failure potential** are given in Tables 1 to 3.

II. FAILURE IMPACT

This element considers the consequences arising from a failure. It is based on an evaluation of the size of tree or parts thereof, probability of hitting a target, and the value of the target. The rating scale, 1 to 3, is as follows:

Value 1 - minimal damage; probability of hitting target low, tree or parts thereof that could fail are small, target of low value.

Value 2 - moderate damage; medium probability of hitting target, tree or parts that could fail are of sufficient size to cause moderate damage, target could sustain some damage or is of moderate value.

Value 3 - extensive damage; probability of hitting target high, tree or parts that could fail are of sufficient size to injure, kill or cause extensive property damage; targets include people and/or their property or high value public facilities.

III. HAZARD RATING

The hazard rating of a defective tree is derived by adding the value obtained for **failure potential** to the value obtained for the **failure impact;** for example:

FAILURE POTENTIAL RATING	+	FAILURE IMPACT RATING	=	HAZARD RATING
3	+	2	=	5

The value for the **hazard rating** should be entered on the Tree Hazard Site Inspection Record (Form 1).

FORM 1

TREE HAZARD SITE INSPECTION RECORD

Sheet ________ of ________

District: ______________ Site: ______________ Officer: ______________ Date: ______________

Tree	Sp.	dbh cm	Location	Description of defect	Failure Potential rating (1)	Description of target	Failure Impact rating (2)	Hazard rating (1 + 2)	Action Recommended	Action Completed	
										Date	Initials

CONDUCTING SITE INSPECTIONS

INSPECTION PERSONNEL

Trees should be examined annually by individuals knowledgeable in defect appraisals. These people should be familiar with signs and symptoms of diseases that cause defects, be able to recognize anatomical features associated with failures, and be aware of local weather and environmental conditions which may contribute to tree failures. By utilizing this publication, augmented by training workshops, field staff should become sufficiently knowledgeable to conduct inspections.

TIMING

Coniferous trees can be inspected at any time during the year when the ground is free from snow, but the best time is in the spring after the trees have been exposed to winter storms. Deciduous trees are best examined during leafing-out, when dead tops and branches are more easily seen. Special inspections should be made during the high use season after unusually heavy rainfalls and severe winds. Recreation personnel should always be alert to the development of serious hazards, regardless of the season.

If possible, select a bright day for the inspection. Observations of tree defects become more difficult and the dedication of the inspector tends to diminish as weather conditions deteriorate.

OFFICE PREPARATION

When planning a site inspection, the inspector should review all available information related to the area, including previous tree hazard inspection records. Past records are of value in alerting inspectors to trees with recorded hazard ratings and to site conditions that may contribute to tree hazards; for example, stand age, tree vigor, species composition, locations where water accumulates and the direction of prevailing strong winds. Using a site development map, select a tentative starting point and route to follow. Make a record of, and mark on the site map, the location of all trees that have a hazard rating. Complete the site description under the pertinent headings on the Tree Hazard Site Inspection Record (Form 1).

Assemble the materials and equipment needed for the site inspection as follows:

axe - with at least a 1 kg head, for sounding trees for hollows and decay
borer - hand increment borer and power borer for detecting fungal

stain and decay in the wood
binoculars - for checking the trunk, tops and branches of tall trees
shovel or mattock - for checking the condition of roots
diameter tape - for taking tree diameters
tags and nails - for numbering defective trees
site development map - for plotting the inspection route and locations of trees with a hazard rating
tree hazard site inspection forms - for recording inspection data

FIELD PROCEDURES

The site examination must be done in a systematic manner to ensure that all trees within target areas are inspected. Determine if the starting point and inspection route chosen in the office is suitable; and modify, if necessary. Estimate the height of dominant trees around the targets; the height of the dominant trees is the distance back from the targets that must be examined (target area). Note landmarks that will serve as boundaries of the inspection area.

1. Proceed to the first tree (if it is too small to cause damage to the target or it is leaning away from the target, it need not be examined) and systematically inspect (Fig. 3):
   a) the ground around the base of the tree for fungus fruiting bodies (Figs. 19 and 21), root injuries and soil cracks or heaving indicating recent movement
   b) the butt of the tree for fruiting bodies (Fig. 4), wounds (Figs. 9 and 11), frost cracks (Fig. 5), etc., that indicate presence of decay
   c) the trunk for fruiting bodies (Fig. 37), wounds, cankers (Fig. 50), swellings (Fig. 53), etc.
   d) the top and branches for decline in vigor, broken top (Figs. 14 and 15), dead branches and other defects that indicate possible hazards. Use binoculars when examining tall trees.

If defects are found in roots, butt or lower trunk, the tree should be bored on 3 sides (more if the tree is over 50 cm diameter), to determine the extent of fungal stain or decay.

2. If no defect indicators are found, proceed to next tree and repeat inspection. Keep in mind that only trees within a target area are inspected and only trees with defect indicators are rated.
3. If a defect (see Tables 1-3) is noted on a tree that is large enough to cause damage and may hit the target if it failed:
   a) tag the tree, keeping the tag as high and out-of-site as possible

Fig. 3 Flow diagram of a procedure that may be followed for tree inspections.

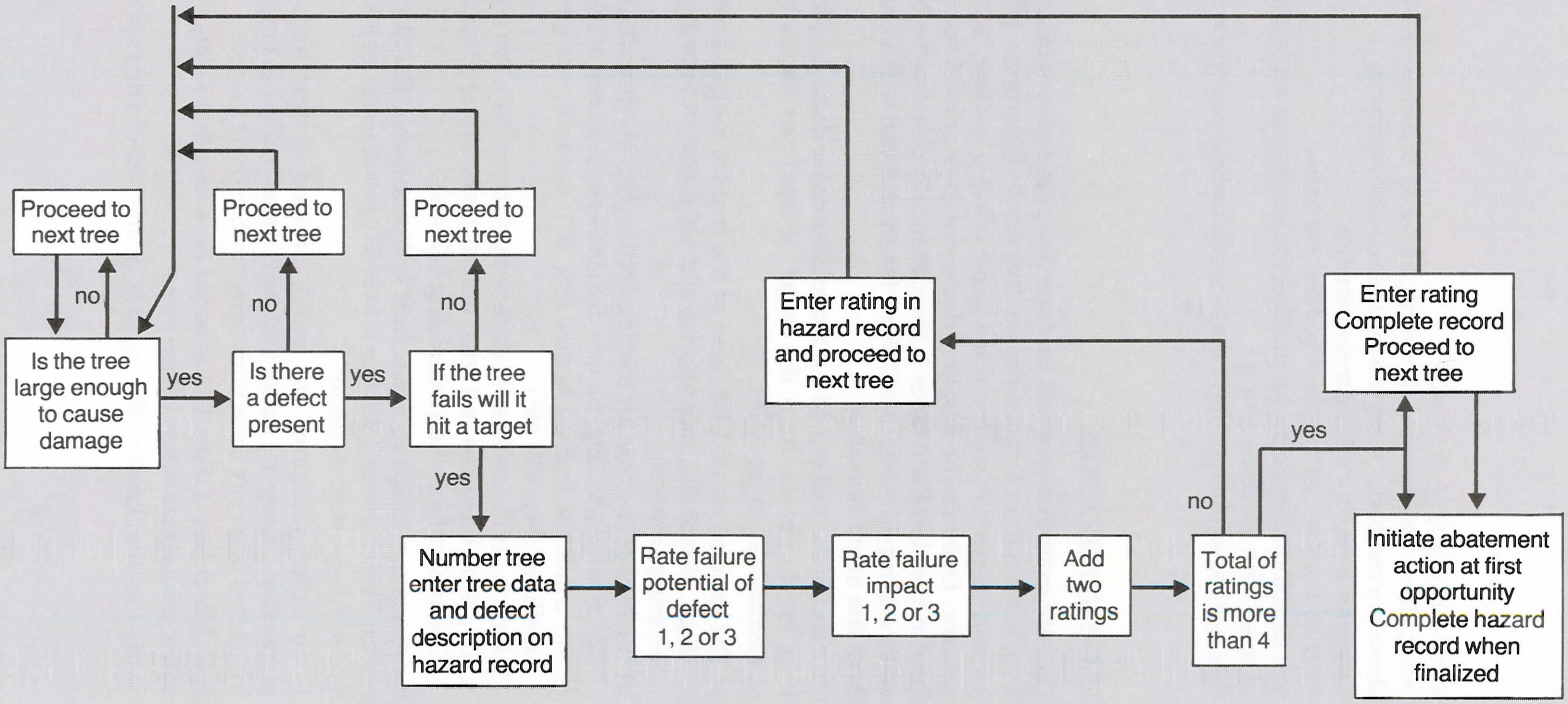

Fig. 4
Fruiting bodies on the butt of a tree indicate that the heartwood is in an advanced stage of decay and there is a high potential for failure.

b) record the tree number, species, d.b.h. and location on the inspection form and mark the location on the site map
c) record the description of the defect indicator
d) rate and record the **failure potential** (high - 3, moderate - 2, low - 1); use Tables 1-3 as guidelines
e) record description of the target
f) rate and record the **failure impact** (high - 3, moderate - 2, low - 1). In rating **failure impact**, keep in mind three factors:
- is the size of the tree or parts thereof, such that it would cause major, moderate or minor damage to the target if it failed
- is the lean of the tree such that the probability of hitting the target is

high, moderate or low if the tree failed
- is the value of the target high (people, washrooms, picnic site eating enclosures, etc.), moderate (picnic tables, buildings of moderate value, etc.), or low (wood corals, fences, etc.)

g) add the values for the **failure potential** and **failure impact** to obtain the **hazard rating** and record

h) record the action required to abate the hazard, keeping in mind the requirements of the Tree Hazard Control Policy; namely, all dead trees must be removed if within a target area and all trees with a hazard rating of 5 or 6 must be considered for hazard abatement.

4. Continue systematic inspection until all trees within target areas have been examined. Be particularly careful that all trees with a previously recorded hazard rating are reinspected.
5. Carefully check all tree hazard site inspection forms to ensure that they are complete.
6. Summarize hazard abatement recommendations and submit to appropriate authority.
7. Undertake hazard abatement action and record date of action on Tree Hazard Site Inspection Record form.

INSPECTION RECORDS

Records of site inspections and any ensuing hazard abatement measures must be maintained (Form 1). These augment the information obtained from tree failure reports and, **most importantly, document inspection activities and abatement action. The care with which these records are completed and maintained may determine the outcome of any litigations arising fom tree failures.**

Table 1. Guidelines for evaluating the failure potential of specific defects

Conifer species except cedars

The following Table provides guidelines for making failure potential judgements; it is not a "magic formula" that provides definitive answers to hazard rating. Two extremes, low and high, are noted, corresponding to a **failure potential** of 1 and 3, respectively. Variations from these extremes **(failure potential 2)** will vary from tree to tree and can be judged only by the investigator on the site.

DEFECT	LOW FAILURE POTENTIAL	HIGH FAILURE POTENTIAL
Whole Tree Failure		Dead trees Leaning trees growing on sites with a high water table
Root and Butt Failure		
1. Soil		Cracks or heaving in soil around tree indicating recent movement
2. Roots	Few small roots severed or injured	Most of the roots on one or more sides of the tree severed or badly damaged
3. Wounds	Root and butt wounds less than 5 years old provided there is little advanced decay	Root and butt wounds more than 10 years old and with extensive advanced decay
4. Wounds	Scar with little wood injury	Scar with the wood deeply gouged, possibly fractured
5. Fruiting Bodies		Fruiting bodies on the butt of the tree (Fig. 4), or on the ground around the tree (Fig. 19)
6. Hollow Butt	Hollow butt if less than a quarter of the stem is affected	Hollow butt if a majority of the stem is decayed
7. Resin	Resin flow from the butt near the ground line (Fig. 27), with less than a half the circumference of the stem affected	Resin flow from the butt near the ground line (Fig. 27), with most of the circumference of the stem affected. Mycelium fans below the bark (Fig. 28)
8. Mycelium	*Phellinus weirii* mycelium on the roots but no stain or decay in the butt	*Phellinus weirii* mycelium on the roots and red-brown stain and/or decay in the butt (Fig. 25)
9. Foliage		Thin chlorotic foliage (Fig. 22), indicates a tree is dying as a result of root rot
10. Frost Cracks	Frost cracks (Fig. 5), with little or no associated advanced decay	Frost cracks (Fig. 5), with extensive associated advanced decay (Fig. 6)

11. Dwarf Mistletoe	Young dwarf mistletoe swelling in butt	Dwarf mistletoe swellings in the butt, (Fig. 53), particularly if associated with advanced decay
12. Cankers	Butt cankers with bark still intact	Butt cankers with more than half the face of the canker dead (Fig. 50)

DEFECT	LOW FAILURE POTENTIAL	HIGH FAILURE POTENTIAL
Stem Failures		
1. Wounds	Scars less than 5 years old provided wood not deeply gouged	Scars more than 5 years old and with extensive associated advanced decay
2. Wounds	Scars with little wood injury	Scars with wood deeply gouged, possibly fractured
3. Fruiting Bodies	One or two small fruit bodies in the upper stem	Multiple fruiting bodies along length of stem (Fig. 37)
4. Dwarf Mistletoe	Dwarf mistletoe stem canker with the bark still intact	Dwarf mistletoe stem canker with more than a half the circumference dead (Fig. 53)
5. Forked Stems	Forked stems, one or both fork being of a small diameter	Large forked stems joined part way up the stem
6. Leaning Stem	Old lean, upper section of stem growing vertically	Recent lean, soil around tree cracked or heaving indicating recent movement
Top and Branches		
1. Dead Tops	Dead small tops and branches	Dead large tops and branches
2. Forked Tops	Small forked tops and crooks	Large forked tops
3. Broken Tops	Broken tops with adjacent branches healthy	Broken tops with adjacent branches unhealthy
4. Fruiting Bodies	One or two small fruiting bodies in top of stem	Numerous fruiting bodies in top of stem
5. Cankers	Top and branch cankers with the bark still intact	Top cankers where most of the canker face is dead
6. Dwarf Mistletoe	Small dwarf mistletoe branch and top swellings and witches' brooms	Large dwarf mistletoe, witches' brooms on branches (Fig. 51)

Table 2. Guidelines for evaluating the **failure potential** of specific defects

Cedar

The following Table provides guidelines for making failure potential judgements; it is not a "magic formula" that provides definitive answers to hazard rating. Two extremes, low and high, are noted, corresponding to a **failure potential** of 1 and 3, respectively. Variations from these extremes (**failure potential 2)** will vary from tree to tree and can be judged only by the investigator on the site.

DEFECT	LOW FAILURE POTENTIAL	HIGH FAILURE POTENTIAL
Whole Tree Failure		Dead trees Leaning trees growing on sites with a high water table
Root and Butt Failure		
1. Soil		Cracks or heaving in soil around tree indicating recent movement
2. Roots	Few small roots injured or severed	Most of the roots on one or more sides of the tree severed or badly injured
3. Wounds	Basal scars where the wood is not gouged	Basal scars where the wood is deeply gouged and possibly fractured
4. Hollow Butt	Hollow butt provided less than a half of the circumference of the stem is affected	Hollow butt with more than a half of the circumference of the stem affected and with significant advanced decay
5. Fruiting Bodies		Fruiting bodies on lower bole
Stem Failures		
1. Wounds	Scar with wood not deeply gouged	Scar with wood deeply gouged, possibly fractured
2. Fruiting Bodies	One or two small fruiting bodies in upper stem	Fruiting bodies along much of the stem
3. Forks	Forks and crooks	
4. Twin Stems	Small twin stems	Large twin stems joined part way up stem
5. Leaning Tree	Old lean, upper section of stem growing vertically	Recent lean, soil around tree cracked or heaving indicating recent movement
Top and Branches		
1. Dead Branches	Small dead branches	Large dead branches, especially if broken and lodged in other branches

2. Broken Tops	Broken top with adjacent branches healthy	Broken top with adjacent branches unhealthy
3. Spike Tops	Spike top not weakened by woodpeckers or decay	Spike top weakened by woodpeckers or decay
4. Multiple leaders	Small, volunteer tops	Heavy U-shaped branches formed when side branches turn up to become leaders

Table 3. Guidelines for evaluating the **failure potential** of specific defects

Deciduous Species

The following Table provides guidelines for making failure potential judgements; it is not a "magic formula" that provides definitive answers to hazard rating. Two extremes, low and high, are noted, corresponding to a **failure potential** of 1 and 3, respectively. Variations from these extremes (**failure potential 2**) will vary from tree to tree and can be judged only by the investigator on the site.

DEFECT	LOW FAILURE POTENTIAL	HIGH FAILURE POTENTIAL
Whole Tree Failure		Dead trees Leaning tree growing on site with a high water table
Root and Butt Failure		
1. Soil		Cracks or heaving in soil around tree indicating recent movement
2. Roots	A few small severed roots	Roots on one or more sides of the tree severed or badly injured
3. Wounds	Young small basal scars with little or no associated advanced decay	Basal scar with extensive associated advanced decay
4. Wounds	Scar with little or no wood injury	Scar with wood deeply gouged, possibly fractured
5. Fruiting Bodies		Fruiting bodies on lower bole
6. Butt Rot	Decay in butt confined to small, localized area	Decay extensive throughout the heartwood in the butt
7. Hollow Butt	Hollow in butt confined to a small section of stem	Hollow in butt affecting a major portion of the circumference of stem
8. Mycelium	Mycelium below the bark near the ground line confined to less than a half the circumference of the stem	Mycelium below the bark near the ground line affecting most of the circumference of the stem

9. Cankers	Butt cankers with the bark still intact	Butt cankers affecting a major portion of the circumference of the stem and with much of the canker tissue dead
Stem Failures		
1 Wounds	Young small scars with little or no associated decay	Large scars affecting major portion of circumference of stem and with extensive associated advanced decay
Wounds	Scar with little or no wood injury	Scar with wood deeply gouged
2. Heart Rot		Extensive heart rot, hollow stem
3. Fruiting Bodies	One or two small fruiting bodies in upper stem	Numerous fruiting bodies along length of stem
4. Burls	Burls or galls	
5. Leaning tree	Old lean, upper section of stem growing vertically	Recent lean, soil around tree cracked or heaving indicating recent movement
Top and Braches		
1. Dead Branches	Small dead branches	Large dead branches
2. Dead Top	Recent broken small top. Branches associated with top are healthy	Old broken top with extensive heart rot (Fig. 14). Branches associated with top unhealthy
3. Decay	Branches with little or no decay associated with crotch	Extensive decay in stem and lower portion of large branches
4. Branch Crotch	Sound crotch	Split crotch

AIDS IN TREE INSPECTIONS

1. Determining age of scars:
   Drill callus tissue on margin of wounds with increment borer and count rings added after injury occurred.
2. Ascertaining stain and decay in heartwood:
   Most wood decay fungi cause a discoloration of the wood in the early stages of the infection and a disintegration of the tissues in the later stages of infection. Stain or decay is readily seen in a stem increment core or in wood chips if a power borer is used to sample the stem. Adjacent sound trees can be cored to compare normal heartwood with suspected decay and stain.
3. Hollow butts:
   If the hollow in the butt of a tree is large, it frequently can be detected by striking the tree with the head of an axe. Boring with a hand or power borer is a more reliable method of detecting hollow butts.
4. Dwarf mistletoes:
   Most dwarf mistletoe species are confined to specific tree species and

to certain regions. For explanations, see dwarf mistletoes in the section "Causes of Tree Failures."

5. Trees may have a large part of their root system destroyed by fungi and not exhibit distress symptoms in their crowns. All trees on the margins of root rot centers should be examined for mycelium on the root collar and upper portions of the roots and should be drilled. Only trees showing decay or stain (Fig. 25) in the lower butt when drilled or with advanced decay in the major roots should be removed.

TREE HAZARD REDUCTION AND ABATEMENT

SITE SELECTION AND MANAGEMENT

Sites proposed for new campground and day-use development should be intensively inspected for hazard trees and abatement undertaken before facilities are installed. Old-growth stands usually contain many trees with hidden defects that will continue to present safety problems throughout the life of the installation. Therefore, where possible, these stands should not be considered for future campground and day-use development

In addition to rating and treating defective trees, site managers can manipulate site usage and reduce hazards. In areas subject to heavy snow and ice loads, recreation sites may be closed during the winter months or use areas may be confined to treeless, open sites. Those sites known to have a high water table during the wet season should have restricted access when the soil is saturated and the trees are most likely to be windthrown. In sites subject to wind from a constant direction, for example, those adjoining large clearings or next to lakeshores, defective trees should be removed from the windward side if they could cause damage if they failed.

PRIORITIES FOR HAZARD ABATEMENT

Except in unusual circumstances, first priority for hazard treatment must be assigned to dead trees and to those having a **hazard rating** of 6 and 5. It must be appreciated that some trees with minor defects will always be left because of low **hazard ratings** and aesthetics. These trees should be given particular attention in future site inspections as their **failure potential** will gradually increase with time and/or subsequent site development may change their **failure impact**.

ALTERNATIVES TO TREE REMOVAL

When contemplating hazard abatement action, consider the effects that removal of defective trees will have on surrounding site aesthetics. Whole tree removal is irreversible. Consider the feasibility of some alternative methods for alleviating the hazard. In certain circumstances, the following may be preferable to tree removal:

Altering the target - such as closing sites, relocating tables, fencing areas

Tree work - such as limb removal, topping, bracing and cabling, filling cavities

TREE REMOVAL

When it is necessary to remove a defective tree, felling should be done only by trained personnel. Poor felling, aside from the danger to the unskilled operator, can result in extensive damage to surrounding trees, making them unsightly and providing entrance courts for wood decay fungi, thereby compounding the hazard problem. If the number and condition of the felled trees warrants, arrangements should be made to recover the commercial values. Otherwise, attempt to find a use for felled trees on site; for example, firewood, protective barriers, educational features.

TREE FAILURES

In the following sections, types of tree failures are discussed in a generalized context of tree structure - **Root and Butt, Stem, and Top and Branches** - in relation to their relative contributions to tree hazard. Causes of failures are covered in considerable detail under two categories **"Non-pathological Causes of Tree Failures" and "Pathological Causes of Tree Failures."**

1. TYPES OF TREE FAILURES

A. Root and Butt

Root and butt defects account for the major portion of the hazard trees in recreation sites. Roots provide the structural support and anchorage for trees; consequently, defects in roots frequently result in whole-tree failures (Fig. 23). Cracks and heaving in the soil surrounding a tree indicate structural weakening in the root system and a high potential for failure.

B. Stem Breakage

Most stem failure results from breakage caused by extensive heart rot (Fig. 2), or large fungus or dwarf mistletoe cankers (Figs. 50 and 53). Mechanical failures can be a problem in deciduous species because of their spreading form, and in conifers where twin stems are allowed to reach a large diameter (Figs. 7 and 8).

C. Top and Branch

Large limbs, often associated with dead and broken tops on conifers, frequently break and fall. Deciduous species, because of their open, wide-spreading branch pattern, are more subject to branch failures than are conifers. Branches with a V-shaped crotch are more subject to breakage than are those with a crotch approaching 90 degrees. Witches' brooms (Fig. 51), caused by dwarf mistletoe and rust infections, which overhang camping pads and picnic tables, will be a hazard only if they are allowed to reach large sizes. Snow accompanied with high winds frequently results in extensive top and branch breakage.

2. CAUSES OF TREE FAILURES

Non-pathological Causes of Tree Failures

TREE FORM AND SPECIES

Generally, deciduous species are more prone to mechanical failures than are coniferous species because of their wide spreading, often irregular branching pattern. Most failures will occur at the crotch of the branch and stem; this is particularly true where heart rot is present in the stem and extends into the branch. Unlike conifers, failures in deciduous trees are most common during the summer when they are in full leaf. Form defects in conifers are forking (multiple leaders) and crooks (deviations from a straight stem).

WEATHER

Wind, snow and ice acting on points of weakness in trees are the most common cause of failures. Many hazards are removed by these agents during the winter months when the majority of recreation sites are closed to visitors; however, permanent facilities may be damaged. At any time during the year, under extreme storm conditions, even sound trees may be broken or toppled by wind or lightning. Such events are unpredictable and must be accepted as risks that usually cannot be controlled in a meaningful manner.

Not all failures occur during windy periods. Fatal accidents have occurred during periods of still air. These failures have usually been

Fig. 6
Extensive heart rot that entered the stem through a frost crack.

Fig. 5
← Frost crack in base of western hemlock.

associated with root, butt and stem rots, dead tops, or trees that have been weakened by previous storms.

LIGHTNING AND FROST CRACKS (Figs. 5 and 6)

Lightning striking a tree may cause only minor damage or its death. In the former, the **failure potential** will be low. However, where splitting and cracking is extensive, the tree should be considered for removal if it could cause damage to a target. Wood decay fungi frequently become established in lightning wounds, further weakening the tree.

Frost cracks are characterized by black raised lines on the bark in the lower bole (Fig. 5). They do not indicate a high **failure potential** unless they are associated with advanced decay (Fig. 6).

FORKED STEMS (Figs. 7 and 8)

Where a forked stem is allowed to reach a large diameter (Figs. 7 and 8), the potential for splitting at the crotch is high (Fig. 8); the time of

Fig. 7
Large forks, particularly if decay is present in the crotch, have a high failure potential.

Fig. 8
Large, forked western hemlock with extensive split in one fork.

failure is usually unpredictable. Decay in the crotch of forked stems, depending on the height of the fork, can often go unnoticed, but will seriously weaken the stem. One side of a forked stem should be removed, preferably when the tree is small.

WOUNDS (Figs. 9 - 13)

Wounds, where the wood has not be gouged to the point of structurally weakening the tree, do not create a hazard until the decay that becomes associated with them reaches an advanced stage. A period of at least 5 years, varying with tree species, is usually required.

During site construction, machinery can deeply gouge trees (Fig. 9), causing massive tissue rupture. These stems may fail at any time, creating a high hazard to any target in the path. Wood decay fungi will colonize wounds rapidly where the wood has been gouged.

Wounds caused by recreationists are a major contributing factor to potential tree hazard. Unthinking mutilation (Fig. 10) by chopping and hacking at the tree bark (Fig. 11) creates entrances for decay organisms (Fig. 12) that eventually weaken or kill the tree. Evidence of this is becoming more noticeable in many campgrounds.

Attachments to trees, for example, crossarms (Fig. 13) and cables, will in time deform and weaken the stem and provide entrance courts for wood decay fungi. Where more than half of the circumference of the stem of the tree has been affected, the potential for breakage is high.

Excavation during road construction and site development will frequently result in root damage. Where the major roots on one or more sides of the tree have been severed or badly injured the potential for failure is high. Also, severed and injured roots provide favourable entrance courts for wood decay fungi; bore the stem immediately above the roots that are more than 10 cm in diameter and injured 5 or more years previously to determine if decay fungi have become established.

Fig. 9
Wound caused by construction machinery.

Fig. 10
Wound on base of spruce caused by campers in a campground.

Fig. 11
Wound on base of western hemlock caused by campers in a campground.

Fig. 12
Section through a wound caused by campers which allowed entry of wood decay fungus.

Fig. 13
Overgrowth of this crossarm caused a severe weakening in the stem of Douglas-fir.

TOP AND BRANCH BREAKAGE (Fig. 14 and 15)

Dead tops (Fig. 54) and branches (Fig. 15) are not usually a high hazard until they have been weakened by decay, insects or woodpeckers; their condition is usually difficult to see from the ground. Remedial action should be considered if dead tops and branches are large enough to cause damage to a target in their path of fall. Branch breakage is more common in deciduous trees than in conifers.

Broken branches frequently become lodged in the crown of trees. These can fall at any time and, if large enough, must be considered a high hazard.

Snow and ice, usually combined with wind, are responsible for the majority of breakage in sound limbs and tops. In campgrounds open year round, overnight camping should be confined to open areas away from overhanging trees when heavy snowfalls are expected.

Broken tops provide a good entrance point for wood decay fungi (Figs. 14-15), and if more than 3 or 4 years old, frequently have associated heart rot. If branches immediately below the break (Fig. 15) show signs of decline, the heartwood is deteriorating and the top should be considered for removal if overhanging a target. A branch growing up to replace a broken top usually does not present a hazard as long as it remains healthy and free from decay at its point of attachment.

LEANING TREES

Trees leaning over a target should be examined closely for the cause of the lean. Those that have recently developed a lean should probably be removed immediately if a threat to a target. Examine the soil around the base of the tree carefully for cracks or heaving indicating recent movement. Trees that have been leaning for many years, on which the top has turned back to a vertical position, should be considered a low hazard except under conditions of heavy snow load, recent soil uplifting around the roots or decay in the butt. Leaning trees growing in areas with a high water table have a high potential to fail during wet, windy weather.

BURLS AND GALLS (Figs. 16 and 17)

Burls (Fig. 16) are abnormal swellings on the main stem or branches. They vary greatly in size, reaching up to a metre or more in length. The potential for failure is low unless the entire circumference of the stem is affected and decay or dead tissues are present over much of the burl.

Galls are localized branch or trunk (Fig. 17) swellings in which the bark tissues are affected with little or no damage to the underlying wood. The potential for failure is low if the gall tissues are living. Dead

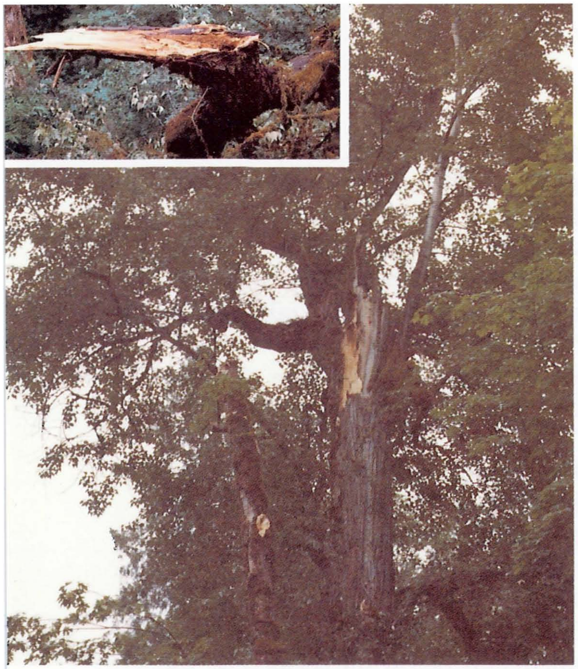

Fig. 14
This broken top on black cottonwood allowed wood decay fungi to become established in the heartwood.

Fig. 15
Dead branches and branches with poor vigor associated with dead top on Douglas-fir.

Fig. 17
Stem gall on aspen.

← Fig. 16
Stem burls on spruce.

galls, however, may be associated with extensive decay.

UNDERMINED ROOTS

Trees with undermined roots have a high potential for failure. This condition frequently occurs along streams, lakes and along road cuts where soil is eroded.

Pathological Causes of Tree Failure

Fungi, and in certain instances dwarf mistletoes, are responsible for the majority of pathologically induced failures. Some defects, such as rust, cankers and witches' brooms caused by dwarf mistletoes, are readily apparent to an observer. However, many defects, such as heart rots and root rots which cause very high failure potentials, are hidden to the casual observer. Detection of these defects will require careful examination and familiarity with tree defect symptoms.

All examiners of tree hazards should be aware of the considerable variation among tree species in susceptibility to deterioration by wood decay fungi. In general, deciduous species, western hemlock, and true firs (*Abies* spp.) have a rapid rate of deterioration following infection by wood decay fungi. Spruce, larch, Douglas-fir and pine have a moderate rate of deterioration, while western red cedar and yellow cedar have a low rate of deterioration following infection.

In the following section, pathological causes of tree failures are described according to the previously outlined types of tree failure.

DEAD TREES (SNAGS)

Tree mortality results from a variety of causes, ranging from root diseases to environmental stresses. Lacking the defence mechanisms of living trees, dead trees vary greatly in stability, depending on species and climate. They are subject to rapid colonization by wood decay fungi and attack by insects and woodpeckers. The time of failure and direction of fall is, for the most part, unpredictable. For these reasons, all dead trees should be judged as having a high failure potential and should be removed as soon as possible, **if there is a target in the vicinity.**

ROOT AND BUTT DISEASES

Root and butt rots are caused by a number of fungi and are responsible for one of the most serious defects affecting trees in recreational areas. They are usually difficult to detect in the early stages; crown symptoms (Fig. 22) usually do not become apparent until the root system is in an advanced stage of decay. Some trees fail when the foliage is still green, and the symptoms are not readily apparent to the

Fig. 18
Brown, crumbly heart rot caused by *Polyporus schweinitzii* in the butt of Douglas-fir.

Fig. 19
Polyporus schweinitzii fruiting body in the duff at the base of an infected tree.

Fig. 21
Old *Polyporus schweinitzii* fruiting bodies turn a uniform brown.

Fig. 20
← *Polyporus schweinitzii* fruiting body on the butt of Douglas-fir.

untrained observer.

The above-ground symptoms common to most root rots are first, a reduction in growth, followed by thinning and discoloration of the foliage (Fig. 22); this may occasionally be accompanied by a distress crop of cones. Death of the tree will usually follow within 5 years after crown symptoms become severe.

Root rot fungi spread from tree to tree at points of contact between diseased and healthy roots. Consequently, infected trees usually occur in groups, resulting in openings in the tree cover. Old openings frequently contain fallen trees (Fig. 23), with standing dead and dying trees around the margins (Fig. 24).

Five root rot fungi common in recreation sites in British Columbia are detailed in the following sections.

Polyporus schweinitzii (brown cubical butt rot) (Figs. 18-21)

Brown cubical butt rot caused by *Polyporus schweinitzii* (Fig. 18) is common in over-mature trees, particularly Douglas-fir and Sitka spruce; occasionally it occurs in young trees. This fungus frequently enters the tree through basal fire scars, spreading to adjacent trees at points of root contact to form infection centers.

Brown cubical butt rot is usually confined to the heartwood. Crown symptoms are rare. The most common indicator of the disease is stalked fruiting bodies on the ground around the base of the tree (Fig. 19) or shelf-like fruiting bodies on the butt of the tree (Fig. 20). These fruiting bodies are annual, developing in late summer and fall, but may remain in place for several years. When fresh, the upper surface is velvety and reddish-brown, often with concentric circles (Fig. 19). The margin is round and light yellow-green. The lower surface is yellow-green. When mature, the entire fruiting body turns dark brown (Fig. 21).

In the incipient or early stage, the decay is identified by a light yellow discoloration of the wood. In the advanced stage, the wood becomes brittle, breaking into large red-brown cubes (Fig. 18). A licorice-like odor is often associated with the advanced decay.

Trees that have fruiting bodies on their butt or in the soil around their base should be drilled near the gound line. Extensive heart rot indicates a high potential for windthrow or breakage near the base of the stem.

Phellinus weirii (laminated root rot) (Figs. 22-26)

Disease expression on conifers other than cedar.

Laminated root rot is a common cause of tree mortality and windthrow in young-growth stands throughout the Douglas-fir region of British Columbia. Damage is most severe where Douglas-fir is a major compo-

Fig. 22
Douglas-fir infected with *Phellinus weirii* root rot, show reduced height growth, and chlorotic, thin foliage.

Fig. 23
Windthrown Douglas-fir infected with *Phellinus weirii*. Most roots have been rotted off, leaving "root balls".

Fig. 24
Douglas-fir killed by *Phellinus weirii* root rot.

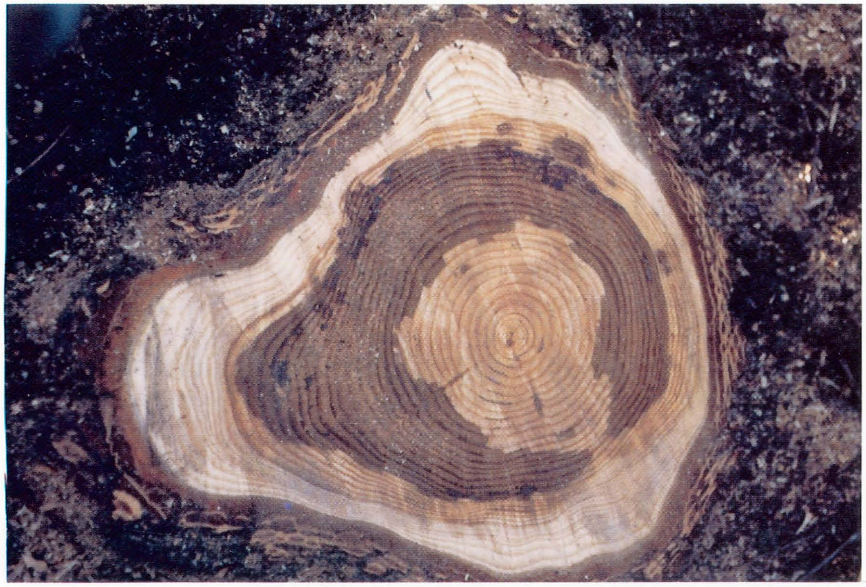

Fig. 25
Red-brown stain in butt of Douglas-fir caused by *Phellinus weirii*.

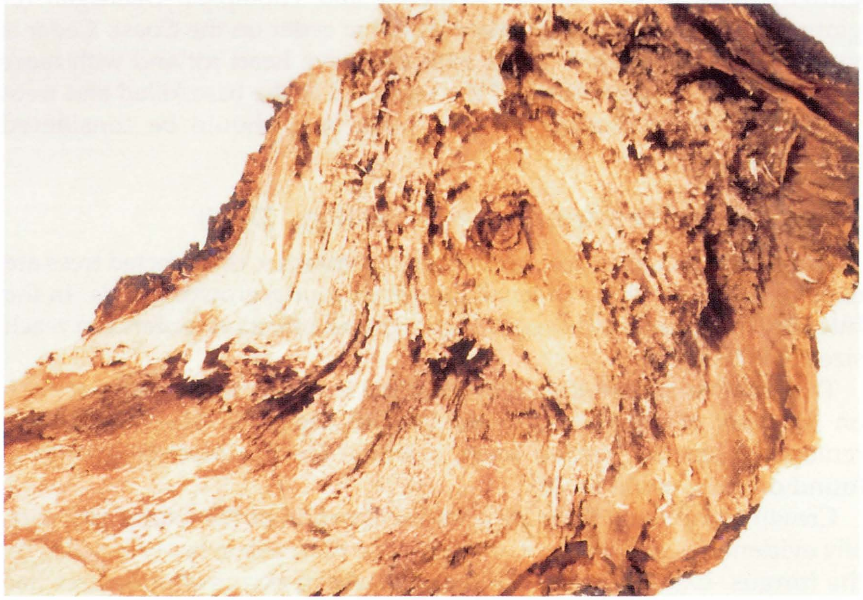

Fig.26
Laminated, pitted rot caused by *Phellinus weirii*.

nent of the stand.

The fungus spreads by root contact. The diseased trees occur in groups, root rot centers, which may occupy an area of up to a hectare. The fungus remains viable in infected stumps and roots for decades after the death of the tree, providing an infection source for susceptible tree species restocking the centers.

The first indications of the disease are a reduction in height growth, followed by thinning and discoloration of the foliage (Fig. 22). Old infection centers will usually contain fallen trees on which the roots have broken close to the root collar, forming "root balls" (Fig. 23). Dead and dying trees will usually be present on the margin of the openings (Fig. 24). Depending on tree size, the fungus may take several years to kill a tree. Consequently, many trees on the margin of disease centers will be infected but show no crown symptoms.

The early stage of the decay appears as a red-brown stain in the outer heartwood (Fig. 25). Later the stained wood becomes laminated (sheet-like) with many pits (Fig. 26). If stain or decay is found when the stem is drilled near the ground line, the root system is in an advanced stage of deterioration and the tree has a high potential to fail.

Disease expression on cedar

Phellinus weirii causes root and butt rot of cedar, particularly old-growth trees, in the Skeena, Kootenay and Thompson-Okanagan regions; it is found only to a limited extent in cedar on the Coast. Cedar is rarely killed by *P. weirii*. Trees with extensive heart rot and with more than half the circumference of the sapwood at the base killed and trees with the fungus fruiting on the lower bole should be considered hazardous.

Armillaria mellea ((Armillaria root rot) (Figs. 27-29)

Armillaria attacks all tree species. In coastal sites, the infected trees are usually found singly or in small groups in young-growth stands. In the Interior, the fungus kills trees of any age and infection centers can reach sizes of 0.25 hectares.

The first evidence of attack by Armillaria is usually a heavy flow of pitch on the bark of the stem near the ground (Fig. 27). When the bark is removed from the pitched areas, a white, fan-like mycelial growth is found on the wood (Fig. 28).

Crown symptoms, thinning and discoloration of the foliage, are usually evident when 50 per cent or more of the root system has been killed by the fungus. Extensive decay of the root system occurs after the tree has been killed; hence, removal of trees with advanced crown symptoms or extensive basal resinosus will avoid any hazard.

Fig. 27
Pitch on the butt of Douglas-fir infected with *Armillaira* root rot.

Fig. 28
Armillaria mycelial fans below the bark in the butt of an infected Douglas-fir.

Fig. 29
Fruiting bodies (mushrooms) of *Armillaria mellea*.

Armillaria fruiting bodies are mushrooms that develop in clusters at the base of infected trees (Fig. 29), usually in September and October. They have a honey-colored cap with small dark scales, white gills, a yellow-brown or rust-tinged stem and an inconspicuous ring surrounding the upper part of the stem.

Fomes annosus (annosus root rot) (Figs. 30-32)

Annosus root and butt rot is common in over-mature and young-growth trees in coastal regions and in the interior wet belt. Although the fungus attacks most tree species, hemlock is particularly susceptible to attack.

Initial infection occurs through spore infection of fresh-cut stumps or fresh wounds. Local tree to tree spread is via root contacts. The fungus survives for many decades in infected stumps and roots providing an infection source for new trees restocking the infection center.

Mortality and crown deterioration are rare in *annosus*-infected trees; the fungus is confined primarily to the heartwood. Windthrown trees (Fig. 30) may on occasion serve to pinpoint infection centers, but frequently the problem will not be found until trees are bored or cut.

Early stages of decay vary with tree species. For example, in hemlock, the wood becomes yellow-brown, while in Douglas-fir, the stain is distinctly red-brown. Advanced decay has a yellow-stringy texture, often spotted with black flecks (Fig. 31).

Fruiting bodies of *Fomes annosus* are relatively common on the coast (Fig. 32), being found on the bottom of infected roots, the sides of infected stumps and the underside of downed trees and upturned roots. They are flat to shelf-like; the upper surface is grey-brown to black and the lower surface is white to cream with small, regular pores.

Polyporus tomentosus (red-brown root and butt rot) (Figs. 33-36)

Red-brown root and butt rot caused by *P. tomentosus* is found most frequently in the spruce-pine forests in central and northern British Columbia. Damage (mortality, windfall and butt rot) is most severe in white and black spruce, but *P. tomentosus* has been found attacking most conifer species. The fungus spreads from tree to tree at points of root contact; consequently, diseased trees occur in groups and mortality results in stand openings. Mortality is most common in trees more than 50 years old, but trees as young as 20 years old have been killed. Windthrow may occur before the trees have been killed. Heart rot may extend several metres up the stem from the butt.

Root infection by *P. tomentosus* results in reduced leader and branch growth, followed by thinning of the foliage (Fig. 33) and death of the tree.

Fig. 30
Windthrown western hemlock with roots decayed by *Fomes annosus*.

Fig. 31
White stringy decay with black flecks caused by *Fomes annosus*.

Fig. 32
Fomes annosus fruiting body.

Fig. 33
Stand opening caused by *Polyporus tomentosus* root rot.

Fruiting bodies may be found on the base of the stem (shelf-like) or on the ground (stalked) (Fig. 34) around infected trees in August and September. They are annual and leathery. The upper surface is yellow-brown to rust-brown and hairy. The lower surface is lighter yellow-brown and pored. The whole fruiting body becomes dark brown with age. Fruiting bodies on or around trees indicate that 3 or more metres of stem rot may be present.

The advanced decay caused by *P. tomentosus* has large, elongated to rectangular spindle-shaped pits, separated by red-brown to brown firm wood (Fig. 35). The cross section of an infected stem has a honeycomb appearance (Fig. 36). The early stage of the decay is characterized by a dark red-brown discoloration of the wood.

STEM DISEASES

Decay fungi are the major cause of stem defects in recreational sites. However, canker-causing diseases and dwarf mistletoes (detailed under Top and Branch Diseases section following) also cause weaknesses in the stem, resulting in failures.

Stem decays are caused by a wide variety of fungi. Those commonly found in recreational sites in British Columbia, with their principal tree hosts, are outlined below. For a more extensive listing of tree diseases and their descriptions, refer to "Common Tree Diseases of British Columbia" by R.E. Foster and G.W. Wallis, available from the Pacific Forest Research Center, 506 West Burnside Road, Victoria, British Columbia V8Z 1M5.

Fig. 34
Polyporus tomentosus fruiting bodies.

Fig. 35
Advanced decay caused by *Polyporus tomentosus* in white spruce (*Picea glauca*) illustrating large, elongated pits.

Fig. 36
Cross section through decay caused by *Polyporus tomentosus* illustrating the honeycomb appearance.

Stem decay fungi gain entrance to a tree through wounds, broken tops and branches. Growth of the fungus in the stem occurs primarily in the heartwood. A stem may lose an appreciable percentage of its heartwood without being significantly weakened, provided the outer shell of wood remains intact and healthy. In trees with extensive heart rot, particularly in the butt, or where the decay has gained entrance through a scar and is encroaching on the sapwood, the potential for failure is high. Sap rot is found most frequently in dead trees, but it may also occur where the sapwood has been killed by causes other than fungi. Sap rot in living trees occurs more frequently in deciduous trees than in conifers. Where sap rot has killed more than half the circumference of the stem, the tree has a high potential for failure.

The number, location and size of fruiting bodies on the stem of a tree are indicative of the extent of decay in the heartwood. However, the amount of decay associated with fruiting bodies varies greatly among species of fungi. For example, a single fruiting body of *Fomes officinalis* on a tree indicates that most of the wood volume has been destroyed. On the other hand, decay may extend only a few metres on either side of a small *Fomes pini* fruiting body. The presence of numerous fruiting bodies along the length of the stem (Fig. 37) is indicative of a high failure potential.

Heart rots tend to be confined to the stem in conifer species. In deciduous trees, heart rots frequently extend into the base of large branches. Branches so affected have a high potential for failure at the crotch.

Heart rot fungi, infecting through broken tops 7 cm and larger in diameter, frequently advance rapidly down the stem, particularly in deciduous species. Large branches adjacent to broken tops (Fig. 14) will often tear away when heart rot reduces the stem to a thin shell.

Fomes pini (white-pitted rot) (Figs. 37-40)

White pitted rot (Fig. 40), caused by the fungus *Fomes pini*, is found primarily on Douglas-fir, Sitka spruce, white spruce, western larch, true firs and western hemlock throughout most of the province. Fruiting bodies are shelf-like, woody and perennial (Figs. 37, 38 and 39). The upper surface is brown through black and the lower surface is brown with irregular pores. They frequently form adjacent to branch stubs (Fig. 38).

The following rule of thumb may be used when estimating the extent of decay.

In stands less than 100 years of age, heart rot extends up to 3 metres above and below the highest and lowest fruiting body; in stands 100 to 200 years, 4 metres; stands 200 to 300, 6 metres, stands 300 to 400 years, 9

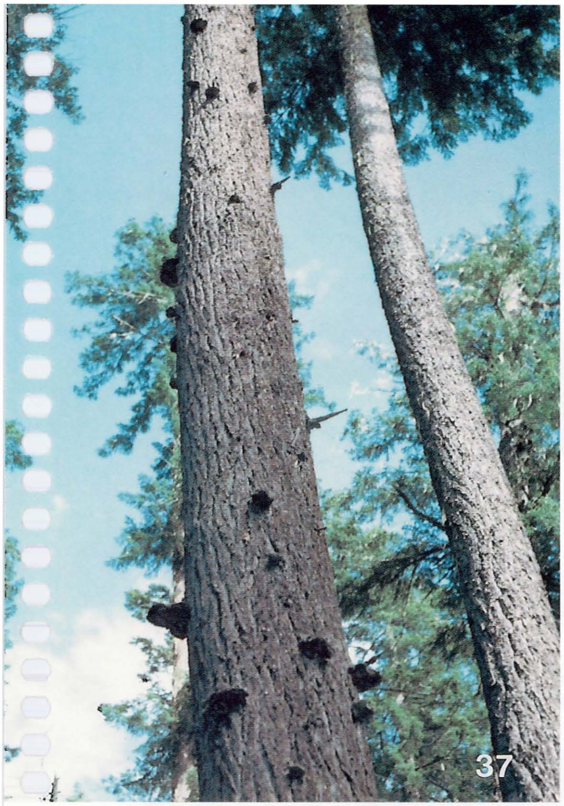

Fig. 37
Fomes pini fruiting bodies along the length of western hemlock.

Fig. 38
Fomes pini fruiting bodies on branch stub of western hemlock.

Fig. 39
Fomes pini fruiting body.

Fig. 40
White pitted rot caused by *Fomes pini*.

Fig. 41
Echinodontium tinctorium fruiting bodies.

Fig. 42
Red-brown stringy trunk rot caused by the Indian paint fungus, *Echinodontium tinctorium*.

metres, and stands over 400 years, 11 metres. When heart rot is extensive, fruiting bodies will be found along much of the length of the stem (Fig. 37).

Echinodontium tinctorium (Indian paint fungus) (Figs. 41 and 42)

Brown stringy trunk rot (Fig. 42), caused by the Indian paint fungus, occurs most frequently on western hemlock and the true firs. Although primarily found in the Interior, it occasionally occurs on the coast. Fruiting bodies are hoof-shaped, hard, woody and perennial (Fig. 41). The upper surface is fissured and dark grey through black. The lower surface bears grey through brown, long, downward pointing spines. Fruiting bodies are usually associated with branch stubs. Substantial amounts of decay are indicated by a single fruiting body. Even when fruiting bodies are confined only to a portion of the stem, it can be assumed that most of the heartwood is destroyed. The advanced decay is brown and stringy with rust-colored flecks or streaks (Fig. 42).

Fomes pinicola (brown crumbly rot) (Figs. 43 and 44)

Brown crumbly sap rot (Red Belt fungus), caused by the fungus *Fomes pinicola,* attacks most coniferous species and is found occasionally on deciduous trees. Fruiting bodies are usually found on dead trees, but may occur on living trees associated with dead wound tissues. The fruiting bodies are hoof-shaped, shelved, hard, woody and perennial (Fig. 43). The upper surface is grey through brown to black, frequently with an orange-red rounded margin. The lower surface is white to cream, with small, regular pores. In the advanced stage of decay, the wood breaks down into small, brown cubes which are soft and crumbly (Fig. 44). Relatively thick white felts of mycelium may form in the cracks between the cubes.

Fomes igniarius (white trunk rot) (Figs. 45 and 46)

White trunk rot, caused by *Fomes igniarius*, is found primarily on aspen. Fruiting bodies are hoof-shaped, hard, woody and perennial (Fig. 45). The upper surface is deeply zoned grey-black to black. The lower surface is brown with small, regular pores. The presence of a single fruiting body indicates a substantial volume of decay (Fig. 46).

Fomes fomentarius (white spongy trunk rot) (Figs. 47 and 48)

White spongy trunk rot is found in a number of deciduous species, but is most common in birch. Decay first appears as a slight brown discoloration. Wood with advanced decay is yellow-white, soft and spongy, and

Fig. 43
Hoof-shaped fruiting body of *Fomes pinicola*.

Fig. 44
Brown crumbly rot caused by *Fomes pinicola*.

Fig. 45
Fomes igniarius (white trunk rot) fruiting body on aspen.

Fig. 46
Yellow-white spongy rot caused by *Fomes igniarius* in aspen.

frequently contains brown to black zone lines (Fig. 48). Small radial cracks filled with yellow mycelium may develop, giving the decay a mottled appearance.

Fruiting bodies are hoof-shaped, woody or leathery and perennial (Fig. 47). The upper surface is zoned grey to brown or grey to black, smooth and with a thick crust. The lower surface is brown with small, regular pores (Fig. 47). Fruiting bodies are found most usually on dead trees; when present on living trees, they are usually associated with extensive heart rot.

Pholiota destruens (yellow laminated butt rot) (Fig. 49)

Yellow laminated butt rot is the most destructive decay of black cottonwood in British Columbia. In the early stages, the decay is difficult to detect, appearing as buff to dark brown streaks in the heartwood. In the final stages of decay, the wood becomes uniformly yellow to tan, and readily separates along the annual rings.

Fruiting bodies are large mushrooms (Fig. 49) growing on the surface of scars or breaks in living trees or on the broken ends of fallen stems from mid-summer to late fall. When fresh, the cap is light brown and covered with white scales; the gills are white drying to dark brown. The stem is white to light brown and covered with white scales; the annulus is white. The fruiting bodies are usually associated with extensive decay.

Cankers (Fig. 50)

Some fungi invade the stem and branches, producing localized areas of infection in the bark and wood. These are referred to as cankers (Fig. 50). Cankers may girdle the stem near the top of the tree, resulting in top killing, or below the crown, resulting in death of the tree. Branch death also results from girdling by canker fungi.

Most cankers are small and cause little if any weakening of the stem or branches. However, where more than half of the circumference of the stem is affected and the canker tissues are dead (Fig. 50), the potential for failure is high, particularly if decay has become established. Cankers are common on deciduous species, particularly poplars, and frequently have decay associated with them.

TOP AND BRANCH DISEASES

Wood Decays

Wood decays, as detailed under Stem Diseases above, are one of the major factors contributing to failure in the tops and branches of trees in recreation sites. Decline in the vigor of branches associated with old

Fig. 47
Fomes fomentarius fruiting body on birch.

Fig. 48
White spongy trunk rot caused by *Fomes fomentarius* in birch.

Fig. 49
Pholiota destruens fruiting body on black cottonwood.

Fig. 50
Fungus stem canker.

broken tops indicates that heart rot is in an advanced stage and the failure potential is high. In deciduous species, heart rot frequently moves into the base of large branches, resulting in a high potential for failure at the branch crotch.

Dwarf Mistletoes (Figs. 51-55)

Dwarf mistletoes are parasitic flowering plants (Fig. 55) capable of survival only in living coniferous trees. With the exception of cedars, juniper and yew, all conifers in British Columbia are subject to attack. Infection of western hemlock is confined to the Coast, while infection of Douglas-fir is found only in the Interior.

Dwarf mistletoe infections are recognized by swellings on the main stem (Fig. 53) and branches (Fig. 51) and by witches' brooms (Fig. 51). Heavy infections may result in death of the tree or parts thereof (Fig. 54). Dead tissues, resulting from parasitic action of dwarf mistletoe, provide an entrance point for wood decay fungi (Fig. 52). Swellings affecting a major portion of the circumference of the stem and containing significant dead tissue have a high potential for breakage. Witches' brooms will become a hazard only if they are very large and heavy, causing the branch to break and fall on a target.

Cankers

Canker diseases, as detailed under Stem Diseases above, may occur frequently on branches, causing their death. The degree of hazard will be dependent on size and location of the affected branch.

TREE FAILURE REPORT

Tree failures are due to a wide variety of causes, varying with species, age and site conditions. Unfortunately, in British Columbia, very few records of failures and their causes have been kept. Therefore, data for developing a hazard rating system based on defects common to British Columbia and specific to areas within the province are unavailable.

Tree failures in recreation areas in the Pacific Northwest of the United States have been recorded systematically for the past 8 years. Together with selected input from Idaho and California, these data have been compiled in a report by the Forest Insect and Disease Management Division, United States Forest Service, Portland. The causes of failures appear to closely approximate those in British Columbia and have thus been used as a basis for the material presented on tree defects.

In order that a comparable bank of information specific to British Columbia conditions can be accumulated, failures in our developed areas

Fig. 51
Dwarf mistletoe witches' broom.

Fig. 52
Broken top, dead branches and large witches' brooms caused by dwarf mistletoe. Arrow points to a fruiting body of the wood decay fungus, *Fomes pinicola,* which entered through the dwarf mistletoe infected branch.

Fig. 53
Stem swelling caused by dwarf mistletoe on hemlock.

Fig. 54
Dead trees, dead tops and dead branches, and large witches' brooms caused by dwarf mistletoe.

Fig. 55
Dwarf mistletoe plant on western hemlock.

FORM 2

TREE FAILURE REPORT

District: ____________ Park: ____ Location: ________ Officer: __________

Time of Failure: ______________________ Site open for use: Yes ___ No ___

hour day month year

Tree and Stand

Tree species: ________________

Approx. diameter (cm) ____________

Approx. age ________________

Stand age class: ___ overmature

___ mature

___ young growth

___ all aged

Class of Mechanical Failure

___ upper bole (top half)

___ lower bole

___ butt (bottom 2 metres)

___ branch

___ root, including uprooting

Tree Defect Leading to Failure

___ tree dead (snag)

___ dead top

___ root or butt rot

___ stem rot

___ wound-type ____________

___ dwarf mistletoe canker

___ twin stems

___ cracks or splits

___ leaning

___ other ________________

___ unknown ____________ none

Contributing Factors

___ wind

___ snow

___ soil bank erosion

___ erosion (other)

___ lightning

___ soil saturation

___ shallow rooting

___ other ________________

____

___ unknown ____________ none

Consequences

None: ________________

Cleanup work only required: ________

Property damage: (describe giving approx. value): ________________

____

____

Injuries (describe and note if medical attention was required): ____________

____

____

____

Comments: ____

____

____

Record only failures capable of inflicting damage or injury. **Do not** report the death of a tree or parts of a tree unless it fails. Trees, or parts thereof, removed prior to failure should not be reported.

and their probable causes should be recorded on the form opposite (Form 2) and submitted to Provincial Park System Headquarters. Form 2 is compatible with the United States Forest Service form and, as such, can be included in their data management system from which data for examination of individual species, sites and other information can be retrieved.

Information recorded on Form 2 is cumulative. It is anticipated that over the next 5 years sufficient data will be gathered to allow meaningful comparisons to be made. In this context, the form is a request for information and, as such, does not have the priority of Form 1, which is the basis of legal documentation in the system. However, please make an effort to utilize the Tree Failure Form as it will ultimately improve the tree hazard control program.

GLOSSARY

Abatement: diminishing or modifying the hazard to life and property created by defective trees.

Basal: see butt; usually considered the bottom 2 metres of the stem.

Bole: the trunk of a tree.

Bracing: strengthening or supporting a weakened or defective tree.

Burl: large woody growth, often spherical in shape, usually on the stem of a tree (Fig. 16).

Butt: the lower 2 metres of the stem of a tree.

Callus: the tissue that develops around a wound on the stem or root.

Canker: an area of dead tissue in a woody stem caused by fungi, bacteria or dwarf mistletoes. It is marked by sloughing of tissue that leaves an open wound surrounded by zones of callus (Fig. 50).

Canker face: the area of dead tissue in a canker (Fig. 50).

Chlorotic: yellowing of green foliage due to a disease or mineral deficiency.

Conk: the fruiting body or spore-producing structure of a wood decay fungus (see fruiting body); forms on the external surface of the host (Figs. 37, 41, 43).

Crown: the branch- and foliage-bearing portion of a tree.

Defect: a fault or point of weakness in a tree caused by non-pathological or pathological agents.

Entomological: pertaining to insects.

Forks: formed when two or more leaders develop following the death of the original leader.

Fruiting body: in the higher fungi, the reproductive structure that bears the spores; usually forms on the external surface of the host (see conk).

Fungi: a group of lower organisms that lack chlorophyll and therefore cannot produce their own food; must depend on a host to produce their food.

Gall: small, local swelling on the stem or branch of a tree caused by fungi, bacteria, insects or physiological disorders (Fig. 17).

Heart rot: decay in the heartwood (center) of a tree.

Heartwood: the central, usually dead, wood of the stem and roots of a tree. In some species, e.g., Douglas-fir, cedar and larch, the heartwood has a distinctive coloration.

Host: as used here, a plant or tree that furnishes sustenance for, or harbors, another organism; e.g., a fungus.

Mycelium: the vegetative portion of a fungus that penetrates the wood, grows on the bark and through soil to spread disease.

Root collar: that portion of a tree where the roots merge from the stem at or near the ground line.

Sap rot: decay in the outer living zone of wood below the bark.

Sapwood: outer living zone of wood below the bark.

Spike top: dead top with few if any branches remaining.

Stain: as used here, discoloration in the wood caused by wood decay fungi usually (incipient or early stage of decay where the wood has not started to break down). Chemical interactions will, on occasion, cause discoloration in wood in trees.

Target: persons or property that may be damaged if a tree fails.

Tree wound: an injury in which the bark and sometimes the wood has been removed from the roots, stem or branches. Wounds serve as points of entry for wood decay fungi.

Volunteer top: new leader that forms when a lateral branch turns up following the death of the original leader.

ADDITIONAL READING

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