HOW TO DETECT, ASSESS AND CORRECT HAZARD TREES IN RECREATIONAL AREAS

Minnesota Department of Natural Resources

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Statement of support:

The production of this manual was partially funded by the United State Forest Service - State and Private Forestry - Northeast Area.

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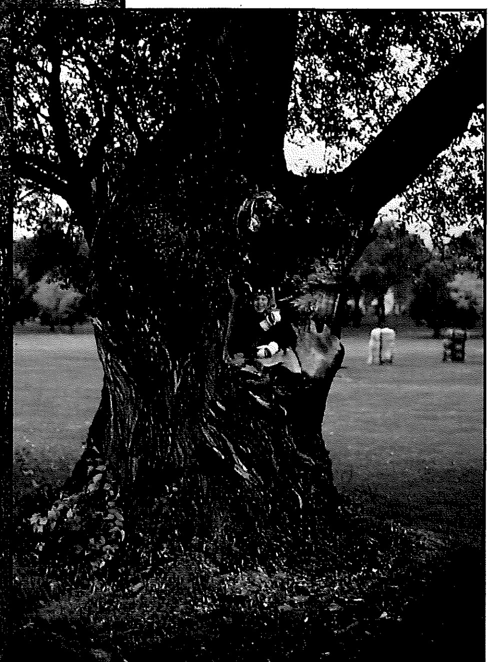
A hazardous situation requires both a defective tree and a potential target. Here the dead oak could fall on the picnic table.



Large, old, defective trees often attract people. They may have historic or sentimental value or just an intriguing character.

Who could predict this failure? Once an assessment program is in place, the majority of defective trees are detected and removed.

INTRODUCTION

Over the years, the increase in both leisure time and society's affluence has created tremendous pressure on recreational facilities. Visitors seek a pristine, wooded recreational facility, but recreation activities themselves can induce or intensify detrimental changes in forest and shade trees. Intensive recreation activities, such as camping, can cause tree damage by altering the tree's natural environment, or by directly damaging roots, stems and branches. These changes can lead to the development of hazard trees which pose a safety risk for visitors to recreation sites.

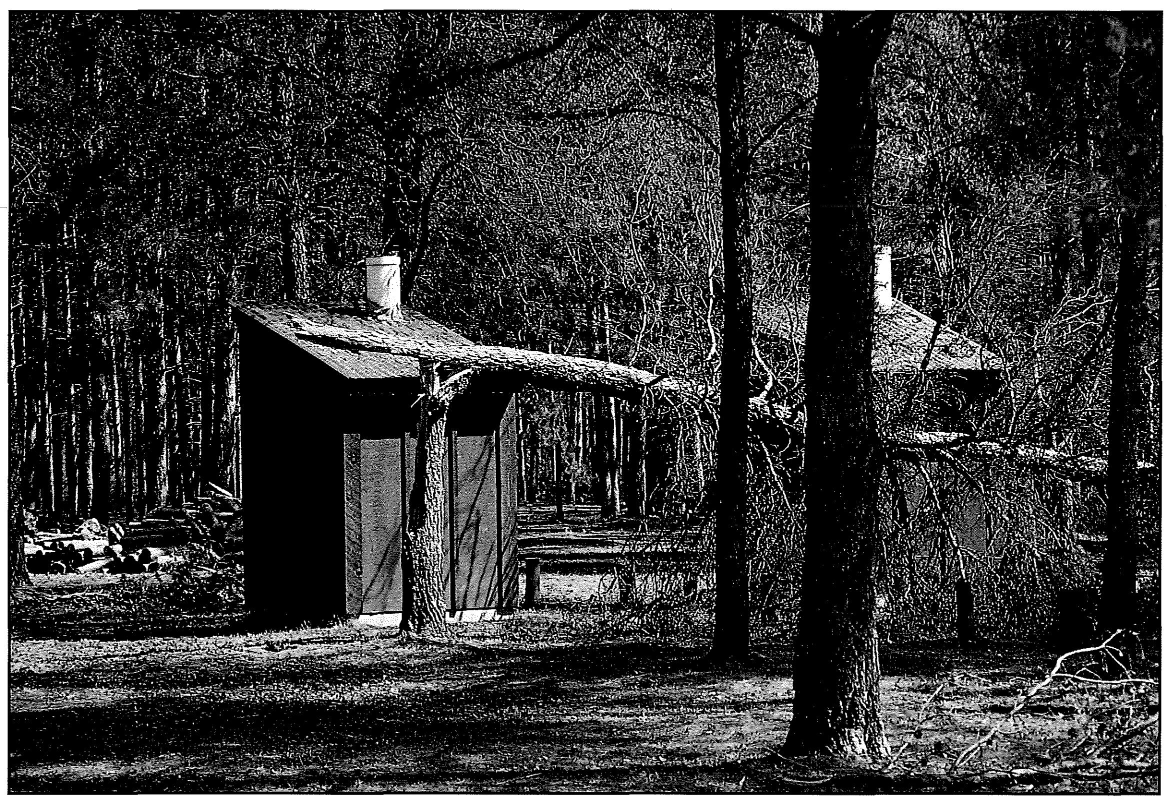
Just what is a hazard tree? A hazard tree is defined as any defective tree, or tree part, that poses a high risk upon its failure or fracture to cause injury to people or damage to property. A hazard tree has one or more defects which decreases its structural integrity and gives it an increased potential for failure. Defects that are visible or detectable include cracks, decayed wood, weak branch unions, cankers, poor tree architecture, root problems and dead trees or branches.

A defective tree is not considered hazardous unless there is a nearby target that it could hit. A target could be a person, vehicle, tent, building, picnic table, campfire ring, recreation equipment and so on. The term target area is used to describe an area where people or their equipment are likely to stop and congregate. An individual campsite is an example of a target area. By definition, **a hazard tree = a defective tree plus a target.**

Recreation site managers are in the unenviable position of trying to preserve a recreation site's natural setting while trying to provide reasonable public safety by identifying and then correcting hazard trees. Some tree failures can be predicted on the basis of identifiable defects; some failures cannot be predicted. There will be failures during severe storms that have nothing to do with tree defects. Even the most experienced and knowledgeable arborists admit that the processes that contribute to tree failure are not clearly understood. There are significant unknown or undetectable interactions occurring within forest and shade tree communities that may result in hazard trees.

All hazard trees can not be detected, corrected or eliminated. However, trained tree inspectors implementing a hazard tree management program can help make a recreation site reasonably safe while preserving its natural setting. This manual, then, provides the framework for a hazard tree management program which consists of regular and systematic inspections based on readily identifiable tree defects. It will help reduce the uncertainties in identifying potentially hazardous situations. The manual establishes guidelines by which defective trees are judged, provides a process for rating trees and sites, suggests corrective actions to remedy identified hazardous situations, and, summarizes tree care actions to help prevent the occurrence of hazard trees. Finally, the manual provides a form that documents the inspection process and provides a record of corrective actions.

Unpredicted tree failures due to severe storms. Even trees with no visible signs of defect can fail.



POLICY

The Department is authorized by law to provide sites for public recreation and to manage these sites for their natural resources. It is the Department's policy to try to preserve the natural beauty of its recreation sites while providing for reasonable public and employee safety on intensively used recreation sites and administrative sites by detecting and correcting situations involving hazard trees insofar as it is feasible within the constraints of the Department's resources.

Inspections, maintenance and corrective actions will accomplish this goal. On an annual basis, trees in drive-in campsites in developed campgrounds will be evaluated and corrective actions taken. Every other year, trees in picnic areas, buildings and facilities in developed campgrounds will be evaluated and corrective actions taken as appropriate. Trees on public water accesses, administrative sites, day-use areas, parking lot peripheries and near buildings will be evaluated less often. For these sites, special trips or visits for the sole purpose of hazard tree inspections do not have to be made. Instead inspections and corrections will be done as a part of the regularly scheduled maintenance activities for the sites.

Not covered by this policy are trees along trails, trout streams and forest roads and trees in old growth/forest areas and "wilderness experience" areas. The document, "How To Detect, Assess And Correct Hazard Trees In Recreational Areas" establishes procedures to use in detecting and correcting hazard trees.

DETECTION

A. Inspections

An inspection is a systematic method of examining and rating trees. The purpose of a hazard tree inspection is to detect defective trees in target areas, assess the severity of the defects and recommend corrective actions before tree failure occurs.

The first step of an inspection is to decide which areas should be inspected. In general, inspection priorities are based upon human mobility within the target area, the duration of site occupancy and the level of site maintenance. Each agency has developed priorities for the type of sites for which it is responsible. See section B, "Scheduling inspections."

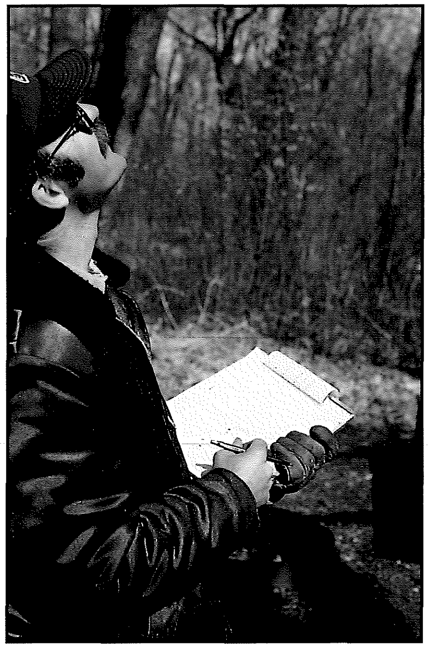
The second step is to choose trained people to do the inspection. All inspectors and site managers should be familiar with the tree species found on that site, tree defects and their potential for failure.

Choosing the inspection method is the next step. At the discretion of the site manager, one of three methods can be used to inspect the sites:

1. On campsites, picnic areas and near buildings in campgrounds, it is recommended that a 2-tiered approach be used. A 2-tiered approach involves two teams of trained inspectors. The first team inspects trees for defects, maps hazard trees and makes recommendations for the correction of hazard trees. The second team inspects **only** the hazard trees identified by the first team and makes the final decisions regarding correction of the hazard trees. The final authorization for corrective actions lies with the site manager.

2. A team approach may also be used on campsites, picnic areas and near buildings in campgrounds. The inspection is accomplished in one visit to the site. The team is composed of the site manager and one or more trained inspectors. In this method, the manager receives the benefit of rating the potentially defective trees but the team has to inspect all the trees, not just the hazard trees. This approach saves time because there is only one inspection team, but it is more time consuming for the site manager.

3. On all other types of sites, a 1-tiered approach is sufficient. On these sites, the trained person or team that inspects the trees can make the final decisions for the correction of hazard trees. Corrections can be made at that time or done later. On occasion, the inspector will have to confer with the site manager for guidance on how to handle a sensitive or technically difficult situation.



Inspections can be done any time of the year. Their purpose is to detect, assess and document the presence of hazard trees.

Inspections can be done at any time of the year. The best time to see structural defects is during the leaf-off seasons. Early spring and late autumn, when visitors are few, work well. Inspections done during leaf-on seasons give a better sense of tree condition and location of dead branches.
If construction or severe storms occurred since the last inspection, then additional inspections should be done. As soon as possible after a severe storm, a thorough inspection of intensively-used sites should be done to find trees and branches that failed, fractured or developed a lean during the storm. Strong winds can take a minor defect and change it into a major one that may require correction.

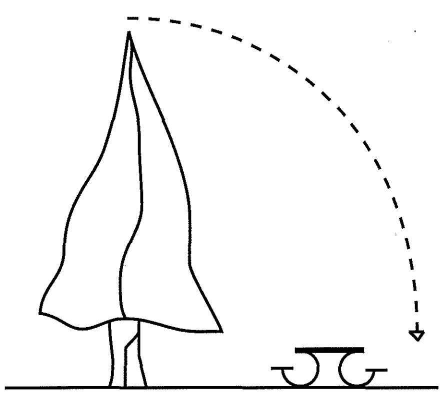
At the discretion of the local site manager, any type of site can be inspected more frequently or be done with a more rigorous approach.

When the inspectors arrive on the site, they must determine which trees to inspect. Not all trees need to be inspected. Only trees that could fall onto a target or into a target area need to be inspected. To determine whether a tree could fall on a target, measure or estimate tree height and the distance to the target. See diagram below. When in doubt, measure heights and distances. Consider tall, distant trees as well as those immediately adjacent to the site.

The next step is to inspect each individual tree for defects. During the inspection, the severity of each tree's defects are judged with respect to defect levels established in this manual. A more detailed explanation of this process can be found in section D, "Individual Tree Evaluations"on page 14.

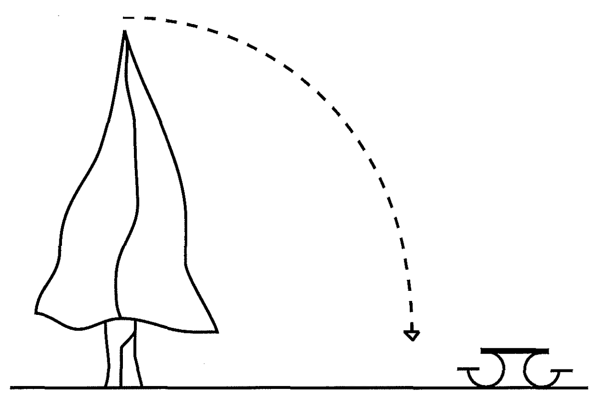
The final step of an inspection is to provide documentation. Use the form supplied in this manual, see Appendix. Use a separate form for each site, each time an inspection is performed. A map is required only on campsites, picnic areas and near buildings in drive-in campgrounds, but mapping is useful on all types of sites.

Needs inspection



Tree could fall on potential target.

Does not need inspection



Tree would not reach the potential target.

Map hazard trees only; it is not necessary to map all the trees on a site. Record the hazard tree's location (or map number) in the table. Provide information on tree species, defect(s) present, the severity of the potential hazard and recommended corrective action as well as any remarks. Use information in the chapter, “Assessment,” to determine hazard potential and the chapter, “Corrective Actions” to suggest options for hazard tree correction.

All the paperwork involved in inspections and corrections should be kept at the local manager's office. Documentation is an extremely important aspect of hazard tree management. Annual or other regularly scheduled updating of the information is advised.

B. Scheduling inspections

In Minnesota, the local site manager has both the authority and responsibility to implement the hazard tree program. The program is broadly outlined in the Operational Order which can be found in the Appendix. The basic guidelines for inspection scheduling are as follows:

Sites	Timing of inspection	Recommended inspection method	Form
Drive-in campsites in Parks and Forestry campgrounds	Annual	2 tiered or team approach	Map of individual site is required
In campgrounds: picnic areas, buildings, facilities	Every other year	Team or 1 tiered approach	Map not required
Admin. sites, water accesses, parking lot peripheries, etc.	Once every 5 years; as maintenance crews visit	1 tiered approach	Map not required
“Wilderness” experience areas, trails, trout streams, old growth forests, etc.	Not Applicable	Not Applicable	Not Applicable

Special trips or visits for the sole purpose of hazard tree inspections do not have to be made for administrative sites, water accesses, parking lot peripheries, etc. Instead, inspections are completed as part of the regularly scheduled maintenance activities.

Inspections can be more frequent and/or more intense than the minimums suggested in the table. The site manager should use discretion in making that decision.

Natural or environmental factors can cause tree failures. The river bank is eroding which undermines the trees' root systems.

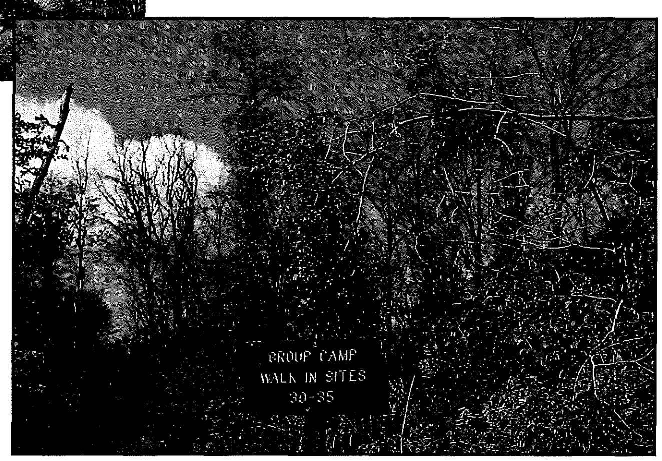
C. Site conditions

Individual tree inspections are enhanced if inspectors have an understanding of the factors that create or accelerate the development of defective trees. An awareness of the environmental and human-related factors influencing the site can aid in detecting and assessing the severity of tree defects.

Environmental factors

The composition, distribution and growth characteristics of forest communities are the result of complex interactions between the climate, landforms and soils. Before rating individual trees, take a step back, look at the site as a whole and ask yourself some questions about the area: what are the main forest cover types? landforms? lakes and streams? direction of prevailing winds?

A shallow root system failed causing the tree to windthrow during a storm.



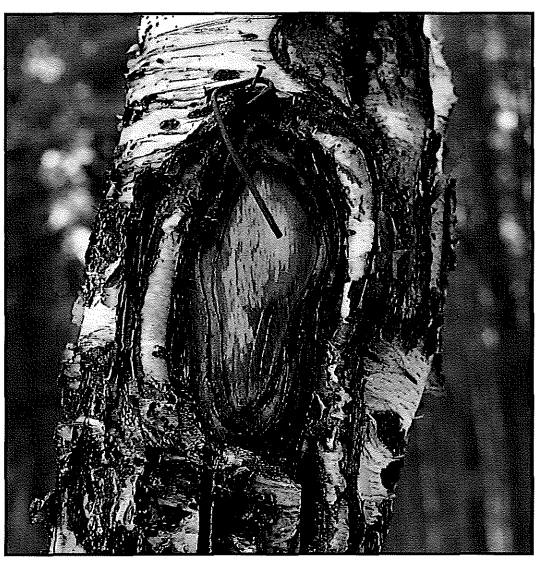
A severe insect infestation killed most of the oaks on this group campsite.

When short-lived, pioneer species (aspen, birch, jack pine) are present, expect breakage and topkill, as well as changes in the species composition. In more mature forests, species composition is relatively stable and trees are long-lived. In these forest communities, expect decay, weak unions, cracks and root problems.

Trees growing on steep slopes or rocky outcrops can move long distances if they fall downhill. Sandy, gravelly and rocky areas within a site often determine how well trees grow and which ones will be more vulnerable to failure.

The following table outlines a few common environmental problems, the respective initial damage or changes they cause, and the type of defects that commonly result from them.

Cause	Initial damage or change	Defects observed
Fire	Wounds to stem	Stem decay, cavities, fire scars
Pest infestation	Crown dieback, stem wounds, reduced vigor	Topkill, cankers, decay, tree mortality, root rot
Drought, lowered water table	Wilting, crown dieback	Topkill, tree mortality
Flooding, raised water table	Root and rootlet mortality, crown dieback	Topkill, tree mortality
Shallow soils or hardpan layer in soils	Shallow root system	Windthrow



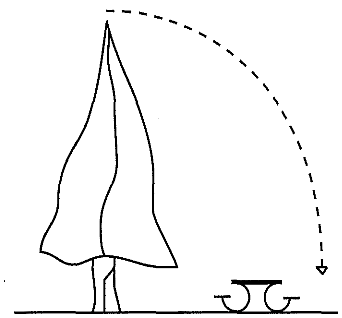
Defects can be caused by people, too. Here, the bark and cambuim have been killed by the heat of lanterns hung from a nail in the birch tree.

This tree will eventually have large branches die because 1/2 or more of the root system has been paved over.

1. Potential target

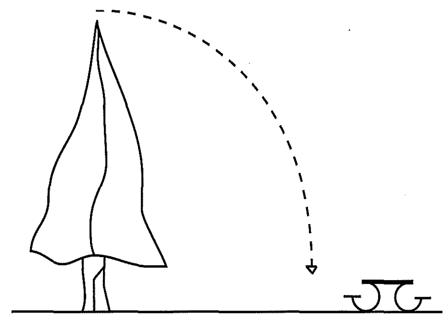
Defective trees are not hazard trees unless there is a target. If the defective tree in question would fail at the groundline, fall and not reach the target, it not considered a hazard tree since it poses no serious threat. Targets may be campsites, parking lots, picnic areas, swing sets, buildings, public water accesses, or anywhere people or equipment are likely to congregate and/or stop.

Hazard Tree



Tree could fall on potential target.

Not A Hazard Tree



Tree would not reach the potential target.

2. Cracks

Cracks are a principle factor in hazard tree evaluation. A crack is a fissure or deep split in the wood. Cracks are the visible sign that tree failure has begun and that corrective action is necessary.

3. Defect(s) present

Defects are visible signals that a tree is failing or has the potential to fail. There are seven main categories of defects: cracks, weak branch unions, stem or branch decay, cankers, dead trees and branches, root problems and poor tree architecture.

Defects affect the structural integrity of the tree. Each type of defect has a range of severity; from no action required to requiring more immediate action. Often, trees will have more than one defect. If defects are physically connected, the potential severity is worse than the sum of the individual defects on the tree.

4. Tree species

The type of defect a tree has is often influenced by the species of tree it is. Some species are more prone to failurefrom certain kinds of defects. For instance,silver maples tend to form codominant stems and thus form weak branch unions. Learn the common defects known to trouble the tree species in your area and actively search for those particular defects. For more detailed information, see the section in Assessment titled, "Common defects listed by tree species."

5. Tree age and size

The majority of serious defects are found in old and/or large trees. This is because old trees have had more time to accumulate injuries and infections and more time for the problems to develop into structural defects. Large trees have greater structural stresses due to their size and weight. Defects identified and corrected in younger trees may reduce future hazard as they grow in age and size.

6. Tree condition

Determining tree condition involves evaluating the overall health and vigor of the tree. Trees in good condition will have live, full crowns, few dead branches and full-sized foliage on actively growing branches. Trees in poor condition or declining trees will have branches dying back, as well as, many dead branches, with smaller and off-color foliage, or epicormic branches. Declining trees have a higher probability of branch failures and of premature death. Dead trees should be removed as soon as possible.

ASSESSMENT

A. Defects and their hazard levels

A sound tree becomes potentially hazardous when the tree's woody structure is weakened by defects. Most defects can be linked to past wounding, pest infestations or severe storms that fractured, destroyed or decayed the wood. Defects are visible signs that a tree has failed, is failing or has the potential to fail. There are seven main categories of defects:

cracks,
weak branch unions,
stem or branch decay,
cankers,
dead trees, tops or branches,
root problems and
poor tree architecture.

Cracks are the most serious defect because they indicate that the tree is in the process of failing.

In this manual, a system has been developed which estimates the severity of a given defect from its external appearance or indicators. Each type of defect has a distinctive range of symptoms that indicates its severity and potential to fail. At the lowest end of the spectrum, the defect does not appear to be currently affecting the structural integrity of the tree. A tree that has a moderate potential to fail is likely to fail in the near future. At the highest level, defects are causing tree failure and are therefore of present concern.

The location of the defect can be a critical factor when determining the hazard level of an individual tree. Tree stems have a zone called the "hot spot" which is presumed to be mechanically weaker than wood above or below it. The hot spot zone occurs from about 4 feet above the groundline up to the lowest branch. See diagram. Hypothetically, this is where the stem would snap off if enough force was applied to bend the tree over. If an additional defect occurs in the hot spot, assume the severity of the defect is worse than it appears because of its location on the stem.

The number of defects a tree has is also critical when assessing hazard. Some trees have more than one defect; if two or more are connected, then the tree may be especially weak in that area of the stem. It may be necessary to rate the tree at the next higher level. Hazardous combinations of defects will be discussed in the following sections.

Trees are living organisms under constant change and the introduction of recreational activities can induce or intensify detrimental changes in them. No two trees will respond to these changes in the same way. There is a natural variability in the trees' responses, so defect severity will also be variable in each individual tree. Use the severity levels found in this manual as guidelines when assessing trees. Remember that these are guidelines, no absolute rules can be made because of the natural variability of trees and their defects.

Although the list of defects appears to be lengthy, it is not exhaustive. Inspectors need to use thier judgement and experience when evaluating and assessing tree defects.

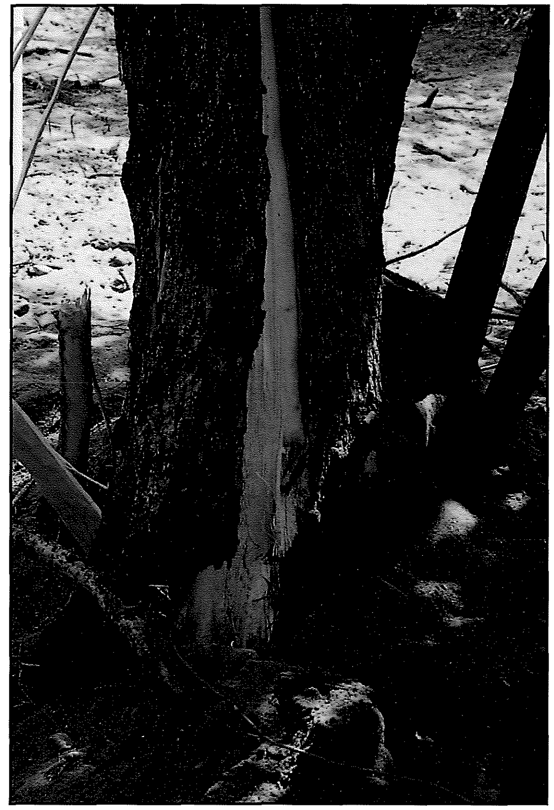
Human-related factors

If you find trees that are experiencing problems, you will usually find some human-made alterations that are to blame. The following table outlines some of the commonly observed defects resulting from a variety of human causes.

Cause	Initial damage or change	Defects observed
Past logging	Stem wounds, stump sprouts, change in species composition	Stem decay, cracks, cankers
Past grazing	Soil compaction causes rootlet mortality, injury to exposed roots	Root rot, windthrow, decay cracks
Compaction due to foot or vehicle traffic	Soil compaction causes rootlet mortality, limited root development	Root rot, crown dieback, tree mortality
Construction	Stem and root wounds	Decay, cracks, cankers, root rot crown dieback, tree mortality
Trenching	Roots wounded and severed	Windthrow, root rot, crown dieback
Raising the soil grade	Rootlet mortality	Root death, crown dieback
Lowering the soil grade	Roots wounded and severed	Windthrow, root rot, crown dieback
Surfacing and paving	Rootlet mortality, lack of water and oxygen	Root dieback, crown dieback, tree mortality
Removing nearby trees	Root and branch growth	Poor tree architecture, windthrow
Transplanting trees	Root loss during process	Slow growth, dieback
Inappropriate species planted	Poor vigor and decline	Topkill, branch breakage, tree mortality
Mowing, weed-whip injuries	Stem and root wounds	Decay, cracks, root rot, cankers, kills small trees
Herbicides	Defoliation, wilting or browning of foliage	Crown dieback, tree mortality
Poor pruning practices	Wounds caused by flush cuts, tipping, topping, long branch stubs	Decay, cankers, cracks, poor architecture
Nails, lanterns, hatchet marks, bark peeling	Wounds to stem	Cankers, decay, cracks, tree mortality

By being aware of a site's history and management practices, inspectors can anticipate some of the defects which might occur and can be better prepared to evaluate the severity of those defects.

Mowers wound stems and root flares, allowing decay-causing fungi to enter and become established in the tree.



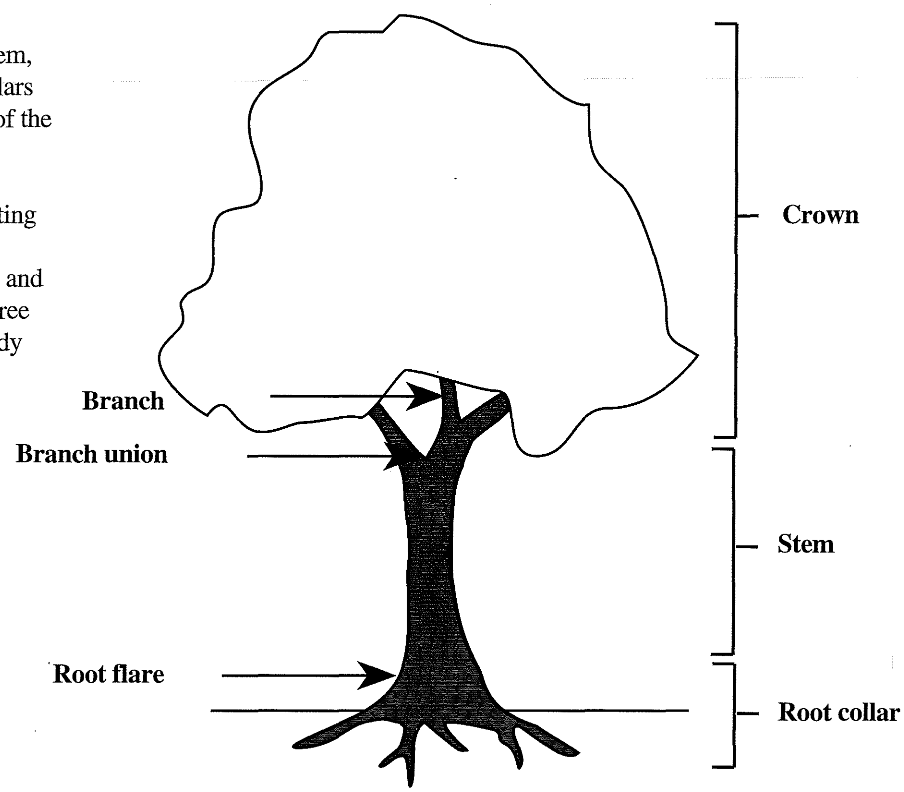
Construction damage. Bark stripping creates a wound where decay-causing fungi can enter. Heavy equipment can break and wound roots. Piling soil on the rooting zone can smother and kill roots.

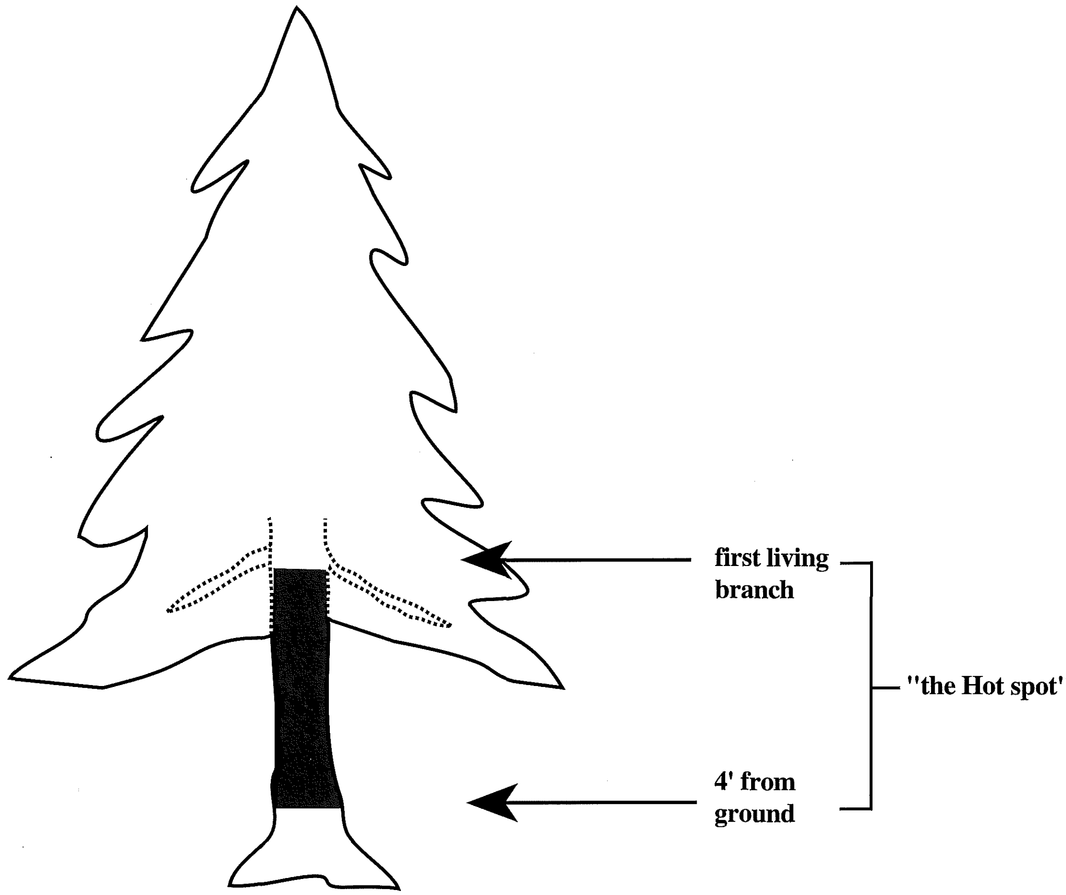
D. Individual tree evaluations

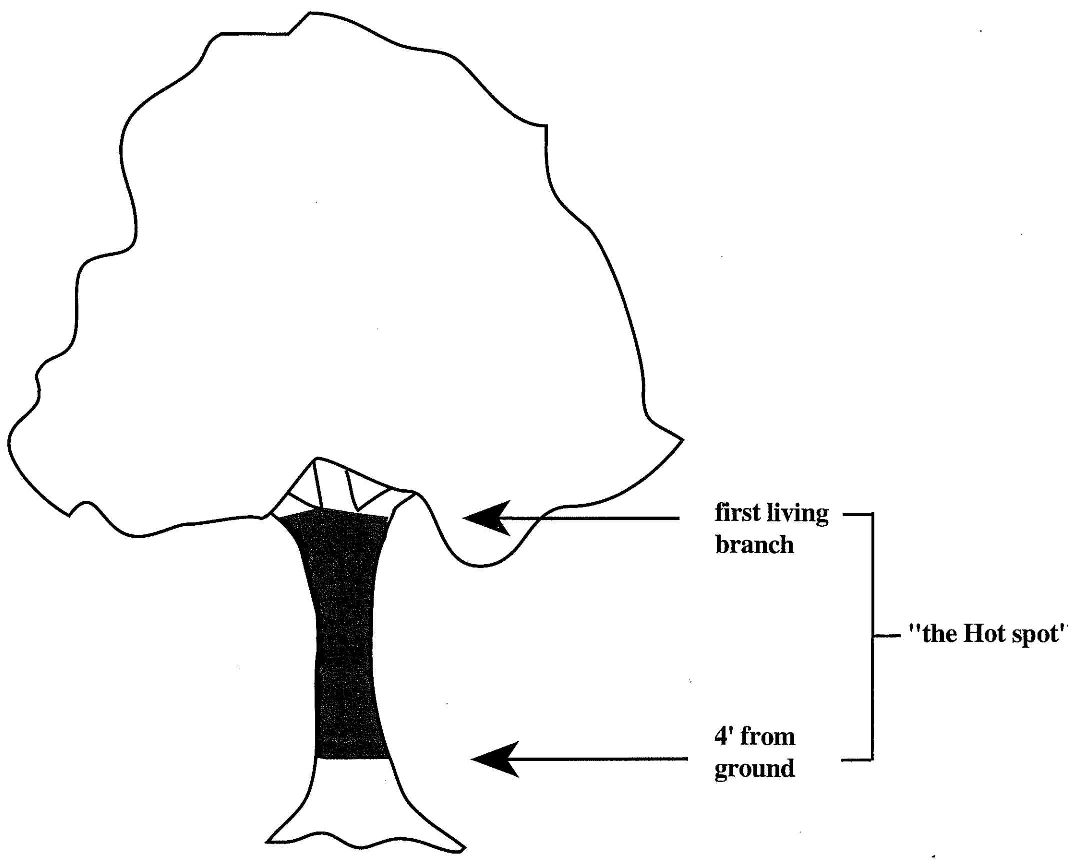
The most important part of an inspection is evaluating individual trees for their potential as hazard trees. The field examinations must be conducted in a careful and systematic manner, therefore, the search for defects in individual trees is a time consuming and repetitive process. Allow plenty of time for the inspections. Individual tree evaluations must include a close inspection of the rooting zone, root flares, main stem, branches and branch unions. Use a pair of binoculars to visually inspect the higher branches. All sides of the tree must be examined.

Several factors should be considered while evaluating individual trees. These factors include but are not limited to; potential targets, the presence of cracks and other defects, tree species, tree age and size, and, tree condition. Site condition is a factor that was already discussed in Section C.

Parts of a tree to inspect




first living branch
"the Hot spot"
4' from ground


first living branch
"the Hot spot"
4' from ground

CRACKS

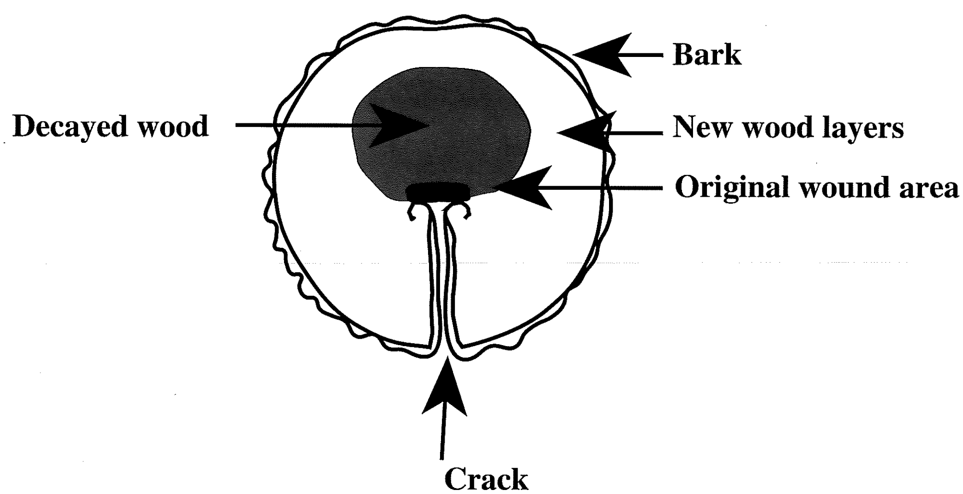
Crack = a separation of the wood, a fissure or deep split in the bark and wood. Cracks can occur in stems and branches; they may even extend up from the roots into the lower stem.

CRACKS ARE THE NUMBER ONE HAZARDOUS DEFECT BECAUSE THEY INDICATE THE TREE IS ALREADY FAILING.

Cracks can be generated in two ways; (1) from short-term injuries such as storm damage or the impact from heavy equipment, or, (2) from improper wound closure over a period of years. Most cracks develop from improper closure of wounds. The wood behind a crack may be sound or decayed.

If a wound does not close, the layers of bark and wood forming the margins of the wound meet but do not grow together and do not seal over the wound. Instead these layers curl inward on each side of the wound and form inrolled bark and wood. As more layers of bark and wood are added, the crack becomes more pronounced. See diagram and Appendix. The crack perpetuates itself by adding new layers of wood to the inrolled bark and wood, increasing the separating force between the two sides and enlarging the crack. Ramshorning is another term for inrolled bark and wood which forces the crack to enlarge. Ramshorned cracks become more hazardous as they enlarge and generate secondary cracks in the stem.

When a tree has two cracks in the same segment of the stem, the stem can be separated into two sections of wood which move independently of each other. One section slides over the other, creating tension, and the crack elongates. Eventually the enlarging crack causes the stem to fail when the tree can no longer support itself mechanically.

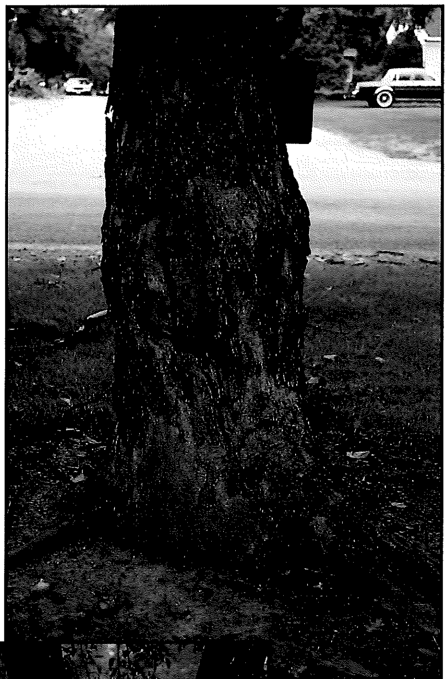


The wound was imperfectly repaired. The bark and wood layers did not grow together; instead they formed inrolled layers of bark and wood which created the crack. Cracks perpetuate themselves over time, cracks become longer, affect more of the stem and can become increasingly hazardous.
Often wood decay will occur inside the tree as a result of fungal infection of the original wound.

If there is another defect in the same stem segment that has a crack (e.g. a canker, or a weak branch union), failure may be imminent and corrective action should be taken as soon as possible.

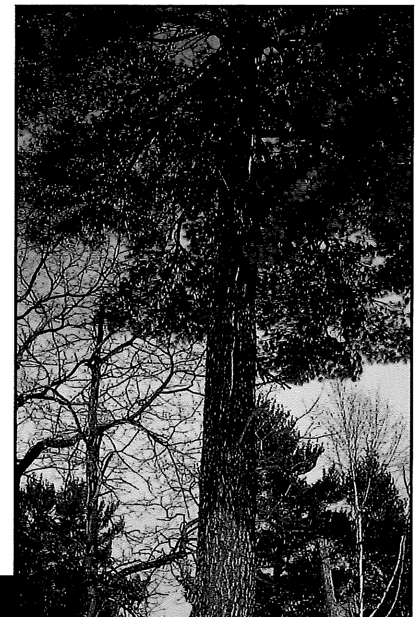
When a tree successfully closes over a wound, a seam may form. As layers of bark and wood from each margin of the wound grow towards each other, the layers mesh and ultimately grow together. This seals the wound. As time passes, a solid cylinder of wood forms, sealing the old wound and strengthening the stem. The wood behind a seam may be sound or decayed.

Seams which have several layers of wood over the original wound are much less dangerous than cracks. However, this may not be detectable from visual assessment alone. If there is another defect in contact with a seam, the stem segment must be closely inspected in order to assess the structural soundness of the segment. In a circumstance like this, an increment core should be taken to determine if the wood behind the seam is sound or decayed.



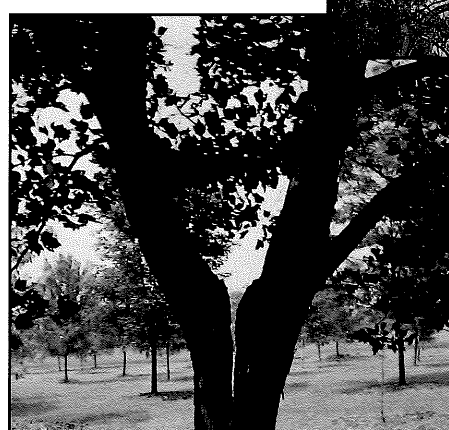
This hardwood tree has a crack extending up and down from an old wound.

Cracks are the number one defect because they indicate the tree is already failing. This 20' long crack originated at a weak branch union.



A crack is a deep split in the bark and wood. Internal cavities may be visible inside the tree.

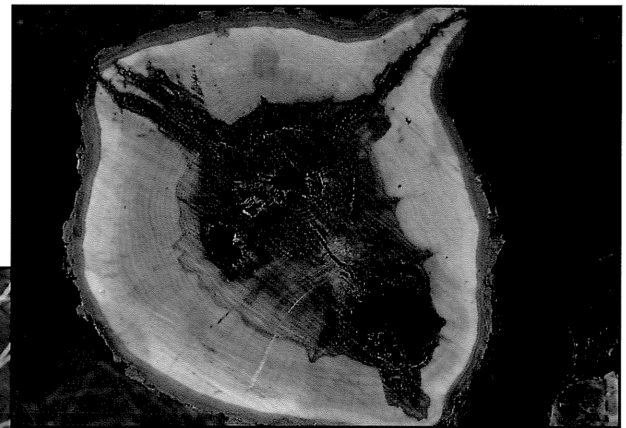
This tree has split all the way to the groundline. Complete failure will occur when the remaining wood can no longer support the two portions of the tree.



Sometimes light is visible through a crack. Corrective action should be taken on cracked stems as soon as possible.

The classic appearance of slowly fracturing wood. As the crack elongates, there is less and less sound wood to support the weight of the branch. It finally fractures and fails.

On most conifers, a crack arising between two root flares indicates root rot. This balsam fir has both decaying roots and a failing stem.



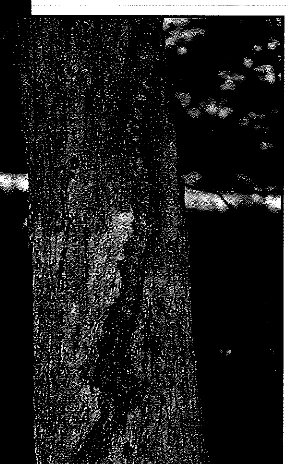
Cracks do not close over; they perpetuate themselves and can become more hazardous.

Cracks often result from inrolled bark that developed over an old wound. Note that the wood inside the original wounded ring has decayed.

Cross section of a crack that has stain but no decay.

A crack with tightly closed margins. Wood behind the crack may be sound or decayed.

A seam forms when a tree successfully closes over a wound with new layers of wood and bark.



Seams are sealed inside the tree over a period of years. Eventually they become indistinct.

There are specific situations which will indicate whether a stem or branch has a high or moderate potential to fail:

High failure potential:

1) A crack goes completely through the stem or branch. You may be able to detect movement of each section of wood.

2) Stem has 2 cracks on the same segment with a cavity or extensive decay on the inside.

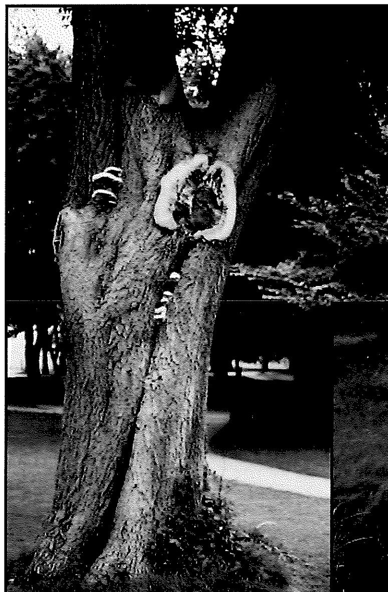
3) Stem has a crack in contact with another defect (canker, decay, weak branch, union, leaning, etc.).

4) 4" or larger branch has any crack. Remove only the cracked branch.

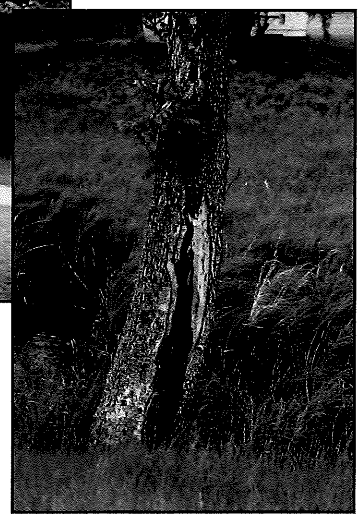
5) Conifer stem has 1 crack that has inrolled bark and the internal cylinder of wood is gone or extensively decayed.

Moderate failure potential:

1) Hardwood stem has 1 crack that has inrolled bark and the internal cylinder of wood is gone or extensively decayed.



A crack that is associated with another defect has a high potential for failure. Here, the crack has extensively decayed wood behind it as indicated by the mushrooms.



This ash stem has two cracks with light visible through the cracks. Note the thin shells of wood supporting the tree.

A weak union is a fork in the stem that is structurally unsound.

WEAK BRANCH UNIONS

Branch union = fork in the stem or union of two or more main branches. A weak branch union is structurally unsound because bark layers are ingrown, in other words, bark has formed inside the wood in the union. The term for this is included bark. Unlike wood, bark has no power to hold the branches together. As more and more bark is included inside the tree, the remaining woody connections between branches can't support the weight of the branch and the weak union fails. The branch breaks off or the tree splits open.

Weak unions are characterized by an acute angle between the stems (V-shaped connection), the presence of included bark in the union and by the presence of inrolled bark on the branch bark ridge. Often, stem tissues are sunken immediately below the branch of a weak union. See diagram on page 23.

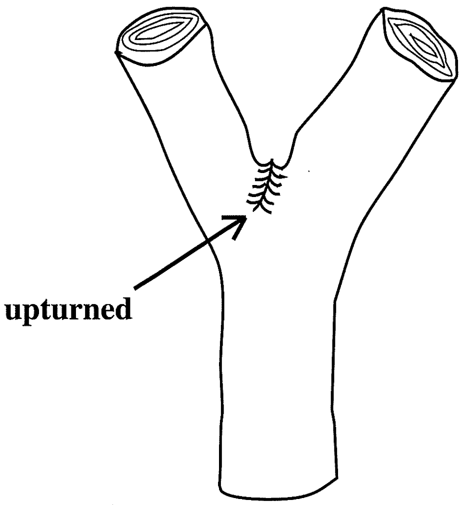
Comparison of a weak (right) and strong (left) union. Weak unions are characterized by V-shaped angle of connection, inrolled bark in the branch bark ridge and included bark inside the union.

Weak unions are unsound because bark is "included", that is, bark has formed inside the union. Unlike wood, bark cannot hold the branches together.

Included bark in a union that failed.

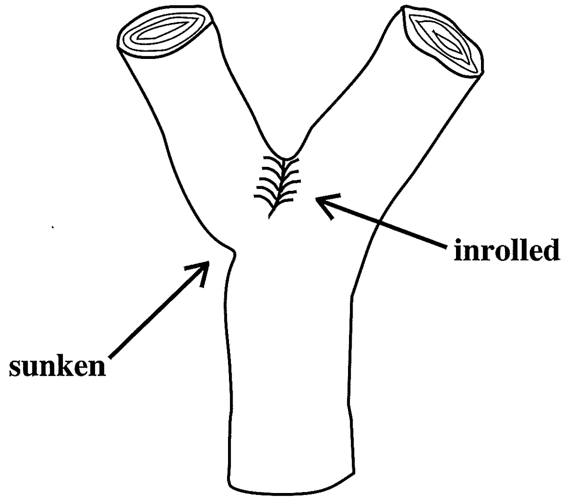
Often, stem tissues are sunken immediately below the branch of a weak union.

Strong branch unions



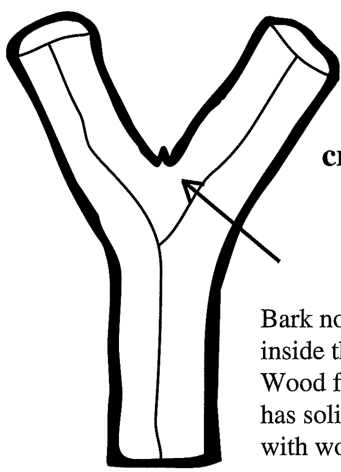
Branch bark ridges
are upturned.

Weak branch **unions**

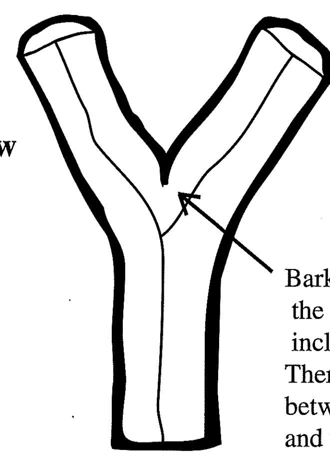


Branch bark ridges are
inrolled.
Sunken area below
branch often found.

cross section view



Bark not growing
inside the union.
Wood from branch
has solid connections
with wood from stem.



Bark is growing inside
the union; termed
included bark.
There are poor connections
between wood in branch
and wood in stem.

Strong branch unions are characterized by a U-shaped connections, branch angles approaching 90 degrees and upturned branch bark ridges at branch junctions. When the branch bark ridge is upturned, there is no included bark. Wood from the branch grows together with wood from the stem creating a sound union.

There are specific situations which will indicate whether a stem or branch has a high or moderate potential to fail.

High failure potential:
1) A weak branch union that is also cracked, cankered or decayed.
2) A weak union in the tree's "hot spot."

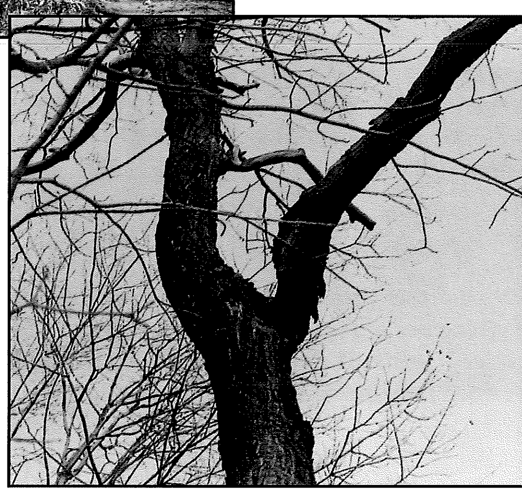
Moderate failure potential:
1) A weak union with inrolled bark at the branch bark ridge.

A strong union is characterized by upturned bark in the branch bark ridge. It does not have included bark inside the union.

U-shaped angle of connection is characteristic of a strong branch union.

A failed branch union. Note included bark and evidence of decay.

Another tree with high failure potential. The weak union is in the tree's "hot spot".



A branch like this has a high failure potential because of its weak union and the presence of another defect, a canker.

A failed branch union with both included bark and decayed wood inside the union.

Fungal fruiting bodies, mushrooms, are reliable indicators of internal decay.

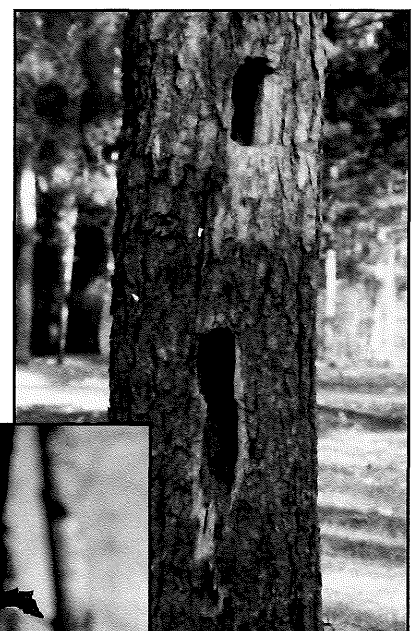
STEM OR BRANCH DECAY

Decayed wood = Wood that has rotted or is missing. Decay always results in less structural strength and stability.

Decay is caused by fungi which infect wounds in the bark and wood. Over a period of years the fungi consume and degrade the wood making it structurally unsound. When a tree is wounded it compartmentalizes, or walls off infected or injured wood, so that new wood laid down after the wound is free from decay. The diameter of the tree at the time of wounding is, with few exceptions, the only part invaded by decay fungi from the wound. If this decay process goes on long enough, a hollow the same diameter as the tree at the time of wounding can result. This process may take many years. Wounds occurring later may result in new decay columns outside the older ones, sometimes enlarging the diameter of the hollow.

The most dangerous decay-causing fungi are the canker-rot fungi. They can overcome the tree's efforts at compartmentalization and spread outward into wood formed after the year it was wounded. Infection by canker-rot fungi usually results in more extensive decay; the entire cylinder of wood can be structurally weakened. Trees are easily fractured at the site of canker-rot infections. Some common canker-rot fungi and their hosts are: *Inonotus obliquus* on birch, *Phellinus pini* on conifers, *Phellinus everhartii* on oak, *Inonotus glomeratus* on maple and *Phellinus tremulae* on aspen.

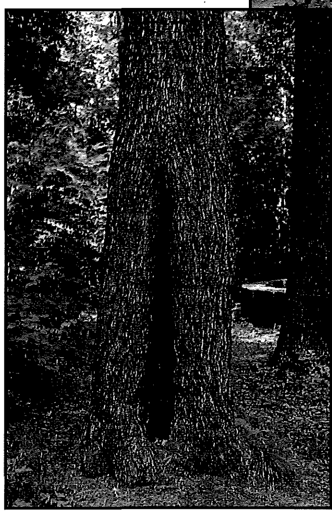
The health and vigor of a tree's crown does not indicate whether there is internal decay or not. Trees require only a thin layer of bark and sapwood to transport water and nutrients to the crown. The crown will be visibly "healthy" even if internal decay is present.



Woodpecker holes which reveal internal decay and cavities.

Fungal fruiting body, a conk, of Phellinus tremulae *on aspen.*

Decayed wood is rotted by fungi. The process takes many years and, given enough time, a cavity culminates the decay process.



Years ago, wildfire wounded this tree and it was infected by fungi which ultimately created this fire scar and cavity.

Decay results in less structural strength and stability. This tree failed at the decay caused cavity.

The most dangerous decay - causing fungi are the canker - rot fungi. This is because the tree cannot contain the infection and even new annual rings of wood become decayed.

Branches can also be decayed and fail.

Fungal fruiting bodies on the tree or roots and growing on the ground adjacent to the tree are reliable indicators of decay. Other indicators are less reliable. As an example, decay in oak was studied and the symptom or indicator of decay was correlated with the presence of decay. See Table below. Other tree species and even oaks growing in other habitats will not have the same correlations.

Indicator	Frequency of decay
Open fire scars	98.7 %
Closed fire scars	64.3
Dead or damaged tops	60.8
Unsound branch stubs	30.8
Mechanical injuries	25.5
Branch bumps (<4" diameter)	23.2
Open branch stub scars	12.2
Unsound branch stubs (2-4" diameter)	10.8
Stem bulges	10.7
Sound branch stubs	9.8

From F. Berry and J. Beaton, 1972. Decay in Oak in the Central Hardwood Region. USFS Research Paper NE-242.

High failure potential in lower stem due to the presence of two cracks, large cavity and thin layer of sound wood.

Upper crown stem with high failure potential due to the presence of extensive decay as indicated by cavities and branch stubs.

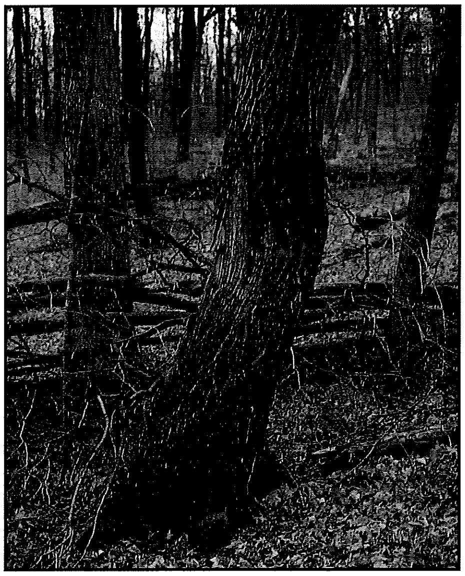
There are specific situations which will indicate whether a stem or branch has a high or moderate potential to fail.

High failure potential:

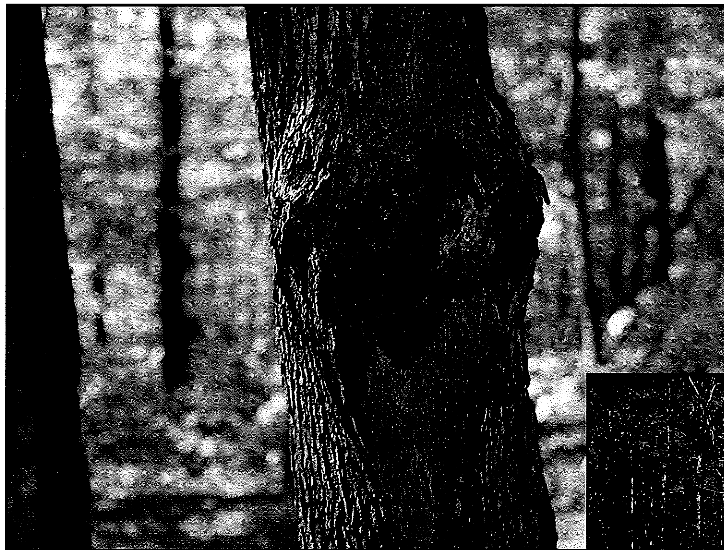
1) Canker-rot infection (fruiting body) present in tree's "hot spot."
2) Cavity or decay present (fruiting body) associated with a weak branch union or an open crack.
3) Any branch with decay.

Moderate failure potential:

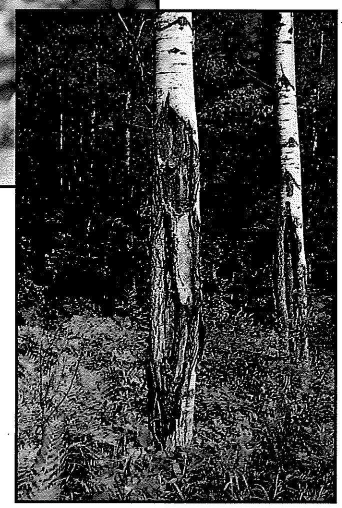
1) Canker-rot infection.



Cankers are dead areas of bark which often affect the wood below it. This canker is the result of a decades long association between a fungus and tree.



Bark may or may not adhere to the face of a canker.



Fungi are very common canker causing agents.

CANKERS

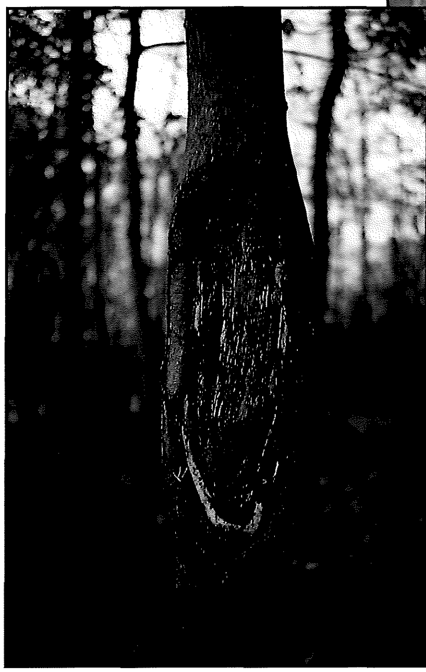
Canker = A dead area of bark and cambium anywhere on the tree; often affecting the wood beneath it. Cankers can be caused by fungi, insects, weather or mechanical damage such as lantern burn-wounds. Stems and branches often fracture on or near cankers.

There are two types of cankers; annual, and, perennial. Annual cankers are injuries or short-lived infections which do not affect the tree's structural integrity. Perennial cankers are long-term tree/fungus associations which can alter the tree form and structure and take on a target or diffused appearence. (See Appendix) Cankers increase the likelihood of stem breakage or kill the tree above the canker location. Cankers are more hazardous if they affect more than 1/2 of the circumference of the tree.

There are specific situations which will indicate whether a stem has a high or moderate potential to fail.

High failure potential:
1) Canker is in tree's "hot spot" and affects more than 1/2 of tree's circumference.
2) Canker and decay in tree's "hot spot."
3) Canker physically connected to a crack or another defect.

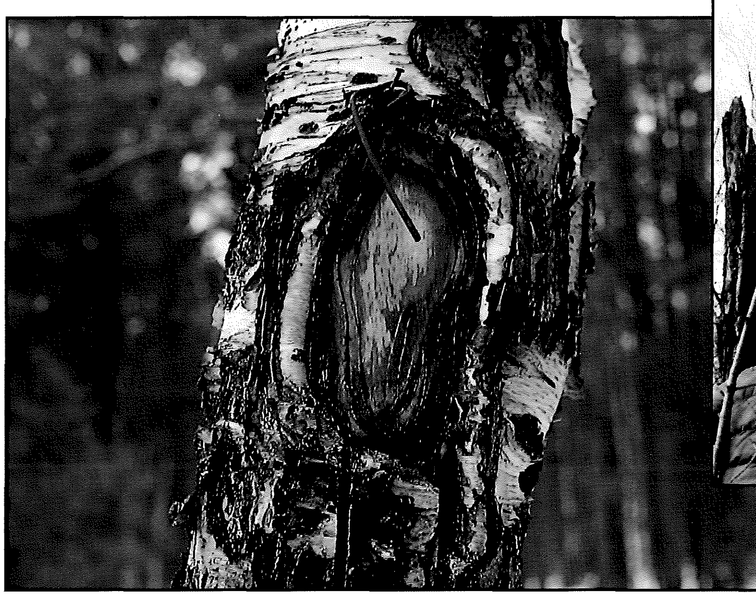
Moderate potential for failure:
1) Canker affects more than 1/2 of the stem's circumference.
2) Large old wound or canker at base of leaning tree.



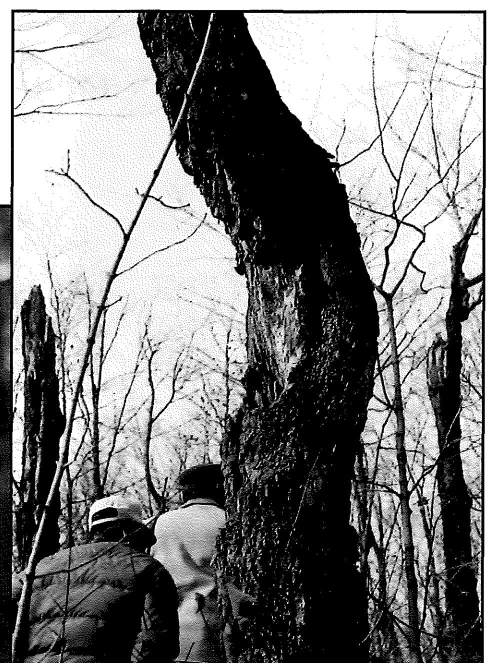
A typical "target" canker. The annual growth rings look like an elongated bulls-eye pattern.

Stems and branches often fracture on or near canker locations.

A white pine blister rust canker. Note the excessive pitching on the bark's surface.



Repeated injuries can also cause cankers. Here annual lantern burns inhibit bark and wood growth.



Cankers can be hazardous if they affect more than 1/2 the circumference of the tree.

DEAD TREES, TOPS OR BRANCHES

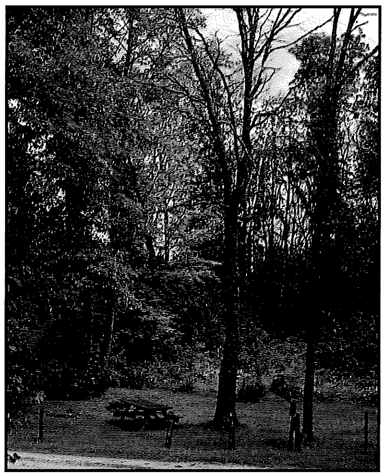
Dead = A dead tree, branch or tree top is structurally unsound.

Dead tops or branches may remain attached to live trees for several years or may fall off suddenly. Dead branches commonly break off near or at the main stem, whereas, dead tops frequently break off just above the live stem. Dead trees can fracture anywhere - at the ground line, in the tree's "hot spot" or anywhere there was a defect. Commonly, branches decay and fall first leaving a snag tree that can stand for many years. Snag trees for wildlife habitat should not be left adjacent to campsites and other target areas. Snag trees should be left in the "wild" areas of less intensively-used recreation areas.

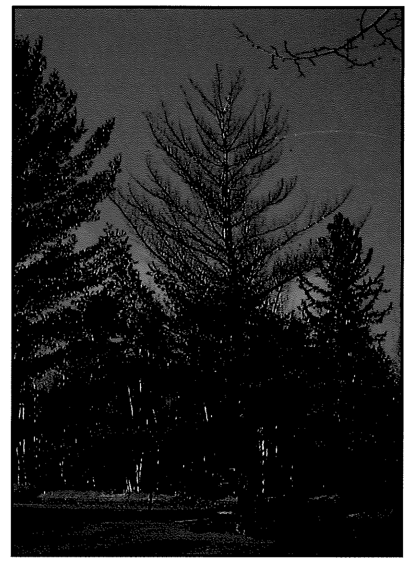
There are specific situations which will indicate whether a stem or branch has a high or moderate potential for failure.

High potential for failure:
1) Any dead tree.
2) Any dead branch or dead top.
3) Any lodged branch.

Moderate failure potential:
1) Any branch more than 2/3rds dead (remove entire branch).

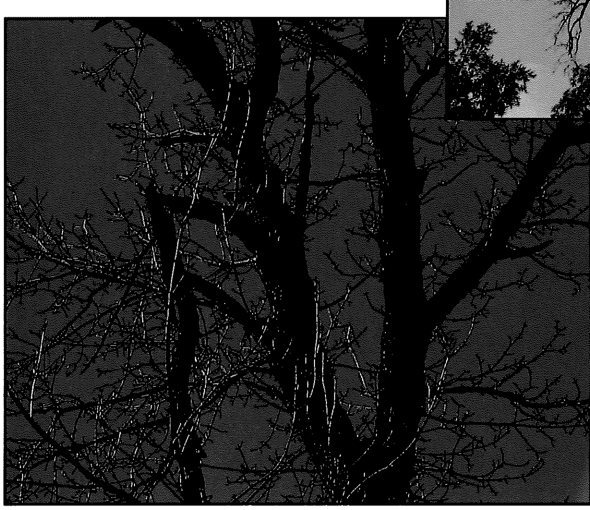


The stability and structural soundness of a dead tree are unknown. Dead trees could fail at any time, so they should be removed as soon as possible.

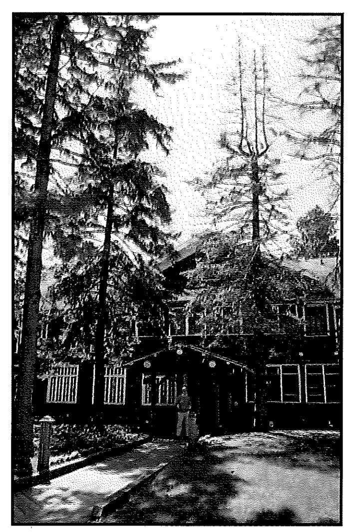


Dead tops frequently break off just above the live stem.

Large dead branches may remain attached for years or they may fall off suddenly. Prune them back to the main stem.



Lodged branches pose a high hazard.



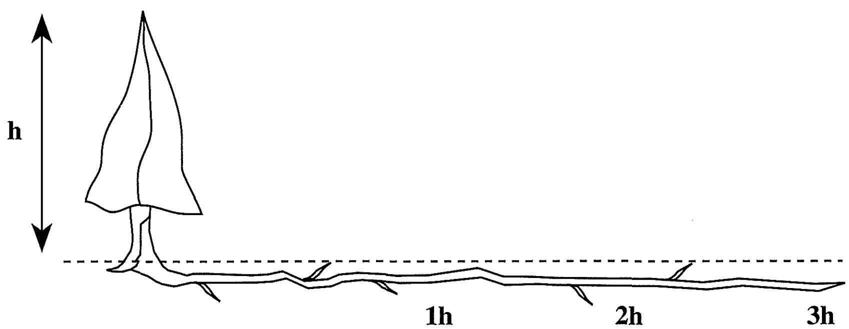
Another tree with a dead top.

ROOT PROBLEMS

Root problems = problems serious enough to warrant correction are partial windthrow (leaning), root severing, missing root system, or extensive root rot.

Root problems are difficult to find and assess since tree roots are underground and out of sight. Tree root systems extend 2-4 times the height of the tree and most of the water and nutrient absorbing roots are within 12 inches of the soil surface.

Roots commonly extend 2-4 times the height of the tree in any direction.

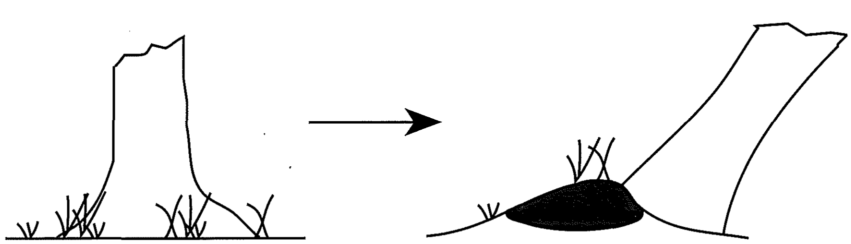


Often, root problems are a combination of mechanical disruption of the root system and reduced vigor of the roots. The mechanical support of a root system can be disrupted by soil erosion, severing the roots or by extensive root rot. This decreases the tree's stability and may cause the tree to lean or be windthrown. Roots can be severed by trenching, utility installation, road construction or by lowering the soil grade. The vigor of a root system can be decreased by reducing the area where roots can grow or by altering normal root physiology. Construction activities, soil compaction, paving, lowering the soil grade, etc. reduce rooting area. Soil compaction is caused by heavy equipment, auto traffic or prolonged foot traffic and is most severe on clayey soils. Flooding, raising the soil grade, and application of salts or herbicides alter root physiology which reduces root vigor.

Fungal root rots affect both vigor and mechanical support. Initially they alter the root physiology and later their extensive decay causes mechanical failure. Root death with subsequent root rot can also be caused by root severing, temporary soil storage over roots, elevating the grade, blacktopping, erosion, prolonged drought, flooding, or soil compaction. On conifers, a crack rising from below the groundline and continuing up the stem indicates root rot.

Root problems only become apparent when tree crowns begin to show symptoms or when signs of root failure become obvious. Root lifting, partial windthrow, soil mounding, or a recently leaning tree are obvious signs that the root system is failing. If construction has taken place under the crown, assess the impact this may have had on the mechanical support of the tree.

Soil mounding



Tree is upright

Soil mounds up on opposite side of leaning tree.

This is particularly important if excavation has occurred within 10 feet of the stem. Inspect the soil at the base of the tree for signs of cracking or lifting which could indicate root failure below the ground line. Take careful note of dead root flares which are indicative of root and butt rot.

Look for signs of soil disturbance or compaction of the soil near the tree, particularly under the crown. Correlate this with signs of dieback or decline in the crown.

Since tree roots are underground, root problems are difficult to find and evaluate.

Soil erosion that undermines the root system.

Loss of mechanical support because of extensive root severing.

Paving over the root system smothers the living roots and eventually the tree dies. This oak died 1 year after asphalt installation.

Trenching, especially within 10' of the tree, decreases mechanical support.

Lowering the grade removes the fine roots which absorb oxygen, water and nutrients.

Raising the grade smothers live root systems. Note the trees' lack root flares near the groundline.

A tree with high failure potential; it's dead, leaning and shows root-lifting.

Root rots are caused by fungi which cause decay (loss of mechanical support) and disrupt root functions (reduce tree vigor).

Root rot fungi can infect roots through mower or heavy equipment wounds.

This conifer has root decay as indicated by the crack arising between 2 root flares.

Fungal fruiting bodies at the base of the tree or on main roots indicate extensive root decay.

There are specific situations which will indicate whether a stem has a high or moderate potential for failure.

High failure potential:

1) Freshly leaning trees with evidence of recent root-lifting, soil movement or mounding near base of tree.

2) Inadequate root support; tree has more than 1/2 of the root system severed inside the dripline.

Moderate potential for failure:

1) Root problem physically connected to stem decay, crack or canker.

POOR TREE ARCHITECTURE

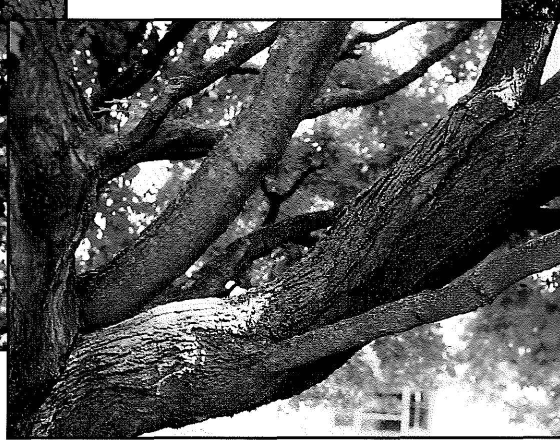
Poor tree architecture = Growth pattern that indicates weakness or structural imbalance in the affected branch or stem.

In most cases, poor tree architecture is the tree's response to past changes. It may take 10 years for the tree's response to fully develop to those changes. Here are some examples.

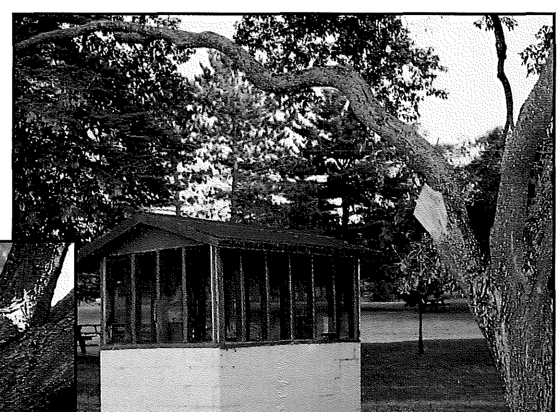
Cause	Watch for
Tree clearing or branch pruning in nearby trees	Change in growth habit or branch losses
Branch out of proportion with rest of tree, growing into a new hole in the canopy	Branch failure
Branch with sharp twist or bend	Branch failure
Multiple branches or codominant stems arising in one area of the stem	Branch failures
Tree was topped in the past	Branch or stem failure in upper crown
Tree growing at a sharp angle from the ground and one of the following: crack, root rot, stem decay, or after a severe storm	Tree failure

Poor architecture is common in trees grown from nursery stock. Common defects include acute branch angles, too many branches arising from a single location on the stem, codominant stems and included bark. Stem cracks also develop on nursery stock due to improper pruning practices.

Poor architecture is a growth pattern that is structurally weak or imbalanced.



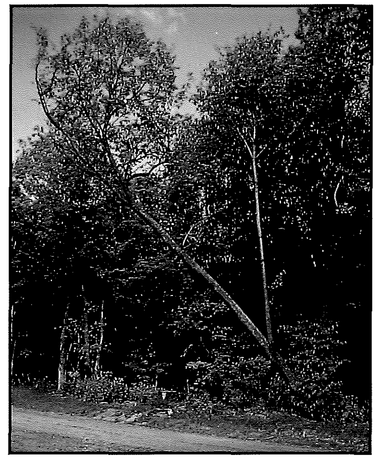
Multiple branches with weak unions.



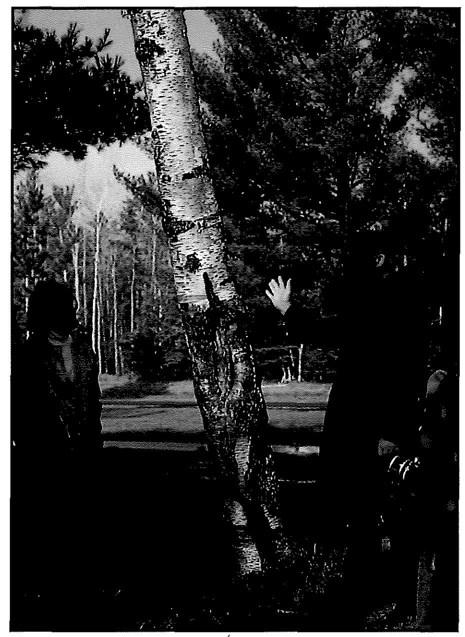
Branches with sharp bends or twists can fail.

Like topping, branch "tipping" allows decay - causing fungi to infect the branch.

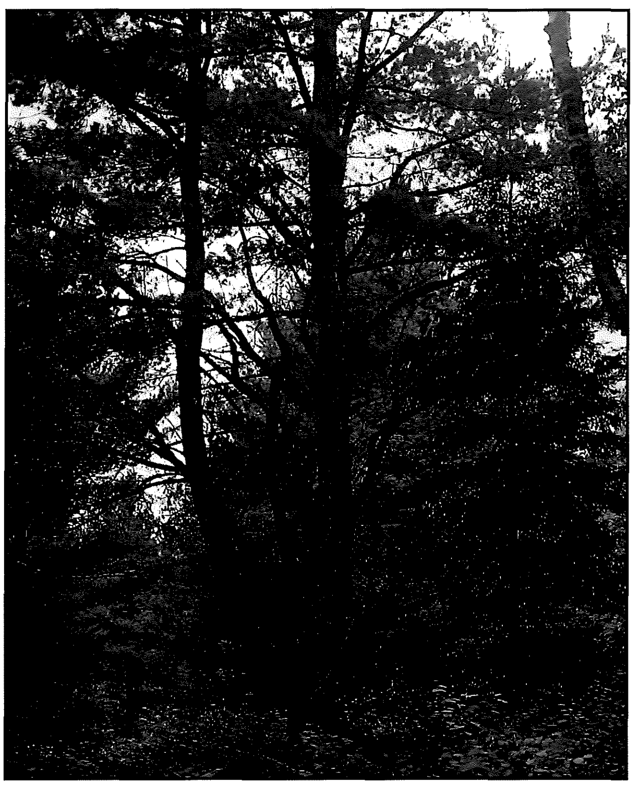
This tree was "topped" in the past and the resulting new top has a sharp bend in it. Either the stem or the new branch could fail.



A leaning tree has a high potential to fail when the angle is > 45 degrees.



A birch tree with multiple defects; it leans, has a canker in its "hot spot", and has a crack running up from the ground line through the canker.



Multiple branches arising from one area of the stem indicates poor architecture.

There are specific situations which will indicate whether a stem or branch has a high or moderate potential to fail.

High failure potential:

1) Tree leaning over target with an angle greater than 45 degrees to the lean.
2) Tree leaning over target and it has another defect in the "hot spot".

Moderate potential for failure:

1) Branches with a twist, sharp angle or bend in them.
2) Branches lopsided or unbalanced with respect to rest of crown, especially if nearby trees were pruned or removed within the last 10 years.

B. Common tree defects listed by species

In each tree species, there are defects that are consistently found. Listed below are some of the common defects found in each species.

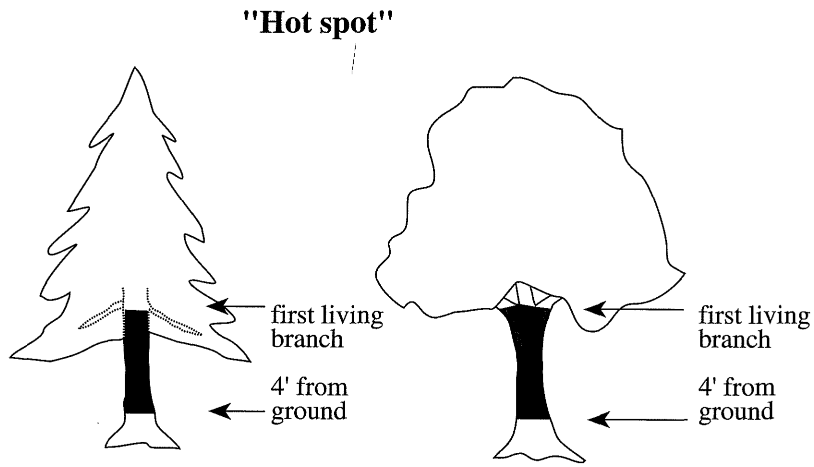
SPECIES	WATCH FOR:	COMMENT/ CHARACTERISTIC
Ash	Branch breakage	Branch shedding in suspect trees. Trees > 15" DBH are suspect.
	Poor architecture	Due to presence of multiple, codominant stems
	Weak branch union	Develop weak unions due to opposite branching pattern, included bark
Aspen	Breakage at canker	Susceptible to *Hypoxylon* canker
	Breakage due to decay	Decay common in older aspen, caused by canker-rot fungus, *Phellinus*
Basswood	Branch breakage	Branch shedding. Trees > 15" DBH are suspect
	Advanced decay	Cracks, holes, cavities and branch stubs indicate decay in this species
Birch	Lower stem breakage	Cracks at root collar indicate potential for breakage
	Advanced decay	Decay commonly caused by *Inonotus,* a canker-rot fungus
	Dieback or decline, upper stem breakage	Susceptible to *Agrilus* borers; stand recently opened up or nearby tree removal
	Root problems	Soil compaction, summer soil temperature increases, rootlets freeze easily
Black cherry	Branch breakage	Old branches can die suddenly, decay rapidly and break close to stem
Boxelder	Branch breakage	Suspect any tree > 15" DBH
Cottonwood	Branch breakage	Branch shedding in large, old trees
Elm	Rapidly declining or dead tree	Caused by Dutch elm disease. Branch shedding will start 2nd year following death
Hackberry	Cracks and weak unions	Weak unions in "hot spot" are common
	Branch breakage	Trees > 15" DBH are suspect
Hawthorn	Weak unions	V-shaped forks and co-dominant stems are common

Hickory	Branch breakage	Trees have large crowns
Honey locust	Twig and branch drop	Branch shedding is common
Ironwood	Root problems	Shallow root system is easily damaged
Locust	Branch breakage or cankers	In trees > 15" DBH
Maples, Sugar, or red	Weak unions	Codominant stems commonly have included bark, V-shaped unions
	Cracks	Internal decay and ramshorning cracks are common
	Cankers	Susceptible to *Eutypella* and *Nectria* cankers
	Decay	Canker-rot caused by *Inonotus.*
Maple, silver	Same as maples above, and,	
	Branch breakage during storms	Wood tends to fracture
	Branch breakage	Trees > 15" DBH are suspect
Oaks	Canker and decay	Susceptible to *Strumella* canker and *Phellinus* canker-rot
	Dieback	Induced by construction damage to roots
	Dying tree	Red and black oaks are quickly killed by oak wilt; all species vulnerable to *Armillaria* root rot and *Agrilus* borers
Walnut	Branch breakage	Decay in branches
Willow	Branch breakage	Branch shedding, natural pattern of growth and dieback. Trees > 15" DBH are suspect
All conifers	Decay	Canker-rot caused by *Phellinus pini*
Fir	Basal cracks	Cracks arising from decayed roots
Pine	Branch breakage	Due to overloading from snow or ice
	Windthrow and breakage	In recently released or exposed trees
	Dead tops and branches in white pine	From white pine blister rust disease
	Dying or dead trees	Bark beetles or *Armillaria* root rot
Spruce	Windthrow	On shallow or rocky soils
Tamarack	Root problems	Due to root rot

C. Hazard tree assessment tatum guide

There are several factors that must be considered while inspecting individual trees. These factors are the defect(s) present, tree species, tree age and size, tree condition and potential targets. This Guide is a synopsis of the seven defects and hazard levels. Trees with high hazard potential warrant corrective action as soon as possible. Moderate hazard defects are discretionary; the manager may elect to correct them before the next inspection.

Defect location can be a critical factor when determining the hazard potential of an individual tree. Each tree stem has a zone called the "hot spot" that is presumed to be mechanically weaker than wood above or below it. The hot spot zone is from about 4 feet above the groundline up to the lowest branch. See diagram. If an additional defect occurs in the hot spot, assume the defect is worse than it appears.



Shaded areas are "hot spots" in conifer & hardwood trees.

The number of defects a tree has is also critical when assessing for hazard potential. Some trees have more than one defect and if two or more are connected, the tree can be very weak in that area. It may be necessary to rate the tree at the next higher level.

Defect	Moderate hazard potential	High hazard potential
Crack	Hardwood stem has single crack with cavity or decay inside	Crack goes completely through stem. May be able to detect movement of section of stem
		Stem has 2 cracks on the same segment with cavity or extensive decay inside
		Stem has crack in contact with another defect or at base of leaning tree
		Branch (4" or larger) has any crack
		Conifer has a single crack with inrolled bark and cavity or decay are inside
Weak unions	A weak union with inrolled bark	A weak union that is also cracked, cankered or decayed
		A weak union in the tree's hot spot
Decay	Canker-rot infection	Canker-rot infection in tree's hot spot
		Cavity or decay (fruiting body) associated with an open crack or a weak branch union
		Any branch with decay

Canker	Canker affects> 1/2 of tree's circumference	Canker in tree's hot spot and affects > 1/2 of tree's circumference
	Canker at base of leaning tree	Canker-rot infection in tree's hot spot
		Canker physically connected to crack, decay or weak union
Dead	Branch more than 2/3rds dead (remove branch)	Any dead tree
		Any dead branch or top
		Any lodged branch
Poor tree architecture	Branch unbalanced with respect to rest of crown mass	Tree leaning over target with > 45 degree angle to the lean
	Branches with sharp bend or twist	Tree leaning over target with another defect in the hot spot
Root problems	Root problems associated with stem decay, crack or canker	Freshly leaning tree with recent root-lifting, soil movement or mounding near base of tree
		Inadequate root support > 1/2 of roots severed inside dripline
Poor tree architecture	Branch unbalanced with respect to rest of crown mass	Tree leaning over target with > 45 angle to the lean
	Branches with sharp bend or twist	Tree leaning over target with another defect in the hot spot

Note: The tatum guide is duplicated in the back with the inspection form.

D. Formulating hazard tree ratings

Developing corrective or management recommendations is a difficult part of the inspection. The inspectors need to take into account the severity of the tree's defects and site conditions that limit options. Site managers should be aware of the cumulative impacts of corrective actions on the site and the recreation area as a whole and the potential damage caused by corrective actions on surrounding trees. On the Inspection Form (see Appendix), record the recommendations for corrections and include comments or special instructions.

CORRECTION

A. Corrective actions

Recommending corrective action is one of the most difficult parts of the inspection since the inspectors should take into account a number of factors including, the severity of the tree's defects, site conditions that limit options, the cumulative impact of tree removals on the aesthetics of the site and the physical effects on the surrounding trees. An additional goal in taking corrective actions is avoiding damage to existing trees and saplings in order to prevent defects from developing.

If a hazardous situation exists, there are three basic options for corrective actions:

1. move the target,
2. remove the hazardous part of the tree by pruning, or,
3. remove the tree.

Tree removal, though it may be necessary in some circumstances, should be considered the last resort. Cabling and bracing are not recommended.

It may be necessary to temporarily close the site until final corrective actions are taken on hazard trees. Where people may gravitate back to a site or simply use it by mistake, the use of warning signs is recommended to keep people away.

Move the target

One way of correcting a hazardous situation is to direct people away from the defective tree by moving the targeted picnic table, fire ring, tent spot, etc. In other cases, it may be necessary to permanently close an area to public access and relocate the campsite or building when the tree can not be removed due to its historical value, stature or position in the canopy.

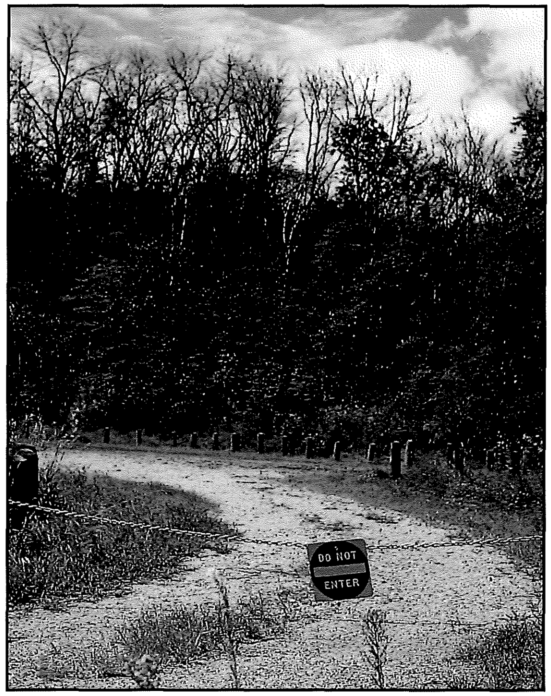
Pruning

A hazardous situation may be caused by a defective branch while the rest of the tree is still sound. In this case pruning the branch would solve the problem. Hazardous situations requiring branch pruning are:

a. branch over 4" dbh with a crack,
b. weak branch union that doesn't affect the entire tree,
c. large branch showing signs of decay,
d. large dead branch,
e. branches that form a sharp angle or bend, or that twist,
f. branch that is lopsided or unbalanced with respect to crown mass, and,
g. broken branches lodged in the crown should be removed and their stubs pruned back.

Pruning is a two-edged sword. If done improperly, the immediate problem is alleviated but cracks, decay, cankers or poor architecture are promoted and remain with the tree. If done properly, pruning does not create defects. It is recommended that "natural target pruning" be used. This method is fully described in the Appendix. Never prune oaks in May or June in order to prevent oak wilt transmission.

In many situations, it is only necessary to remove the hazardous part of the tree by pruning.



One method of correcting a hazardous situation is to direct people away from it. Here the campsites have been closed temporarily.

Another correction method is to move the target. In some cases, simply moving the targeted picnic table, tent spot or fire ring will accomplish the task.

When removal is prescribed, it should be planned so that damage to adjacent trees is minimized.

"Topping," the removal of the terminal portions of live crowns, is a serious injury and has negative, long term effects. It is a temporary measure and the tree will again be hazardous due to decay in the topped stem, poor architecture and weak unions in the newly developed top. It is not normally an accepted practice. However, topping can be acceptable when dead or broken tops need to be removed. For example, it is acceptable to remove the dead top of a white pine killed by blister rust disease. Never cut into live wood when topping or you run the risk of promoting rapid decay in the entire stem.

Tree Removal

Before cutting a tree down, consider alternatives. The effects of removing a tree are often pronounced. First, it takes many years for a tree to grow and thus replacing that tree will be a long term process. Secondly, removal of too many trees may lead to increased windthrow in the remaining stand since the stand will be more open and crowns will be newly exposed. And finally, aesthetic qualities of the recreation area may also be adversely affected by the removal of many trees.

When removal is prescribed, the goal should be to minimize damage to adjacent trees. Wounding of surrounding trees is the major cause of future defects. Damage can be reduced by limbing or topping a tree before felling. When removing felled trees, care must be taken not to wound the trunks or roots of surrounding trees. Trees are especially prone to damage in the spring when the bark is loose. For this reason, the best season for tree pruning and removal is in the winter when the ground is frozen and when trees and their respective pests are dormant.

Preventing future hazards

People wound trees so it stands to reason that wounds can be prevented. When recreation facilities are being constructed, trees are often wounded by trenching, blacktopping, changing the grade and heavy machinery. During site maintenance, wounds are caused by mowers, snowplows, falling trees and limbs and improper pruning techniques. Trees can also be damaged by careless use of herbicides and improperly dumped snow containing road salt. Recreation site visitors inflict many wounds with such activities as, pounding nails into trees, burning trees with lanterns, gathering and chopping firewood, and damaging trees with vehicles.

Future hazards can be prevented in a number of ways:

a. Avoid wounding residual trees

Any activity that scrapes, removes or kills the bark and cambium causes a wound. Roots as well as stems and branches can be wounded. The prevention of wounds cannot be stressed too much because wounds initiate the formation of cracks and other defects. While planning and developing a recreation site, use ideas such as these: minimize human intervention (paving, trenching, changing the grade, etc.), use corridors for equipment travel, use fencing to limit vehicle movement and "save" islands of trees not individual trees. Teach workers not to wound trees when mowing, felling trees, pruning trees or plowing snow. Campers and recreationists can also be taught to respect trees and preserve the site's natural beauty.

Wounds serve as the entrances for fungi which cause the decay process. By preventing wounding and promoting rapid closure of wounds, decay problems will be kept at a minimum. Rapid wound closure occurs when the wound is small and the tree is in vigorous condition. Use natural target pruning as the method of choice when pruning is recommended.

Roots damaged by construction or maintenance activities can develop root and butt rots which often lead to stem cracks and tree failure. In addition, root damage may cause top dieback, increasing the amount of dead wood in the crown.

b. Maintain tree vigor

In the long run, proper tree maintenance and care will decrease the number of defective trees and enhance the vigor of the existing trees. Tree vigor can be enhanced by providing water during dry periods, fertilizing with low nitrogen fertilizer, aerating the soil, mulching, replanting, rerouting trails and shortcuts, promoting the growth of woody understory vegetation, structuring travelways to restrict soil compaction and fencing to protect plantings.

If trees are pruned or removed, it's a good practice to have the inspectors on site to assess their recommended actions.

B. Program follow-up

The effectiveness of the hazard tree program needs to be periodically evaluated. Such an evaluation provides inspectors with the feedback they need to increase their proficiency. Inspectors should be on site when trees they have judged as hazards are removed or pruned. This will allow inspectors to compare their assessment of external indicators and potential hazard to the real evidence of internal defects. It is also recommended that inspectors be on site during storm damage clean-up to gain experience in rating locally important defects and their respective reactions to environmental conditions.

Managers have several factors to assess when determining if the hazard tree program is accomplishing hazard reduction on the site. Among these are: inspector proficiency, choice of corrective action, contract specifications and methods utilized by contractors.

The first two factors are the most important because they have the greatest impact on the trees and on the site as a whole. The manager can enable the inspectors to do a better job by setting the proper working framework. Without it, inspectors may respond emotionally or over-react when rating the trees. In one case, every tree seems to become a source of potential danger and even insignificant defects seem to leap out at the inspector and cry out for correction. Another potential problem is the inspector who can not bear to remove a tree because of its stature, history, species, importance to the site, etc. Non-action is translated into leaving hazard trees on the site when they should have been removed. Both the over-reaction and the non-action scenarios can be addressed by establishing a framework within which to work.

Following are indicators to look for during program follow-up or during the second inspection of a 2-tiered inspection:

Signs too few trees are recommended for removal or were removed:

1. Additional hazard trees are found.
2. The area has an unkempt appearance and the trees are of poor form.
3. The sudden appearance of insect outbreaks, particularly wood boring insects, in what were healthy trees.
4. More woodpecker activity than usual.
5. Disease outbreaks followed by tree dieback, often occurring at the tops or the tips of the branches. Although this does not necessarily mean that the trees should be removed, it is a sign that inspections should be more rigorous and done during the leaf-on period.
6. The presence of fungal fruiting bodies (mushrooms or conks) on a great number of trees.
7. Large numbers of branches that have to be constantly cleaned up.
8. Large numbers of trees with the same type of serious defects.
9. Complaints come from visitors about the condition of the trees on the recreation site.

Signs too many trees are recommended for removal or were removed:

1. The current inspection recommends more than 30% of the trees need to be removed.
2. The area appears too open or there is a great change from what it used to look like.
3. Winds topple apparently healthy trees that were formerly protected from the wind by their neighbors.
4. Hotter conditions are creating changes in the herbaceous layer, the shrub layer or other trees.
5. Several trees have recently developed a lean or are tipping.
6. Visitors are less frequent; complaints increase about the site's vegetation.
7. Most of the branch and tree removals appear to be sound.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
OPERATIONAL ORDER NO. 97
EFFECTIVE DATE: March 1, 1992

Subject: DETECTION AND CORRECTION OF HAZARD TREES* ON RECREATION AREAS AND ADMINISTRATIVE SITES

I. Purpose

The Department of Natural Resources provides a wide variety of recreational opportunities on the forested lands it administers. It is the Department's goal to try to maintain an aesthetically pleasing but reasonably safe recreational environment for visitors. Forest and shade tree communities are living systems under constant change, and the introduction of recreational activities can induce or intensify detrimental changes in the trees. Additionally, there are significant unknown or undetectable interactions naturally occurring within biological systems that may result in structural defects within living trees.

The purpose of this operational order is to establish and maintain a program which provides for reasonable public safety by detecting and correcting situations involving hazard trees in intensively-used recreation areas* where appropriate and feasible within the constraints of the Department's budget. The Department faces the challenge of preserving a forested environment for the enjoyment of visitors while providing for adequate public safety. As there are limits to our capability to detect, interpret and manage hazardous trees, there will be unpredictable tree failures. All of the hazards in forested recreation areas cannot be detected, corrected, or eliminated.

II. Responsibilities

The Commissioner will designate program contacts within each administrative discipline to guide the implementation of this program. The commissioner will identify the need for these program contacts to convene.

The Directors are responsible for guiding program implementation on recreational lands under their jurisdiction, developing and reviewing technical procedures and contracts, training personnel, reviewing annual accomplishments and investigating accidents.

* = definition in the Operational Order Appendix

Region Field Service Supervisors, Forestry Area Supervisor, Parks Managers, Trails and Waterways Area Supervisors, and Area Fish and Wildlife Managers are responsible for scheduled inspections of their intensively-used recreation sites for hazard trees and the correction of hazardous situations.

Additional surveys may be deemed necessary after severe storms. Reports of inspection results, recommendations and corrective actions taken will be maintained at the appropriate office (see section IV. procedure). Managers will identify the need for technical support and budgetary needs. Budget needs can include monies for training, inspections, program implementation and evaluation.

III. Policy

The Department is authorized by law to provide sites for public recreation and to manage these sites for their natural resources. It is the Department's policy to try to preserve the natural beauty of its recreation sites while providing for reasonable public and employee safety on intensively used recreation sites and administrative sites by detecting and correcting situations involving hazard trees insofar as it is feasible within the constraints of the Departments's resources.

Inspections, maintenance and corrective actions will accomplish this goal. On an annual basis, trees in drive-in campsites in developed campgrounds will be evaluated and corrective actions taken. Every other year, trees in picnic areas, buildings and facilities in developed campgrounds will be evaluated and corrective actions taken as appropriate. Trees on public water accesses, administrative sites, day-use areas, parking lot peripheries and near buildings will be evaluated less often. For these sites, special trips or visits for the sole purpose of hazard tree inspections do not have to be made. Instead inspections and corrections will be done as a part of the regularly scheduled maintenance activities for the sites.

Not covered by this policy are trees along trails, trout streams, forest roads, and trees in old growth/forest areas and "wilderness experience" areas. The document, "How to detect, assess and correct hazard trees in recreational areas" establishes procedures to use in detecting and correcting hazard trees.

OPERATIONAL ORDER APPENDIX

Definitions:

Hazard tree	Any defective tree or tree part, which due to a visible or detectable defect, poses a high risk upon failure or fracture to cause injury to people or damage to property.
Target	Anywhere people or equipment are likely to congregate or stop. Examples include campsites, parking lots, picnic areas, swing sets, buildings and public water accesses.
Administrative site	Lands surrounding a DNR office or facility that are maintained for public and employee use.
Intensively used recreation area	Recreation areas where people are likely to congregate or stop. Examples would include campsites, picnic areas, swimming beaches, facilities, public water accesses, etc. This would not include dispersed-use recreation areas, such as, trails.
Custodial supervisor	The person designated by the regional administrator to manage the physical plant of an administrative site.
Area Manager	For the Division of Fish and Wildlife, Section Wildlife, the position Area Manager means Area Wildlife Manager and Wildlife Area Manager.

IV. Procedures

<table>
<tr><th rowspan="2">Step</th><th rowspan="2">Action</th><th colspan="5">Responsibility</th></tr>
<tr><th>Field Services</th><th>Fish & Wildlife</th><th>Forestry</th><th>Parks & Recreation</th><th>Trails & Waterways</th></tr>
<tr><td>A.</td><td colspan="6">Training</td></tr>
<tr><td>1.

2.</td><td>Provide hazard tree training.

Make sure designated employees receive training in hazard tree detection and correction since they will be responsible for inspections.</td><td>Administrator

Regional Supervisor</td><td>Directors

Regional Manager</td><td>Director

Area Supervisor</td><td>Director

Assistant Regional Manager</td><td>Director

Area Supervisor</td></tr>
<tr><td>B.</td><td colspan="6">Implementation</td></tr>
<tr><td>1.</td><td>Designate employees or contract labor to assess trees and make recommendations consistent with manual guidelines. The manual establishes inspection procedures, schedules and approved corrective actions.</td><td>Regional Supervisor</td><td>Area Manager</td><td>Area Supervisor</td><td>Assistant Regional Manager</td><td>Area Supervisor</td></tr>
<tr><td>2.</td><td>Conduct inspections consistant with manual guidelines. Determine and take appropriate corrective actions where necessary. Methods that reduce the risk from hazard trees include target* removal, campsite closure, tree pruning and tree removal.</td><td rowspan="3">Custodial Supervisor*</td><td rowspan="3">Area Manager</td><td rowspan="3">Field Station</td><td rowspan="3">Park Manager Forester</td><td rowspan="3">Area Supervisor</td></tr>
<tr><td>3.</td><td>If a hazardous situation can not be corrected due to budgetary limitations, close the site for public use or divert use until the situation is corrected.</td></tr>
<tr><td>4.</td><td>Maintain records of inspections, recommendations and corrective actions taken at respective offices.</td></tr>
<tr><td>C.</td><td colspan="6">Evaluation of program</td></tr>
<tr><td>1.</td><td>Evaluate corrective actions, contracts and natural tree failures to increase program effectiveness.</td><td>Regional Supervisor</td><td>Regional Manager</td><td>Area Supervisor</td><td>Park Manager</td><td>Area Supervisor</td></tr>
<tr><td>D.</td><td colspan="6">Funding</td></tr>
<tr><td>1.</td><td>Submit budget proposals for training, program implementation and evalutation through normal departmental budget process. Proposals should also identify the alternative actions necessary in the absence of funding.</td><td>Regional Supervisor</td><td>Area Manager</td><td>Area Supervisor</td><td>Park Manager</td><td>Area Supervisor</td></tr>
</table>

HAZARD TREE INSPECTION FORM

Campground or Unit ______________________

Campsite or Subunit ______________________

Inspectors ______________________
____
____

Date ______________________

Remarks ______________________
____
____
____

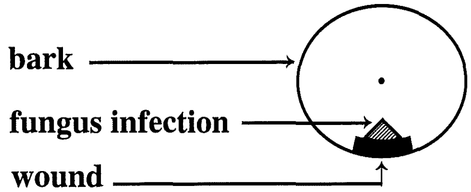
Map required only for campsites, picnic-areas and near buildings in drive-in campgrounds.

Tree location or map number	Tree species	Defect(s)	Hazard potential H or M	Remarks	Recommended action	Action taken/date

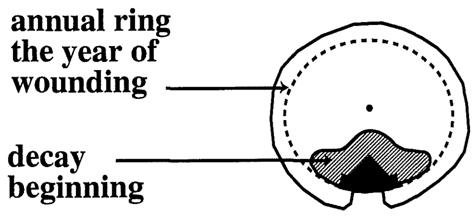
Local Manager ______________________ Date ______________________

Technical Information and Diagrams
Decay

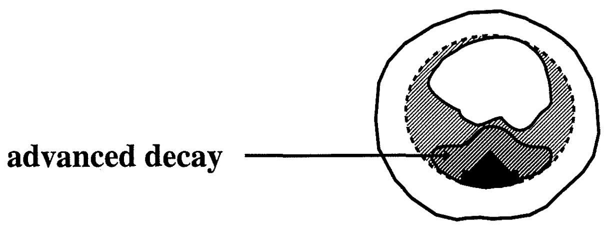
Decay development from an infected wound. It is "compartmentalized" and remains inside the annual ring which was originally wounded.



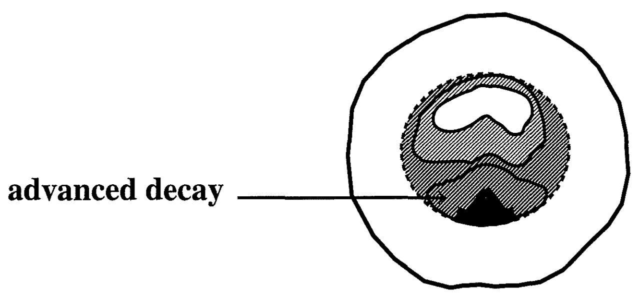
A wound is the entry point for decay causing fungi.



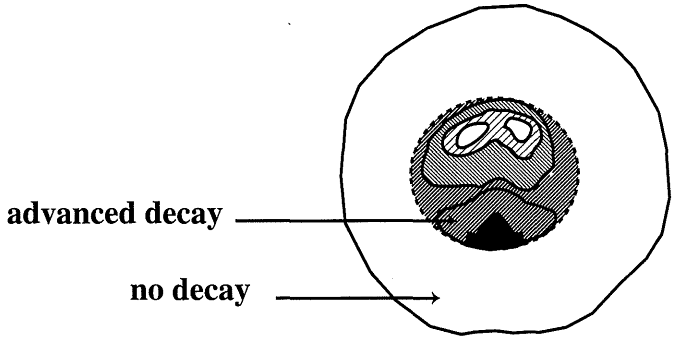
Fungal invasion of wood.



Internal fungal invasion of wood and beginnings of structural degradation.



Decay continues only inward from the annual ring present at the time of wounding.

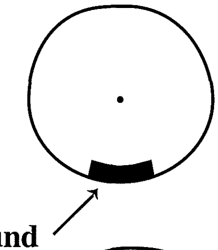


Only wood present at the time of wounding is decayed. All subsequent layers of wood are free from decay. The decay is "compartmentalized".

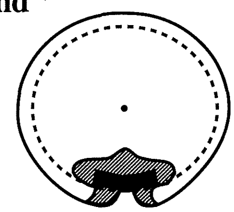
Decay (Canker-rot)

Canker-rot development from a wound. Decay is not "compartmentalized"; all new and old annual rings of wood can be infected and decayed.

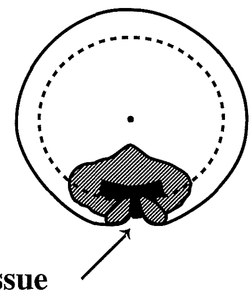
A wound is the entry point for the canker rot fungus.



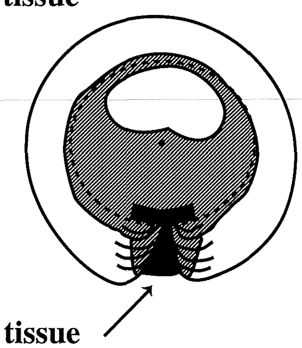
Infection and subsequent decay progresses inward and outward into new annual ring.



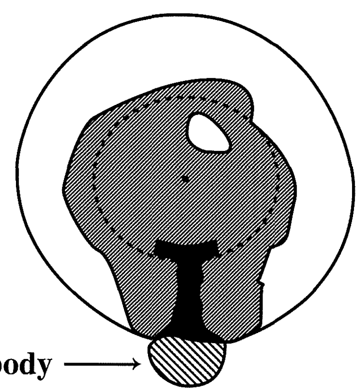
Infection continues to progress into second growth ring and into old annual rings. A fungal wedge of tissue develops.



All new growth rings are infected and fungal wedge grows and keeps the wound open. Infection and decay develop.

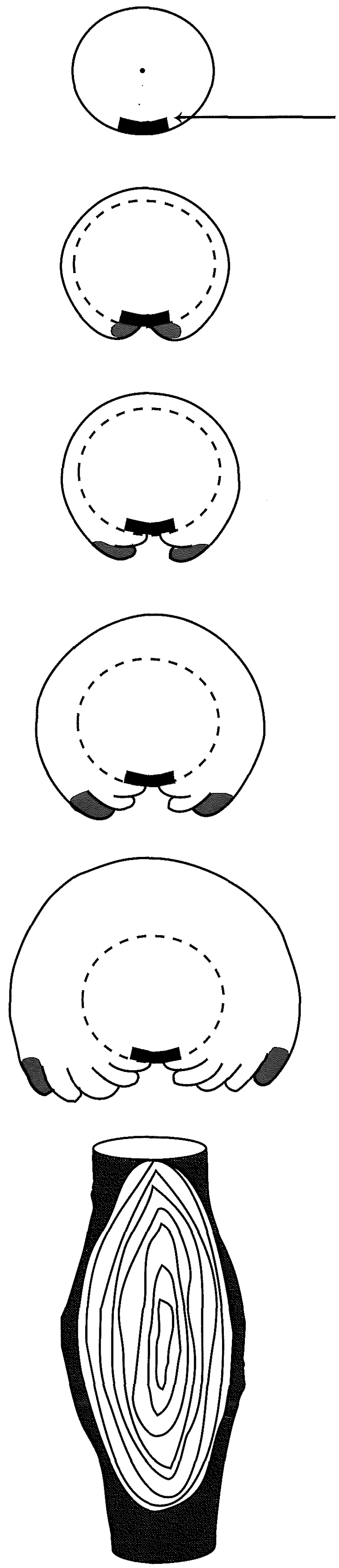


Decay continues in central cylinder and all new annual rings. Fungus often produces a fruiting body on the outside of the tree.



Cankers

Target canker development
Example=<u>Nectria</u> sp. on maple



A wound is the entry point for the canker infection.

The first annual ring of wood forms. It is infected by a canker fungus in the fall which kills the bark and cambium at the canker margin.

Second and third rings of wood form, are infected each fall. The bark and cambium on the canker margins are killed each fall.

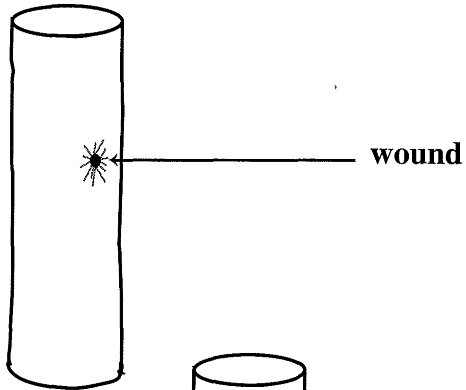
After several years, a balance between the tree's growth and fungal growth is reached. New layers of wood are added then killed each year. This process continues for many years.

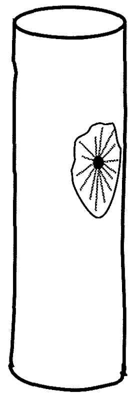
The canker face looks like a target.

Cankers

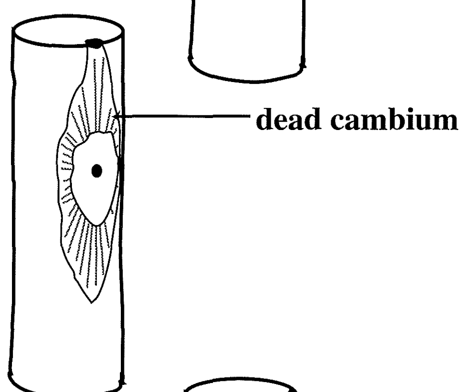
Diffuse canker development.
Example=<u>Hypoxylon</u> sp. on aspen.

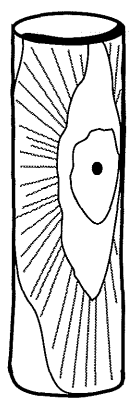
A wound is the entry point for the canker infection



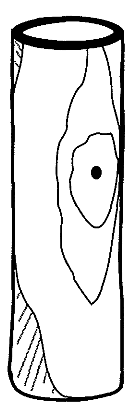


Each year the fungus continues to advance and kill large areas of new cambium.



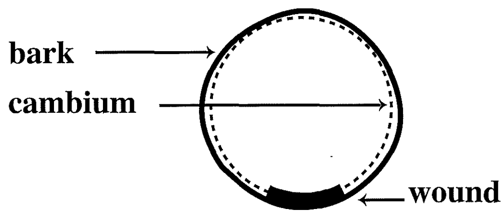


In time the fungus "girdles" the tree.

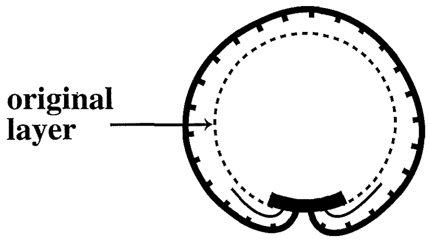


The canker face has a diffused pattern of dead and decayed bark.

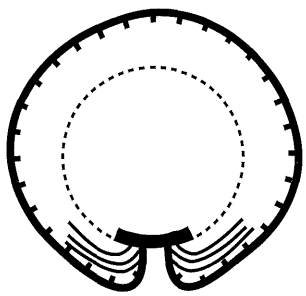
Crack Development



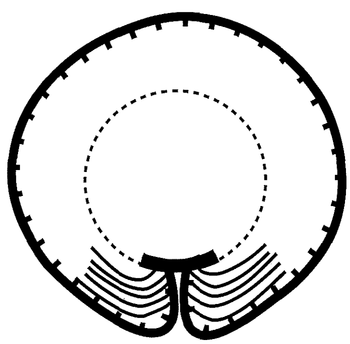
A wound kills cambium layer.



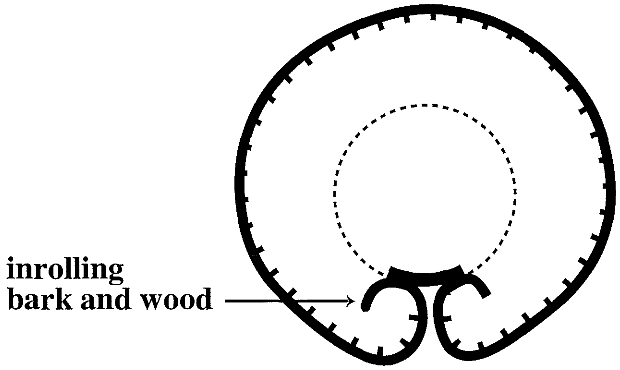
After 2 seasons, wood layers cover part of wound but do not meet.



After 4 seasons, bark and wood layers are not growing together.



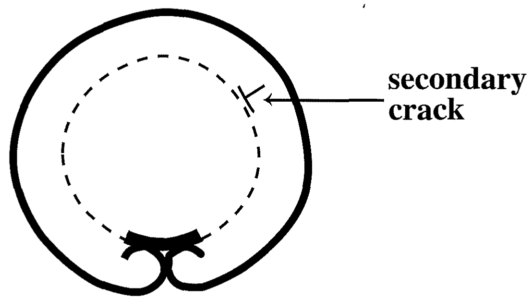
The two bark-covered margins meet and ridges of wood may form. Bark can be found along the entire edge of the crack down to the original wounded layer.



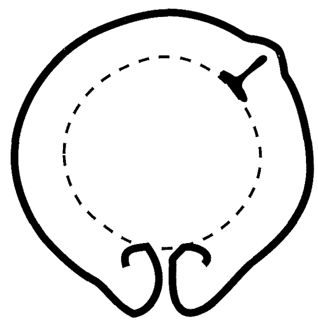
Bark growth continues in crack and along crack margin causing the wood to begin inrolling and pulling away from the original wound surface.

Crack Development continued

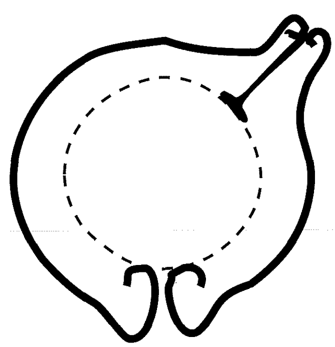
Inrolled bark and wood create tension which causes initiation of secondary crack.



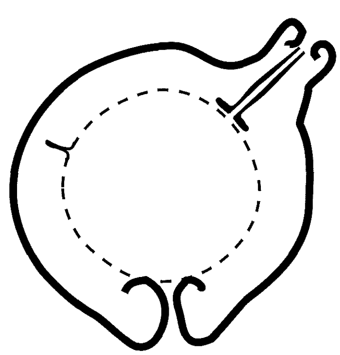
Internal tension causes secondary crack to elongate. Wood ridge begins to form.



Secondary crack elongates to the bark surface. Inrolled bark forms at this new wound.

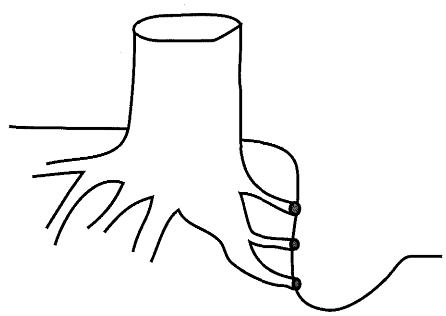


The stem can separate into two sections. Additional secondary cracks can form.



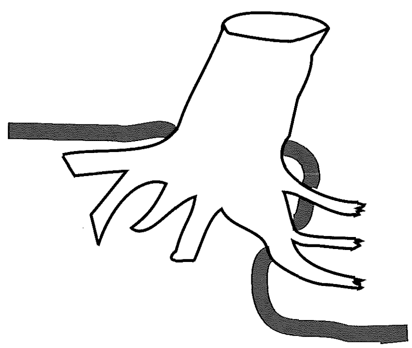
Root problems

Disruption of mechanical support by destruction of root system.



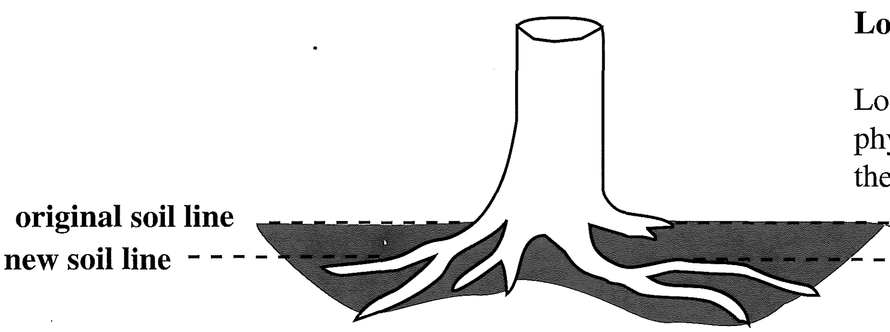
Root severing

When severed inside the dripline, mechanical support is lost immediately. The wounded roots also provide opportunity of root rot infection in the remaining root stubs.



Soil erosion

Soil erosion undermines a tree's root system, causing it to lean and or fall.



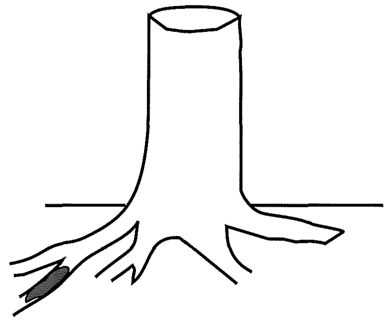
Lowering the soil grade

Lowering the soil grade can both physically destroy roots and make them prone to decay.

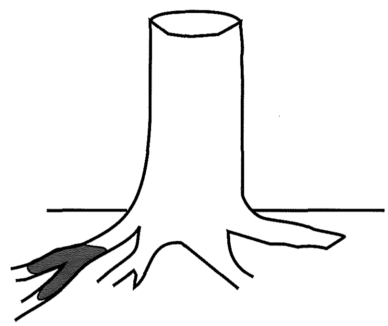
Root Problems

Root rot

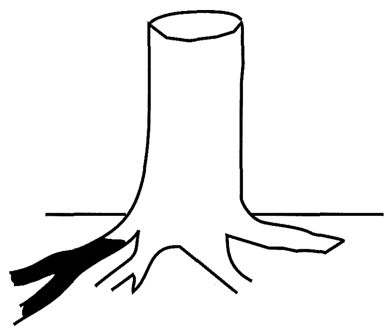
Fungal infection grows up main root, killing it and causing decay.



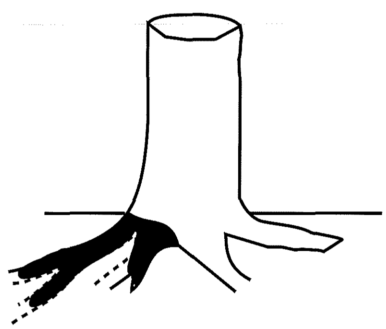
Fungus grows towards stem and spreads into another main lateral roots.



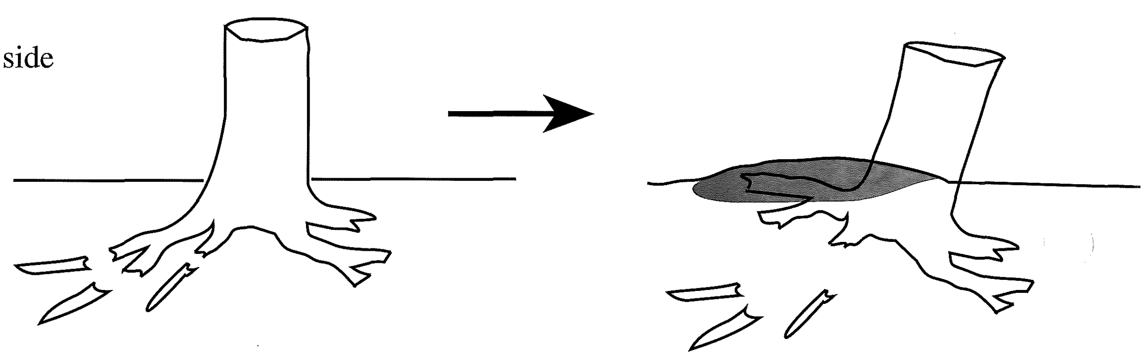
Infection may be halted but decay continues to develop in infected roots.



Loss of mechanical support in rotted roots.



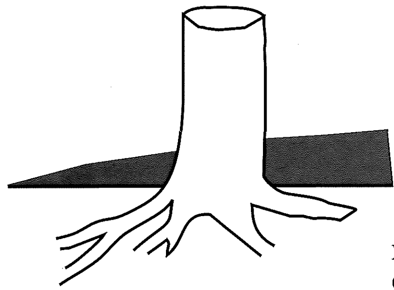
Soil mounding
Soil mounds up on opposite side of leaning tree.



Root problems

Reduction of tree vigor by decreasing tree's rooting zone.

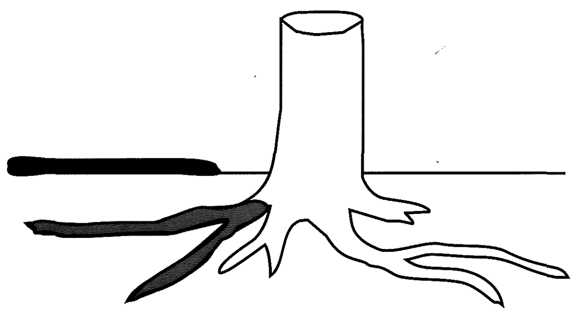
original soil line



Raising the soil grade.

Adding fill dirt anywhere in the rooting zone smothers the root system. Roots die then slowly rot away.

pavement or gravel



Paving over the root system.

Adding gravel or paving anywhere on the rooting zone smothers the root system. Roots die then slowly rot away.

NATURAL TARGET PRUNING & TOPPING

PRUNE CORRECTLY. Correct pruning is the best thing you can do for your tree. Here are the guidelines:

NATURAL TARGET PRUNING

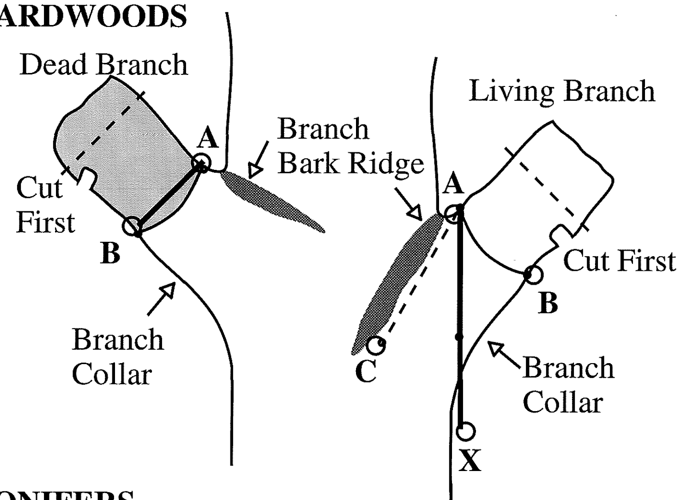
1. Locate the branch bark ridge (BBR).
2. Find target A — outside BBR.
3. Find target B — where branch meets collar.
4. If B cannot be found, drop an imaginary line at AX. Angle XAC equals XAB.
5. Stub cut the branch.
6. Make final cut at line AB (with powersaws make final cut on up stroke.)

Do not:

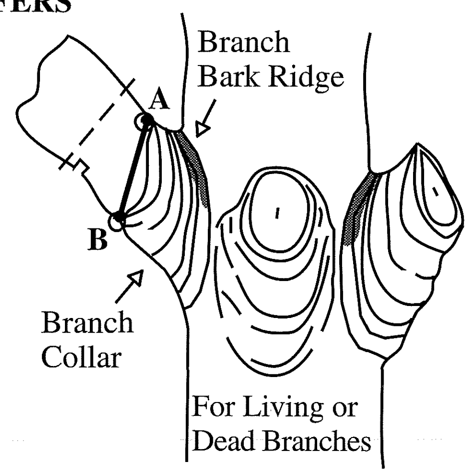
- make flush cuts behind the BBR
- leave living or dead stubs
- injure or remove the branch collar
- paint cuts

The best time to prune living branches is late in the dormant season or very early in spring before leaves form. Dead and dying branches can be pruned anytime. Use sharp tools! Make clean cuts. Be careful with all tools. Safety first!

HARDWOODS



CONIFERS

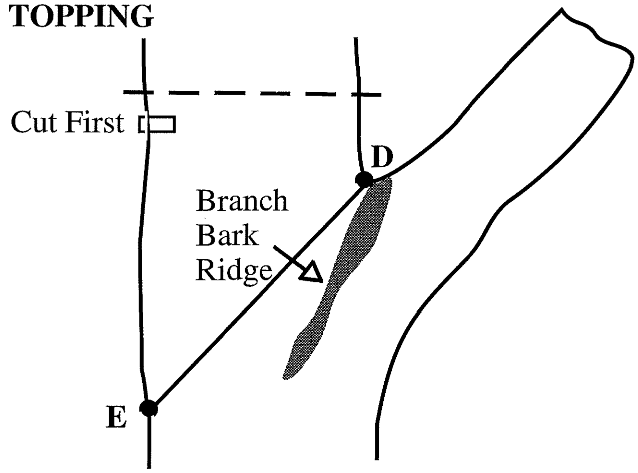


TOPPING

Topping trees is a serious injury regardless how it is done. Avoid it if possible by starting to prune early in the life of the tree to regulate its size and shape. If you must top cut, follow these guidelines:

Cut line DE at an angle approximately the same angle as the angle of the BBR. Do not leave a stem stub. Do no paint the cut. Know your safety limits — call professionals when the job is too big for you.

TOPPING



From: Homeowner's Guide for Beautiful, Safe and Healthy Trees. USFS, Northeastern Forest Experiment Station. Publication NE - INF - 58 - 84. Printed with permission.

GLOSSARY

Branch bark ridge = Ridge of bark that forms at the junction of the branch and stem. An upturned branch bark ridge indicates a strong branch union. An inrolled branch bark ridge indicates a weak union.

Cambium = Layer of living cells between the bark and wood surface that produces a new layer of wood each year.

Canker = Dead area of bark and cambium anywhere on the tree's surface. Cankers can be caused by fungi, insects, weather or mechanical damage such as lantern-burns or mowers.

Canker-rot = Fungal infection that causes an external canker and extensive internal decay.

Cavity = Hollow area in stem, branch or root where the wood has decayed and is now missing.

Codominant stems = Stems that are equal in size and relative importance.

Compartmentalization = A physiological process which creates chemical and mechanical boundaries to resist organisms, such as decay fungi. It results in the separation of healthy tissues and infected tissues by reaction and barrier zones.

Conk = Fruiting body of a fungus. Fruiting bodies on trees indicate advanced decay.

Crack = Separation of the wood, a fissure, or a deep split in the bark and wood of a tree. Cracks are the number one hazardous defect because they indicate that the tree is already failing.

Crown = Portions of the tree above the main stem or trunk; the branches, twigs and leaves.

Decay = Fungal and bacterial decomposition of woody tissues. The decay process reduces structural soundness and stability over a period of years.

Decline = General loss of vigor. It is usually accompanied by crown symptoms, such as, branch dieback.

Defect = Visible sign that a tree or part of a tree is failing or has the potential to fail. Any structural weakness or deformity in the tree's branches, stem or root system.

Defective tree = Tree with one or more defects.

DBH = Diameter of the tree measured at breast height, 4.5 feet from the ground.

Dieback = Death of a branch or branches, generally from the tip towards the main stem.

Epicormic branch = Branches that form on large, old stems or branches as a result of a serious disturbance, such as, improper pruning, disease or extensive dieback in the crown. Epicormic branches usually form weak unions with their stems.

Failure = Breakage of stems or branches or loss of mechanical support in the root system. Trees can fail due to defects or during severe storms.

Fire scar = Triangular scar at the base of a tree due to a past fire. A cavity is generally associated with a fire scar.

Fracture = Cracking or breakage of wood in branches, stems or roots.

Fruiting bodies = Structure where fungal spores are produced. Examples are mushrooms, conks and shelf fungi. They are indicators of advanced decay.

Hazard tree = Any defective tree or tree part that poses a high risk upon failure or fracture to cause injury to people or damage to property.

Hot spot = Zone on the stem of a tree that is presumed to be mechanically weak. The hot spot of a tree is from about 4 feet above the groundline up to the lowest branch. See diagram in Assessment.

Improper pruning = When removing branches, cutting into the branch collar, cutting flush to the stem, leaving long branch stubs or removing too many branches at one time.

Included bark = Layers of bark that have formed inside the tree at a branch union or fork between codominant stems. These ingrown layers of bark make a union weak.

Increment core = Sample of wood extracted from a tree by an increment borer. The core shows the annual rings.

Inrolled bark or wood = Bark or wood tissues that have turned inward and continue to grow inside the tree. See rams-horning.

Inspection = Systematic method of examining trees for visible defects and assessing them for hazard potential.

Lean = Describes a tree trunk that is not growing perpendicular to the ground. If the angle is greater than 45 degrees, it may be hazardous.

Natural target pruning = Method of removing branches that preserves the tree's natural defenses. Only branch tissue is removed leaving the branch collar intact. See diagrams for conifers and hardwoods in the Appendix.

Rams-horning = Process that occurs when two wound margins grow together and their bark and wood layers begin to turn inward. The inrolling tissues curl and form the rams-horn over a period of years.

Seam = Evidence that a tree has successfully closed over a wound. Wound margins meet and grow together. In time, seams become indistinct.

Snag tree = A dead, usually hollow or limbless, tree that is left on the site for wildlife habitat purposes.

Target = A person, vehicle, building, picnic table, tent spot, etc. that could be hit if a nearby tree or branch failed.

Tipping = Removal of branch tips, usually to decrease the tree's width.

Topping = Removal of the top portion of a tree's live crown, usually to decrease the tree's height.

Tree architecture = Natural growth habit or branching pattern that is characteristic for each tree species.

Windthrow = Failure of the root system in anchoring the tree to the ground. Often trees are pushed over during severe storms.

Wound = Any injury to the bark, cambium or wood.

SUGGESTED READINGS AND VIDEOS

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HAZARD TREE INSPECTION FORM

Campground or Unit ______________________________

Campsite or Subunit ______________________________

Inspectors ______________________________
____
____

Date ______________________________

Remarks ______________________________
____
____
____

Map required only for campsites, picnic-areas and near buildings in drive-in campgrounds.

Tree location or map number	Tree species	Defect(s)	Hazard potential H or M	Remarks	Recommended action	Action taken/date

Local Manager ______________________________ Date ______________________________

HAZARD TREE INSPECTION FORM

Campground or Unit ______________________

Campsite or Subunit ______________________

Inspectors ______________________

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Date ______________________

Remarks ______________________

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Map required only for campsites, picnic-areas and near buildings in drive-in campgrounds.

Tree location or map number	Tree species	Defect(s)	Hazard potential H or M	Remarks	Recommended action	Action taken/date

Local Manager ______________________ Date ______________

Hazard tree assessment tatum guide

Defect	Moderate hazard potential	High hazard potential
Crack	Hardwood stem has single crack with cavity or decay inside	Crack goes completely through stem. May be able to detect movement of section of stem
		Stem has 2 cracks on the same segment with cavity or extensive decay inside
		Stem has crack in contact with another defect or at base of leaning tree
		Branch (4" or larger) has any crack Conifer has a single crack with inrolled bark and cavity or decay are inside
Weak unions	A weak union with inrolled bark	A weak union that is also cracked, cankered or decayed
		A weak union in the tree's hot spot
Decay	Canker-rot infection	Canker-rot infection in tree's hot spot
		Cavity or decay (fruiting body) associated with an open crack or a weak branch union
		Any branch with decay
Canker	Canker affects> 1/2 of tree's circumference	Canker in tree's hot spot and affects > 1/2 of tree's circumference
	Canker at base of leaning tree	Canker-rot infection in tree's hot spot
		Canker physically connected to crack, decay or weak union
Dead	Branch more than 2/3rds dead (remove branch)	Any dead tree
		Any dead branch or top
		Any lodged branch
Poor tree architecture	Branch unbalanced with respect to rest of crown mass	Tree leaning over target with > 45 degree angle to the lean
	Branches with sharp bend or twist	Tree leaning over target with another defect in the hot spot
Root problems	Root problems associated with stem decay, crack or canker	Freshly leaning tree with recent root-lifting, soil movement or mounding near base of tree
		Inadequate root support > 1/2 of roots severed inside dripline
Poor tree architecture	Branch unbalanced with respect to rest of crown mass	Tree leaning over target with > 45 angle to the lean
	Branches with sharp bend or twist	Tree leaning over target with another defect in the hot spot