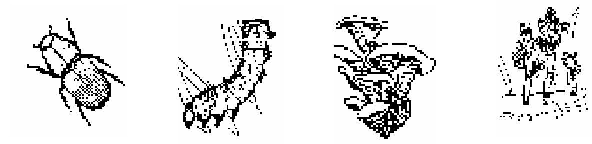
Forest Health Protection



Numbered Report 08-08 **July 2008**

Moose Cr. Ranger Station, Nez Perce NF, Hazard Tree Assessment

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Summary

We conducted a hazard tree assessment at Moose Creek Ranger Station, an administrative site and trailhead for the Selway-Bitterroot Wilderness, on May 20-23, 2008. We assessed trees near the buildings of the station and the nearby airstrip camping area used by pilots and clients accessing the wilderness trailhead.

Moose Cr. station and the airstrip hold the unique status of falling within the boundaries of a wilderness area. The presence of numerous stumps, of various ages, in both the compound and airstrip camping area testify to on-going tree mortality and hazard mitigation.

Although large, the trees around the Moose Cr. Station buildings are relatively young and healthy compared to those in the airstrip campground. The same three root diseases, *Armillaria* root disease, *annosus* root disease and brown cubical root and butt rot, are present in the trees near the station as were found in the airstrip camping area. Heartrot caused by Indian paint fungus is very common throughout in the residual stand north and east of the ranger station but was not found among the trees in the yard area nearer the buildings. The stand in which the airstrip camping is concentrated is very decadent with severe root disease and stem decay caused by Indian paint fungus. Few other significant disease or insect damages were found in either location.

We conducted a standard all-trees hazard assessment with stem mapping in the yard area of the station and in the most heavily-used portion of the airstrip camping area. The remainder of the airstrip camping area and stand near the buildings but outside of the fenced yard were examined to identify only immediate tree hazards based on known targets or customary-use locations.

It was recognized that most of the Douglas-fir and grand fir near the station and in the airstrip camping area have root disease and, as such, pose a hazard to structures and visitors. The unusual situation of having several historically-significant buildings and the concentrated-use camping and airplane parking in a designated wilderness, combined with known frequent tree death and failure in both areas prompted this tree hazard assessment.

This is the final report of our findings including a monitoring plan for trees near the station with know defects. Supporting data appear in appendices.

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Methods

For the most part, we used standard methods to assess hazard trees. Trees within striking distance of a recognized target were examined. In the station yard and around the most frequented campsite near the airstrip (Figure 1), a stem map was developed to allow individual tracking of trees. The species and diameter was noted and observable damages or deformities were recorded by class and severity codes (Appendix A– Tree Hazard Assessment Form). Trees were categorized as: 1) relatively safe, 2) sufficiently hazardous to warrant removal, or 3) having a developing condition that should be monitored.

Outside the fenced yard but still within striking distance of a structure, we examined trees for potentially hazardous conditions and individually identified only those trees we recommended for removal.

Target considerations

An important part of hazard tree assessment is judging the likelihood that a tree will fail in the direction of a target. For any tree, there are 360 degrees in which a tree could potentially fail. The farther the tree is from the target, the narrow the angle of failure that will allow the tree to strike a limited target such as a table or tent pad. The closer a failure-prone tree stands to the target, the broader the angle of failure that will strike the target. Therefore, failure-prone trees nearest critical targets, are most often identified for removal.

Leans are an important consideration for judging probably angle of failure. A strong lean away form a target is a good indication, but not a guarantee. For the purposes of this assessment, trees with neutral or toward-target leans were considered.

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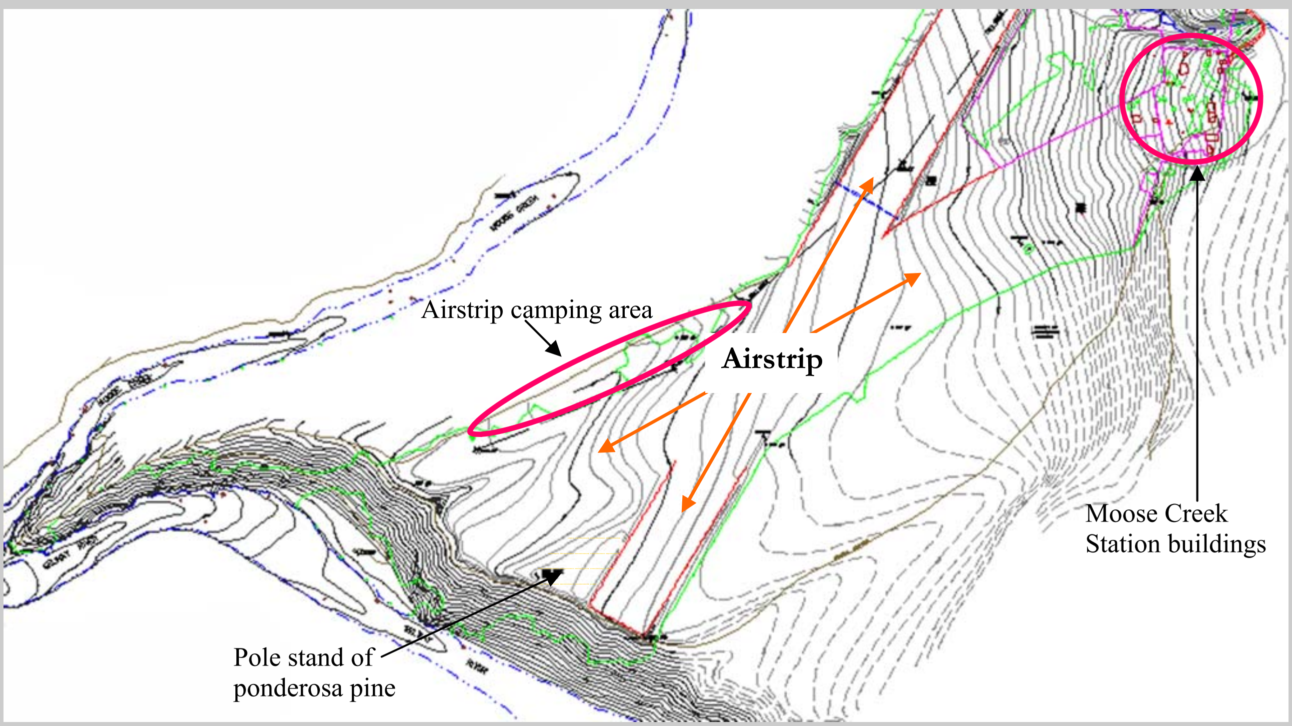

Figure 1. Locations of tree hazard assessment (circled in red.) Trees were assessed in the Airstrip camping area and in and around the Moose Creek station yard (surrounding the buildings.) The pole stand of ponderosa pine has few tree hazards and may be a good alternative site for camping.

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Removal recommendations

The procedure we used to assign a recommendation for tree removal was carefully considered within the context of the wilderness setting. Recommendations were relatively conservative (of trees) compared to that used for established campground and administrative sites outside wilderness. In the airstrip camping area where so may trees were in poor condition, we even went so far as to rank removal recommendations as first priority, for trees that pose the most immediate and significant threat, and second priority, for trees that have a recognized condition that could lead to failure but do not pose as extreme a threat as the first priority recommendation. In many cases the second priority recommendation was used for trees with a lower-ranked target or a lower probability of striking a target.

Because the stand at Moose Creek Ranger Station differs significantly from that of the airstrip camping area, they are assessed separately in this report and are covered individually in this report.

Monitoring

Trees designated for monitoring have conditions that can be expected to worsen with time. In the case of the Moose Creek stands, root disease and stem decay with or without leans or evidence of root movement are the main causes of defects resulting in the decision to monitor a tree. Monitoring results in a yearly expense and should produce a permanent record for each designated tree. It is important to follow through with prescribed monitoring of trees where significant defects have been identified. Anytime a tree with recognized defects is retained, the risk of failure is acknowledged and considered acceptable for the time being.

Annual monitoring is usually sufficient. A table documenting the location and condition of each identified tree is generated following the tree hazard assessment. A row should be added to the table for each tree to enter an update after each yearly examination. Alternatively, a data form can be printed for each tree that allows room for notes from each yearly evaluation to be entered. This permanent record will allow the examiner to determine whether significant changes have occurred and to better judge the rate of change. This background will help in making a decision to finally remove a tree that has become too risky.

Summary of Results

The Station

The stand of trees around the buildings at Moose Creek Station appear to have mostly regenerated shortly after the oldest buildings were constructed in the 1920's to 1930's. Trees were not bored unless absolutely necessary for diagnosis of damage so aging was based on general appearance rather than actual counts. A few older ponderosa pines are scattered around the compound and several suspected older Douglas-fir and grand fir were examined. These are probably the only trees that remain from the original forest stand. Most Douglas-fir and grand fir in the yard-area of the station appear to have been growing in open


Figure 2

conditions for all or most of their lives (Figure 2), suggesting they regenerated after the clearing for building construction was done.

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This origin of most of the grand fir in the yard probably accounts for the absence of heartrot, which typically has it's start in shade-killed branches of understory trees. The *Armillaria* root disease in the yard area is likewise, less frequent and aggressive than that seen in the surrounding stand. Annosus root disease and brown cubical root and butt rot appear to account for most of the live-tree failures in the yard but most of the past mortality is attributable to *Armillaria* root disease.

We examined and mapped 85 trees (Figure 3) within the yard area of the station including two standing, dead trees, two recently failed trees (Table 1). Nine stumps of various ages also were evaluated to aid in the diagnosis and prognosis. Over half of the trees were Douglas-fir. With grand fir and ponderosa pine accounting for most of the other half. Two locust trees (probably black locust) near the Ranger house also were included. These were just beginning to leaf out so our examination was limited to stem and root crowns.

The two recently-failed Douglas-fir were near the Ranger Station sign post. Neither appeared to have caused damage and the stems were being prepared for use in replacement fence components. Both trees had failed because of advanced brown cubical root and butt rot caused by the fungus *Phaeolus schweinitzii*. This is a common root disease of Douglas-fir and was found throughout the areas examined.

Of 83 standing trees, 23% had root disease, 16% had butt rot, and 10% had significant leans toward a highly rated target (Table 2).

(Continued on page 5)

Table 1. Trees examined and mapped within the fenced yard of Moose Cr. Station

Tree Species	Live trees	Dead standing trees	Recent windthrow	Stumps	Total trees and stumps
Douglas-fir	45	1	2	6	54
Grand fir	20	1	-	3	24
Ponderosa pine	14	-	-	-	14
Black locust	2	-	-	-	2
All trees	81	2	2	9	94

Table 2. Station yard: Significant damages of standing trees.

Tree Species	Total trees	Average DBH	Butt rot*	Root disease*	Lean toward target*
Douglas-fir	47	19.8	4	12	6
Grand fir	20	31.0	9	7	2
Ponderosa pine	14	26.5	-	-	-
Black locust	2	16.0	-	-	-
All trees	83	23.5	13	19	8

*Rated severity 2 or higher

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Given the species composition and age, this is relatively good conditions. Of the 82 live, standing trees, 25 are recommended for specific monitoring at least annually (Table 3). Most should be examined for increasing root disease or root disease-associated butt rot or for evidence of increasing instability in leans.

Ten trees are recommended for removal (Table 4). Only two of these are within the fenced yard and one of these recently died. The other eight are outside of the yard but within striking distance of buildings.

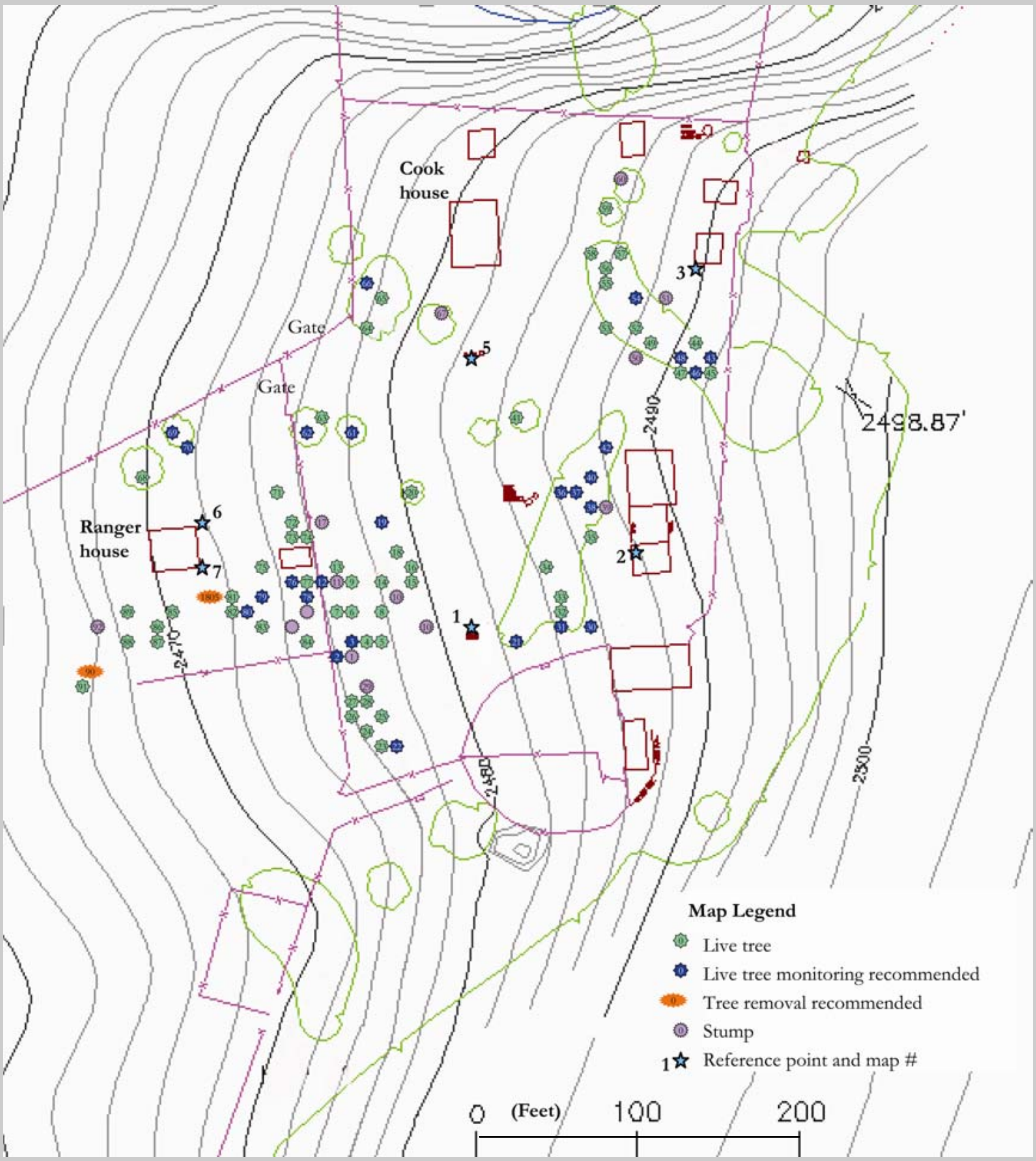

Figure 3. Composite map of trees and stumps on Moose Creek Ranger Station. May 21-23, 2008

Table 3. Station yard: Damages in trees recommended for monitoring							
Tree Species	**Total trees**	**Average DBH**	**Butt rot***	**Root disease***	**Lean toward target**	**Unstable multiple top**	**Bark beetle attack**
Douglas-fir	12	21.5	2	5	6	1	5
Grand fir	11	33.9	6	7	5	1	
Ponderosa pine	2	21.1	1	-	1	1	
All trees	25	26.9	9	12	12	3	5

*Rated severity 2 or higher

Table 4. Station yard and surrounding stand: Damages in trees recommended for removal.							
Tree Species	**Total trees**	**Average DBH**	**Dead Tree**	**Heart or butt rot***	**Root disease***	**Lean toward target**	**Bark beetle attack**
Douglas-fir	6	18.8			6	4	
Grand fir	4	30.3	1	3	4	1	1
All trees	10	23.1	1	3	10	5	1

*Rated severity 2 or higher

Map #1; referenced from the Moose Creek Station sign between the Ranger House and the Barn.

Brown cubical root and butt rot caused by *Phaeolus schweinitzii* was the direct cause of failure of tree #1 (Figure 4). These densely clustered trees are mostly mature, Douglas-firs that average about 14" dbh. Most probably have some level of damage from *P. schweinitzii* and two, trees #12 and 19, appear to have fresh Douglas-fir beetle (*Dendroctonus pseudotsugae*) attacks. Trees 2, 3 and 22 show more advanced signs of *P. schweinitzii* root disease in combination with a lean and should be monitored for signs of root movement that may indicate an increasing rate of progress toward failure. Tree 21

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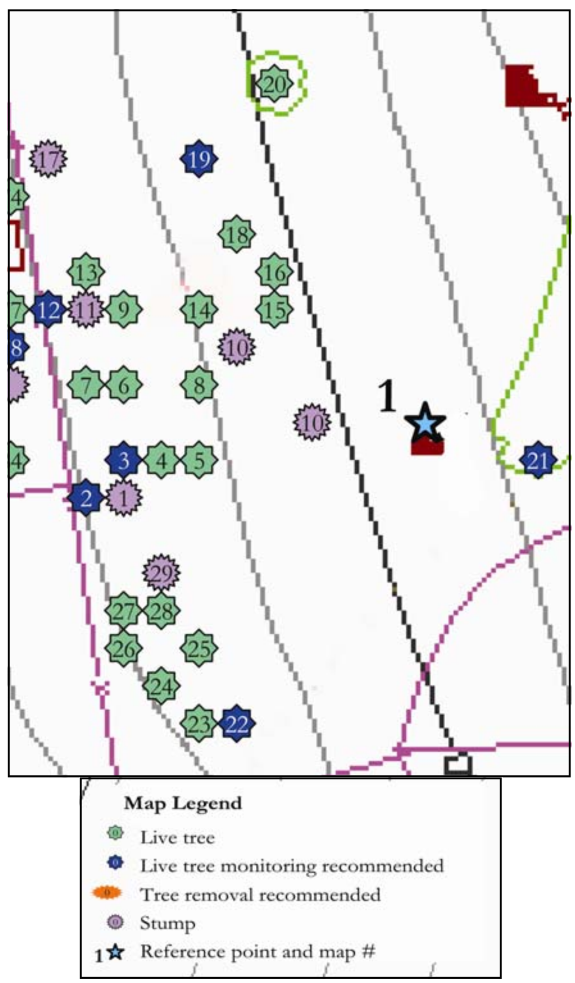

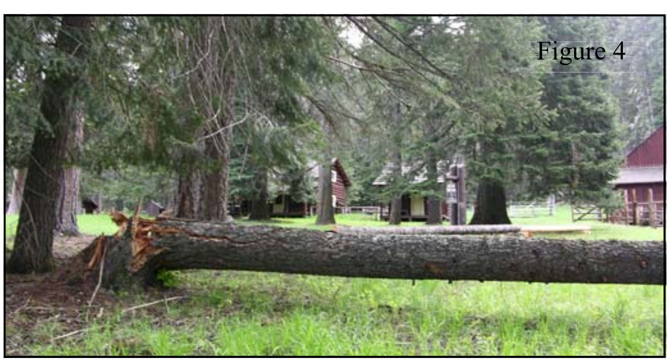

Figure 4

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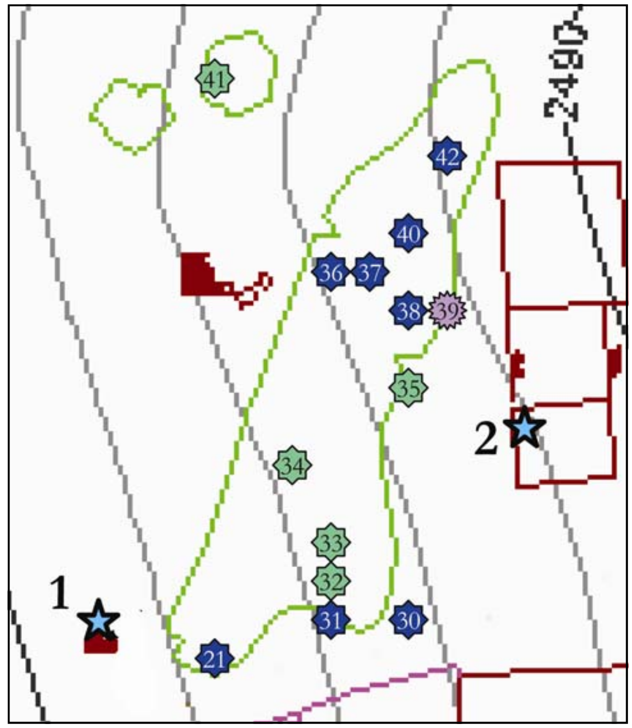
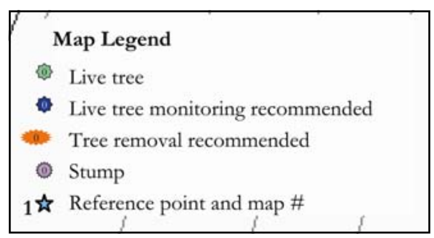
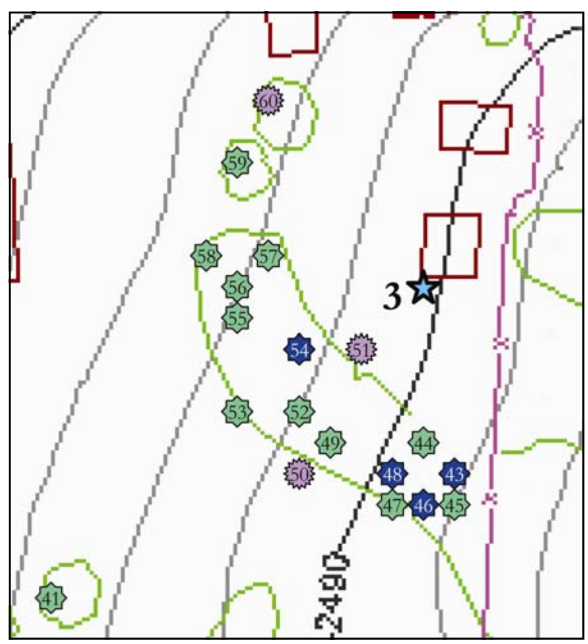
is a 52” dbh grand fir with only 5” of solid rind remaining in the upper butt with evidence of annosus root disease. It has large buttress roots, however, that appear sound at this time.

Map #2; Referenced from the northwest corner of the warehouse porch.
Most of the trees near the Assistant Ranger House, warehouse, and barn are large diameter grand fir. These trees have a variety of symptoms of annosus root disease an butt rot. Most common are cat-faces indicating dead roots and vertical cracking in the butt which indicates butt rot. Seven of these trees, 30, 31, 36-38, 40 and 42, were identified for future monitoring. Stump #39 has obvious annosus decay in the heartwood, evidence the tree had annosus root disease before it was cut.



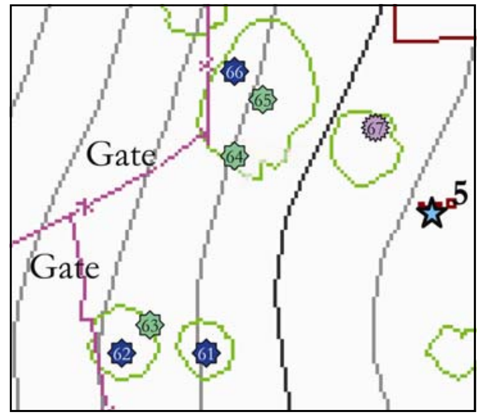


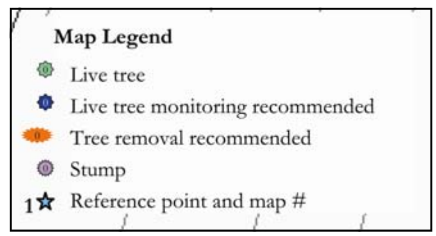
Map 3; Referenced from the southwest corner of the bathhouse.
Mostly mixture of Douglas-fir and ponderosa pines with relatively few problems. The one grand fir, #54 is the only significant hazard on this map. It is a large diameter (34”) tree with probable annosus root disease. Vertical butt cracks and basal cat-faces should be monitored for enlargement.



Map5; Referenced from the flag pole

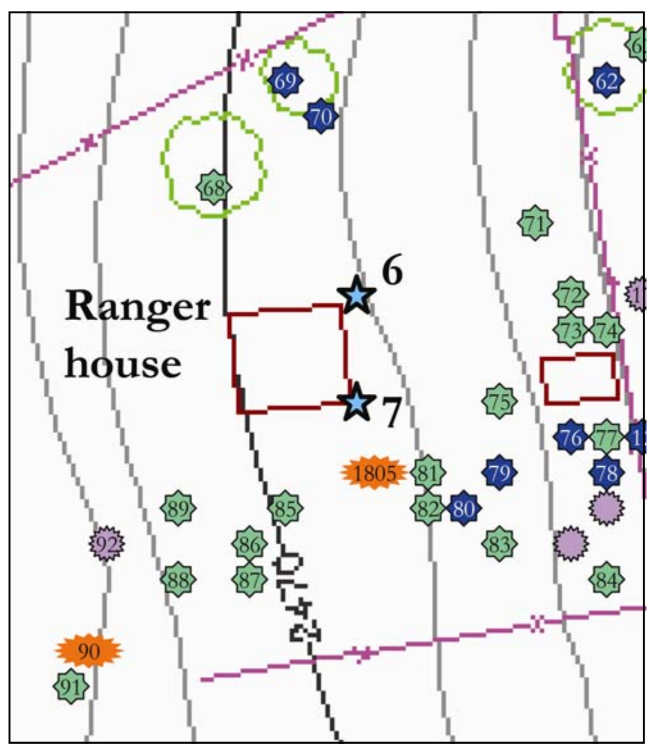
Douglas-fir 61 has evidence of root disease but leans substantially away from any target (other than the fence). Tree 62 is a large grand fir, 38"dbh, with an average sound rind of only 4.9 inches. Butt rot caused by annosus root disease is the probable pathogen so root failure is also possible. The butt is cracked all the way through. Monitor this tree for increases in crack diameter and for signs of root movement. Douglas-fir #66 has a thinning crown with branch dieback typical of *P. schweinitzii* infection. This tree is most likely to die standing, but should be monitored for root movement.





Maps 6 and 7 referenced from northeast and southeast corners of the Ranger House.

Tree 69, a 34" dbh grand fir is dying, probably from annosus root disease. It has butt cracking that appears to go all the way through. Tree 70 is in better shape, but probably has annosus root disease as well. On the other side of the yard (Figure 3), several trees have already been removed, having died of *Armillaria* root disease. Tree 1805, a 33" grand fir, recently died from *Armillaria* and tree 90, a 20" Douglas-fir is nearly dead from this disease. Both are recommended for immediate removal. Several others are recommended for monitoring for a variety of reasons. *Armillaria* root disease will continue to kill trees in this area but most can be expected to die standing. However, tree failure is always a distinct possibility when trees have root decay.



Prognosis for trees in and near the station yard

This mid-seral stand can be expected to continue to loose most of the Douglas-fir component slowly with root disease as the major cause (Figure 5). The grand fir trees will be increasingly weakened by butt rot and become more prone to failure as the roots are decayed. Fir engraver beetles (*Scolytus ventralis*) can be expected to kill many of the trees as root disease weakens their defenses sufficiently for successful attack. Heartrot is not likely to develop because these trees will not have grown under an infected overstory. The ponderosa pine component is in relatively good condition and should hold for many decades. The trees should be monitored yearly for changes in condition, particularly those identified as having developing conditions. Removals may be warranted, occasionally, when trees have died, or when imminent failure places structures at risk.

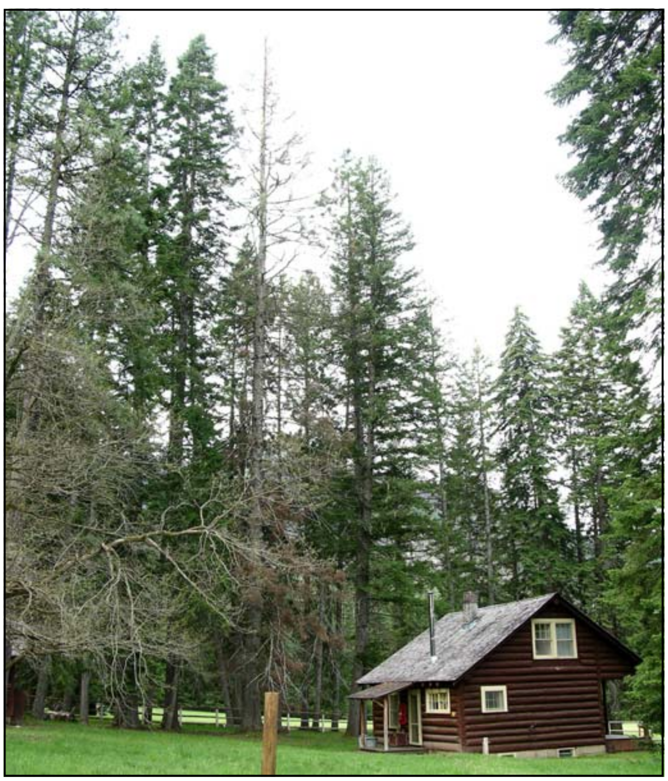


Figure 5. Many significant tree hazards were found northeast of the Ranger House where active Armillaria *root disease is causing active mortality and many trees have thin crowns typical of advanced disease.*

There is little opportunity for regeneration to establish in the yard area because of grass competition but it appears that the few young trees that have established are grand fir. Any grand fir or Douglas-fir that do establish can be expected to become infected by root pathogens and eventually exhibit symptoms similar to those seen in the current stand.

The diseases and insects that afflict the firs here are natural as is their course of development. Ponderosa pines and western redcedar that do establish on and around the station have the potential to create fewer management challenges over the long term. Where practical, these species should be encouraged over Douglas-fir and grand fir.

Recommended actions

- **Remove trees that pose unacceptable hazards or remove the target to reduce the potential for personal or resource injury.**
- **The diseases and insects that afflict the firs here are natural and predictable, as is their course of development. Ponderosa pines and western redcedar that do establish on and around the station have the potential to create fewer management challenges over the long term. Where practical, these species should be encouraged over Douglas-fir and grand fir.**
- **Examine each tree identified as requiring monitoring and maintain an annual record of the exam. This background will be invaluable in anticipating tree failure.**
- **Be prepared to remove additional trees that show unacceptable increases in risk**
- **A complete reassessment should be conducted in about 10 years.**

Airstrip Camping Area

The airstrip camping area has 5 tables and two outhouses. The campsites are informal, and tables are moved around by users to suit their needs. This limits the practicality of identifying hazard trees because the targets are not stationary.

Stand History

The site has a scattered, overstory of older ponderosa pine with a second overstory cohort of mature Douglas-fir and grand fir. This cohort appears to have been originally heavy to Douglas-fir, but more grand fir is currently surviving in this cohort. Most of the original Douglas-fir component died out earlier in stand development leaving a relatively small component of Douglas-fir as a proportion of stems but they tend to be among the larger trees and significant in the basal area. They are dying proportionally more rapidly than the grand fir. The probable cause for most of this mortality is the same as is currently observed, root disease (Figures 6 & 7) and associated bark beetles. The high rate of stem decay has accumulated over time and is typically only seen in mature and older trees. An understory of grand fir and western redcedar established over many years, probably in response to the gradual canopy opening.

Figure 6. Root decay caused by annosus and Armillaria *root diseases is the main cause of tree failure in the airstrip camping area.*

Figure 7: Tree failures are very common in the decadent stand near the airstrip that is commonly used for camping.

Diagnosis

Several large, active *Armillaria* root disease patches are found adjacent to and extending well into the camping area along the Moose Cr. side (Figure 8). *Annosus* root disease is seen throughout the camping area and surrounding stand . Butt rot and lesions with cat-facing are seen in most grand fir. Some lesions are distinct while other appear to be in the early stages of development. Crowns are generally thin with scattered dead branches. These symptoms are typical of slower decline symptoms with annosum.

Those with *Armillaria*, observed as basal resinosus often also have rapid decline symptoms in their crowns. Fir engraver is moderately active with many trees killed in the recent past and many current attacks that may be unsuccessful. Large, old grand fir have a high rate of heartrot caused by Indian paint fungus. Fruiting bodies of this fungus are common on the grand fir in the camping area, each one indicating heartrot extending an average of 8 feet of length in both directions.

.Annosum is present in the roots and butts of most of the failed trees, as is *Armillaria*. A few of the

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recent live-tree failures were due to *Phaeolus schweinitzii*. This fungus also was found fruiting surrounding the base of a very large Douglas-fir (near the far outhouse). *Phaeolus* causes little direct mortality but extensive decay in the support roots and butt, often leading to tree failure. *Armillaria* root disease is causing a high rate of tree failure (from the roots) as well as standing mortality (which, of course, will soon fall as well).

The younger understory grand fir which make up most of the lower canopy layer are very likely to be already infected and destined to have similar rates of heartrot to the current overstory. The understory western redcedar does have some evidence of butt rot and root rot but this is of relatively little concern at this time. They do appear to be experiencing more human-caused damage through bark shredding (unless this is actually an animal-caused damage).

The stand between the trail and Moose Cr. is extremely hazardous but because of the high density of large stems on the ground, it is an unlikely camping, or even hiking, area. The high rate of recent and older tree failure especially uprooting failure is indicative of the continued high risk. Additionally, crown and root crown symptoms are obvious throughout this area. The portion of the stand currently used for camping is relatively less hazardous but still has many hazardous trees especially toward the trailhead signboard.

Recent windthrown Douglas-fir trees have been attacked by the Douglas-fir bark beetle (*Dendroctonus pseudotsugae*). Fruiting bodies of the pouch fungus (*Cryptoporus volvatus*) on many downed trees indicate that the beetle successfully attacked the windthrown Douglas-fir last year, and have emerged this year. Windthrown Douglas-fir trees have little to no defense against Douglas-fir beetle and often beetles bred in windthrown Douglas-fir have a significantly higher survival rate than beetles bred in standing green Douglas-fir. Beetles bred in the down trees have the ability to attack standing green Douglas-fir. Many standing green Douglas-fir trees in the airstrip area and near the building have upper bole pitch streamers which may indicate beetle attack. Douglas-fir beetles often initiate attacks in the upper boles of trees and may not be evident in the lower bole where we can sample. Successful attacks kill the tree. The pitch streaming we observed may be indicative of successful attacks, we were too early in the season to confirm if the trees are dying.

Figure 8. The mature stand of Douglas-fir and grand fir adjoining the airstrip on the west side is used for camping. The general decadence of this mid-seral stand is evident from a distance.

Prognosis

The current trend can be expected to continue until Douglas-fir is a rare remnant in the stand. The older grand fir will take many decades to disappear and by then they will have been replaced by another old and decadent junior cohort of grand fir. Western redcedar can be expected to increase in the stand since it is the successional climax on this site. Western redcedar is a relatively sturdy tree for campgrounds, tolerating a tremendous amount of damage to the roots and stem. They do not often fail while alive, and they are very slow to die. They will, however develop high rates of heartrot, butt rot and root rot as they grow old.

Young ponderosa pine stand near airstrip

We walked through the stand of young ponderosa pines established along the edges of the runway between the two runways. They appear to average about 8-12" dbh and are growing rapidly. Tree hazards are rare here.

Diagnosis

Western gall rust, which could be expected to produce hazardous stem cankers in tree of this age and species, is rare in this stand, perhaps less than 1% of trees are afflicted. Some parts of the stand are sufficiently dense to be attractive to pine engraver beetles (*Ips pini*). No activity was observed at this time but some impact should be anticipated. Generally, the beetle will build in slash from broken or blow-down trees and branches and attack and kill smaller trees (< 8" dbh) or the tops or larger trees. Ips beetles usually kills trees in small groups.

Prognosis

With little evidence of gall rust as this stage, it is unlikely that this disease will cause significant damage in the future. Site characteristics greatly influence the development of this disease and this is apparently not a conducive site. Bark beetles are likely to be the only significant influence here in the foreseeable future, barring unpredictable wind and weather events. Airstrip users may eventually find this stand an attractive (and safer) alternative for camping.

Recommended actions

- **Share our findings with the airstrip users to encourage safer use of the camping and parking area.**
- **Encourage camping in the ponderosa pine stands adjacent to the airstrip. Few tree hazards were found in these stands.**
- **Consider removing targets such as picnic tables and outhouses from the most hazardous portions of the stand.**
- **Remove trees identified as recommended if the target remains.**
- **Relocate tables, fire circles and outhouses to less hazardous positions within the grand fir/ Douglas-fir stand.**
- **Simple barriers such as logs and rocks can be used to discourage airplane parking in the most hazardous locations.**

Airstrip Camping Site A

We examined (Tables 5 & 6) and mapped all of the trees (Figure 9) and tagged recommended removals surrounding the southernmost camp site, referred to here as Site A, which we understood to the be the most frequented. Of the 72 trees mapped and examined, 7 were identified for systematic monitoring and 16 were recommended for removal (Table 7). Of these 6 were dead. The most common reason for removal recommendation was annosus root disease and associated butt rot in grand fir. Heart rot in grand fir caused by Indian paint fungus was the second most common reason for a removal recommendation.

Table 5. Airstrip Camping Site A: Significant damages of standing trees.

Tree Species	Total trees	Average DBH	Dead tree	Heart or butt rot*	Root disease*	Lean toward target*	Unstable multiple
Grand fir	58	17.6	2	30	20	14	11
Douglas-fir	8	21.0	2	-	8	-	-
Ponderosa	5	10.6	-	-	-	1	1
Western	1	17.0	-	1	-	-	1
All trees	72	17.5	4	31	28	15	13

*Rated severity 2 or higher

Table 6. Airstrip Camping Site A: Damages in trees recommended for monitoring.

Tree Species	Total trees	Average DBH	Heart or butt rot*	Root disease*	Unstable multiple tops*	Bark beetle attack
Grand fir	5	18.6	2	3	2	1

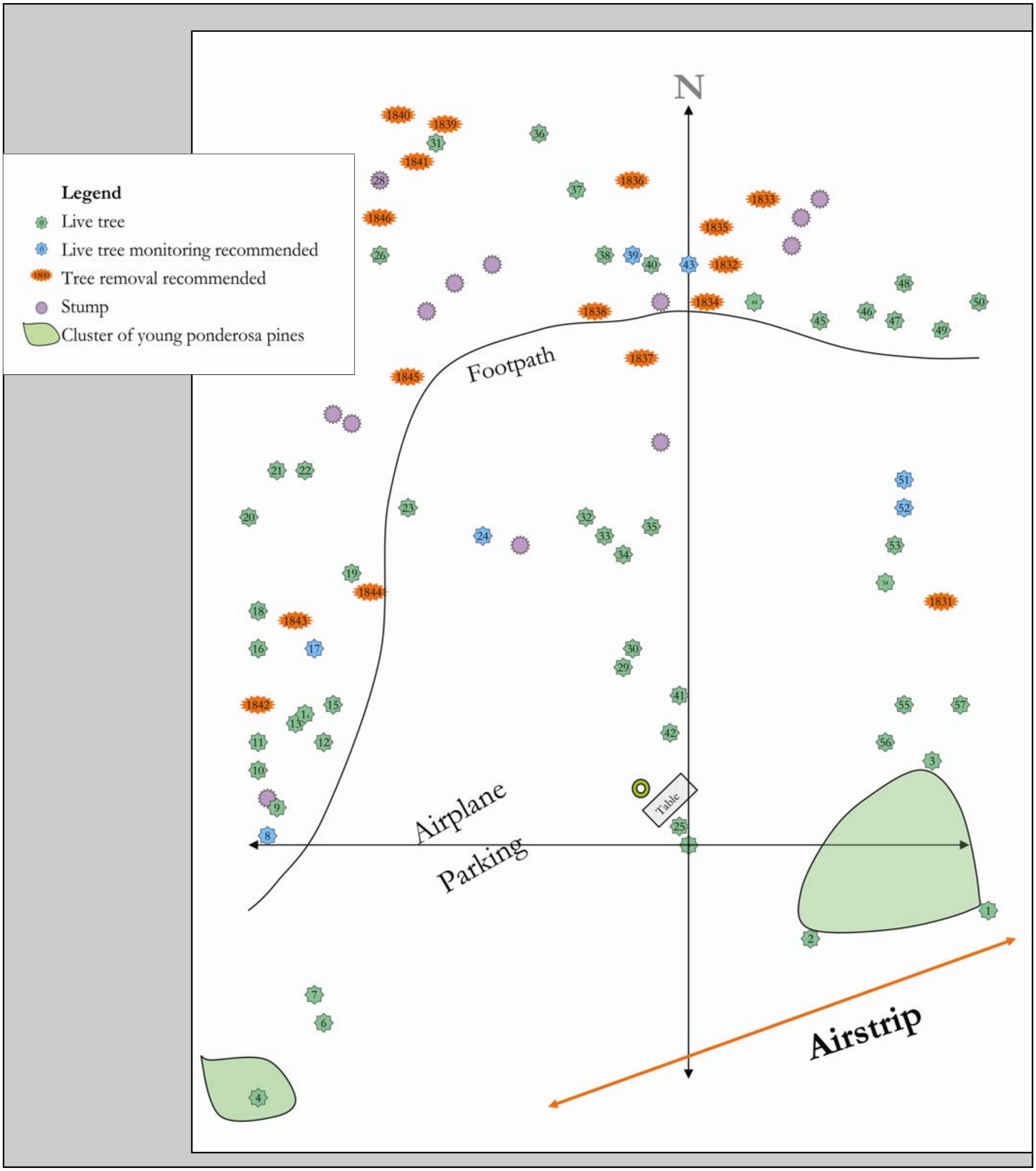
*Rated severity 2 or higher

Table 7. Airstrip Camping Site A: Damages in trees recommended for removal.

Tree Species	Total trees	Average DBH	Dead tree	Heart or butt rot*	Root disease*	Lean toward target**	Bark beetle attack
First priority removal							
Grand fir	3	19.0	2	2	3	1	
Douglas-fir	6	21.8	2	-	6	1	1
All trees	9	20.1	4	2	9	1	1
Lower priority removal							
Grand fir	5	16.4	-	5	5	3	-
Douglas-fir	1	18.6	-	-	1	1	-
All trees	6	16.6	-	5	6	4	-

*Rated severity 2 or higher **Rated severity 2 or higher OR in combination with root or stem decay

Figure 9. Campsite A in the Airstrip camping area. This was the only site mapped in this assessment. An active root disease patch north and east of the airplane parking is evident in the mapped locations of trees recommended for removal, in large part because they are already dead. The stumps are evidence of many earlier tree deaths in this area.



Airstrip Camp Sites B– E

These sites were evaluated for tree hazards only, tagging only those trees we recommended for removal (Table 8). A few trees were identified as extreme hazards on each site and tagged for possible removal. By far the worst was Site E which had considerable downfall and standing dead. It is situated at the edge of a highly active Armillaria patch. Few trees will be left at this site if the recommended removals are done. In fact, within a few years, few trees will be left here even if they die on their own.

Table 8. All Airstrip Camping Sites: Damages in trees recommended for removal.

Tree Species	Total trees	Average DBH	Dead Tree	Heart or butt rot*	Root disease*	Lean toward target
Site A						
Grand fir	8	17.2	2	7	8	4
Douglas-fir	7	21.4	2	-	7	2
Totals A	15	19.2	4	7	15	6
Site B						
Grand fir	3	21.3	-	2	3	2
Douglas-fir	1	16.2	-	-	1	1
Totals site B	4	20.1	-	2	4	3
Site C						
Grand fir	5	19.1	1	3	4	1
Douglas-fir	1	22.9	-	-	1	1
Totals site C	6	19.7	1	4	5	2
Site D						
Grand fir	4	16.6	2	3	3	2
Totals site D	4	16.6	2	3	3	2
Site E						
Grand fir	12	17.0	5	5	11	1
Totals E	12	17.0	5	5	11	1
All Sites						
Grand fir	32	17.8	11	27	29	14
Douglas-fir	9	21.0	4	-	9	6
Totals for all sites	41	18.5	15	27	38	20

*Rated severity 2 or higher **Rated severity 2 or higher or in combination with root or stem decay

Ecologies of the major pathogens and insects found at Moose Creek

Fir-Annosus root disease ecology

Grand fir, Douglas-fir, and subalpine fir are the most damaged hosts of fir-annosum in Idaho. True firs and Douglas-fir are most likely to be killed by fir-annosus, while growth loss and slow decline is typical of annosus-infected western redcedar. Pines and western larch can become infected but lesions are typically limited and damage is rarely significant in these species.

In contrast to *Armillaria* root disease, minimal root-to root spread is seen in fir-annosus root disease. Instead, spore infections of roots and lower stem wounds appears to be the main mechanism used for infection of trees. Spores are produced in abundance throughout most of the year to allow the fungus to take advantage of any fresh wounds. Spores are washed into soil pores by rain and penetrate directly through thin root bark. Root feeding insects and rodents also may be a significant source of root wounds that allow fungus infection. Though the mechanisms are poorly understood, it is clear that high rates of infection are typical of mature grand fir, subalpine fir, and western redcedar in northern Idaho. Despite high infection rates, mortality rates usually are usually low except where *Armillaria ostoyae* is present as well.

The tap root of grand fir is typically rotted off by this fungus in the first few decades. The fungus spreads from the killed taproot into the butt heartwood where it can cause considerable butt decay by the time the tree reaches maturity. Butt rot of this type is especially common in grand fir and western redcedar. Butt rot and associated root decay produce significant risk of tree failure while the tree is alive and such damage can be hard to detect, especially in grand fir.

When trees with root, and especially butt infections die, the pathogen produces shelving conks which produce tens of thousands of spores for several years after the death of the host. Many naturally-occurring saprophytic fungi invade conifer stumps and roots shortly after tree death and can provide some stiff competition for annosus. These organisms have the potential to limit the development of root disease fungi and are probably the most important natural controls for fir-annosus as well as other root diseases as they compete for woody substrates. To the extent that these saprophytes usurp substrates from the pathogen, they can reduce the production of spores by fir-annosum.

Armillaria root disease ecology

Armillaria ostoyae is a fascinating fungus. Several individuals of this species are the largest and most ancient organisms known. Several remarkably large, and potentially very old clones have been found. Those described by Ferguson and others (2003) in the Blue Mountains of Oregon ranged from 20 to 965 hectares. One of these is the largest organism (of any species) reported to date. It covers 2,200 acres (965 hectares) and spans 3.5 miles (5.6 km). It is estimated to estimated to be at least 2,400 years old.

The fungus can survive as a saprophyte on dead organic matter such as old stumps and roots for several decades. The mycelium is the collection of microscopic filaments (called hyphae) that make up the body of a fungus. Even small debris on a site may harbor significant amounts of mycelium. Once established on a root of a live tree, the fungus invades and kills the cambium of the root and the decays the dead root tissues. The mycelium may eventually travel up the root to colonize the root collar, and girdle the tree.

(Continued on page 17)

(Continued from page 16)

Douglas-fir is most susceptible, followed by grand fir, subalpine fir and western redcedar. Root to root spread is the most common mechanism of fungus growth. It spreads from dead root systems to live trees and among the roots of live trees. Once established on a site the fungus is essentially a permanent feature. They are long-lived organisms that can take advantage of the presence of hosts from one generation of trees to the next. They survive forest fires by slowly decaying root systems well below ground.

As stands approach maturity and canopies close, root contacts and root biomass also reach a critical point at which fungus spread and subsequent tree mortality can be quite rapid stand-wide. In general, the disease kills Douglas-fir more rapidly than grand fir. Thus, by the time grand firs are visibly declining, much of the Douglas-fir component of stands has already been killed.

Honey-colored mushrooms may be produced at the base of infected trees during late summer or early autumn. The good news is; these mushrooms are considered "edible and choice" by knowledgeable collectors.

Indian paint fungus ecology

Infected overstory grand fir with stagnated understory grand fir provides the ideal situation for development of Indian paint fungus (*Echinodontium tinctorium)* infection. Spores produced in the infected overstory drift down to the understory grand fir. Indian paint fungus initially establishes infections in shade-killed branches. The fungus produces a quiescent infection in which it fails to progress much beyond the original point of establishment for some years. As the tree grows, the dead, infected branch stub is incorporated in the heartwood. Once surrounded by the no-longer-living heartwood, which is thereby no longer resistant, the fungus begins to grow. It lives entirely by decaying dead heartwood, never invading live sapwood.

Decay caused by *E. tinctorium* can be especially extensive. A single young *E. tinctorium* conk may indicate a decay column extending 8 feet above and 8 feet below the conk. Larger, older conks may indicate 20 feet below and 21 feet above the conk. Two or more conks, widely separated on the stem, probably indicate that virtually the full length of the stem has a central column of decay. The longer the column is, the greater the width of the decay column.

Wounds that kill a patch of cambium are known to greatly accelerate the extent and perhaps the rate of decay caused by Indian paint fungus. It is thought the dead tissue, which essentially becomes a part of the heartwood by virtue of being dead. A wedge of dead wood often will extend behind the wound to merge with the heartwood, thereby increasing aeration of the heartwood and improving growing conditions for the fungus.

Wounds are a highly significant factor in predicting decay volumes in grand fir. Root disease or beetle caused mortality which leads to trees falling, wind breakage and animal or human-caused stem damage all result in stem wounds that contribute to stem decay acceleration.

Schweinitzii root and butt rot ecology

Douglas-fir is the most common host for *Phaeolus schweinitzii* in Idaho. The pathogen often causes extensive decay of root and butt heartwood of aging trees; though it can be damaging in younger trees, especially on poor sites. Among the significant damages, the root ends are killed causing them to terminate in gall-like swellings. This greatly reduces structural support of roots. Consequently infected trees are highly susceptible to uprooting and lower- stem breakage. The fragile brown cubical decay will extend from the structural roots into the butt heartwood 8 feet or more above ground.

Field evidence suggests that mycelium growing in duff or direct infection of thin-barked roots by germinating spores may account for most of the disease. Infections are also thought to occur directly though deep basal stem, or root wounds. Logging and fir-caused wounds may become infected. Even if the infection didn't originate with the wound, such scars almost certainly increase the extent of decay, presumably by aerating the infected heartwood, as seen in other heartwood decays.

The fungus grows directly into the center of roots. It decays the root heartwood and spreads from root to root through heartwood, also using grafted roots to move from tree to tree. In the early stages the decay is punky and only slightly discolored. In the advanced stages, the decay is red-brown with cubical cracking.

Trees infected with *P. schweinitzii* root disease develop thinned crowns, scattered dead branches, and rounded crowns, symptomatic of slow growth. These crown symptoms are usually not detected until the root system has been seriously degraded. Likewise, root decay is usually extensive before decay can be detected in the butt. This is a slow-developing disease that does not usually cause direct mortality. Rather, other, more aggressive root pathogens or bark beetles kill the weakened trees.

Fruiting bodies produced by the fungus are annual, spongy to leathery conks. They develop during periods of wet weather in late summer or fall. The upper surface of conks are reddish-brown and velvety with concentric rings; the lower surface is pored, green when fresh and becoming brown with age. Conks on the ground emanate from either decaying roots, or from the base of severely infected stems. Conks occasionally form on the cut end of logs with brown cubical heartrot.

Douglas-fir beetle ecology

Douglas-fir beetle is a bark beetle that attacks trees as an adult, laying eggs under the bark. The eggs hatch into larvae that feed on the cambium and effectively girdle and kill successfully attacked trees. The process from the initial attack to tree death usually takes about a year. The beetle produces one generation per year, emerging from the tree as a young adult in the spring. Mating takes place in the cambium of the tree. Spring emergence of adult beetles varies with elevation, latitude and weather, but usually occurs from mid-April to early June.

The first evidence of attack may be reddish-brown boring dust found in bark crevices on the lower portion of the tree's bole or on the ground at its base. An occasionally evident sign of infestation may be clear resin which has exuded from the upper level of attacks-typically 30 to 35 feet off the ground. These pitch streamers are often visible for a considerable distance. Streams of pitch lower on the bole may be evidence of unsuccessful attacks or other injury. As a rule, successful attacks can only be confirmed by removing sections of bark to reveal egg galleries, eggs, and/or developing brood.

The egg galleries are distinctive and a valuable aid to identifying the beetle. They are made by the females as they bore through the cambium and inner bark. The bore vertically about 8 to 10 inches, making small niches alternately along both sides of the channel in which they lay one egg each. The larvae mine at right angles to the egg gallery, thus radiating horizontally in both directions.

Most will over-winter as larvae and pupate under the bark in early spring to emerge within weeks to restart the cycle.

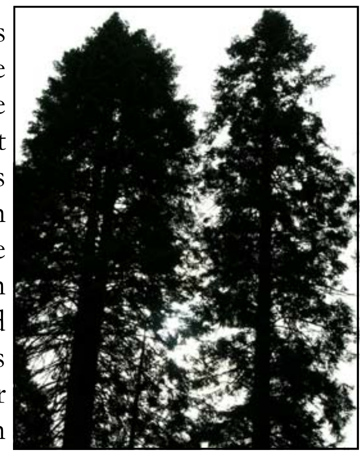
Tree death can take several months to become evident. Trees become chlorotic and fade to reddish brown. Discoloration rate varies with local conditions and individual trees. During dry years, trees fade more quickly; occasionally showing color changes in the same year they are attacked. More typically, they begin to fade the spring following attack. In endemic populations, many attacks are unsuccessful and result in death of the attacking beetles.

Recommendations for Monitoring of Hazard Trees

Grand fir with Annosus root disease

Both root and stem decay are important factors in producing tree hazards. Taproot decay is usually the first damage to occur in a tree and does not cause crown symptoms. Butt rot develops from the decayed taproot and likewise does not cause crown symptoms but advanced butt rot can result in stem cracking. Decay in the butt heartwood causes instability in the lower stem and probably results in differential freezing and thawing, either condition may cause vertical cracks to form. Water is a decay process byproduct. The stem decay produces excess water that will often exude from these vertical cracks.

Cracks should be monitored for increases in width and length as well as increased flow of water which often is discolored and foul-smelling.



Crown symptoms indicating root disease progression may be evident after sufficient lateral root decay has occurred. Crown deterioration may be slow to develop in annosus-afflicted grand fir and root systems may have 60-80% or more root destruction with little or no crown symptoms. If symptoms are seen, however, they should be taken to indicate an extremely compromised root system. Even after the tree has ceased to move water or nutrients up from the roots, it can take a year or more for the crown to die.

Tree crowns should be monitored for thinning of foliage from nearest the stem and lowest in the tree. The oldest compliment of needles are cast first and the stem becomes increasingly visible through the foliage. The shape of the crown becomes increasingly rounded as terminal growth declines. Individual dead branches scattered through the crown often indicate slow root disease progression giving the crown an overall "ratty" appearance. Near the end, the crown will become chlorotic (yellow-green) and finally red.

Root movement is also a strong indicator that tree failure is imminent. Generally some increase in leaning can be observed as well but if a tree is already leaning, root movement may be the more obvious symptom. Exposed roots may also indicate root damage caused by foot or other traffic (including wildlife trails).

To monitor for root movement, watch for ground heaving or lifting within two or three feet of the butt. Trees with root movement are often very unstable.

Figure 10. Root movement is indicated by roots that are exposed near the root crown. These roots may be progressively lifting as decay destroys the structural strength of the unseen portions of the root.

Douglas-fir with Armillaria root disease

Generally the first symptom of this disease is a patch of resin between root buttresses near or just below the ground line. Lesions typically travel up the underside of a root and begin girdling the stem in the depression between main roots. The appearance of fresh resin in this location is a strong indicator of imminent death— generally within 5 years, depending on the size and condition of the tree. At times, especially on older, thick-barked trees, crown symptoms are the first hint of *Armillaria* root disease infection. As with annosus, thinning from the bottom of the crown up, and from the inside out is the typical progression of crown thinning. The crown generally becomes rounded as growth declines and chlorosis develops near the end of the trees life. A red crown usually indicates a tree that has been dead at least a year.

Basal resin: Monitor for fresh and increasing resin on the outer bark first between roots and then progressing around the base of the stem at the ground line and higher up the stem (still usually not more than a foot above the ground line).

Crown symptoms: Inside out, bottom up thinning pattern, rounded crown, chlorosis.

Figure 11. Tree #17 had been recently cut. The basal resin and white mycelium fans in the cambium under the bark are diagnostic for Armillaria root disease.

Crown symptoms of root disease usually show for several years before a tree dies. The amount of root system decay can be expected to be at least as much, proportionally, as the loss of foliage in the crown. The tree on the left in this photo has lost about 80% of it's foliage and can be expected to have at least 80% root mortality. Decay follows root mortality and is a function of how long the root has been dead. The slower the disease develops the higher the proportion of decay in killed roots.

It follows that trees that have been recognized as declining for many years can be expected to have more severe decay, and less support, than trees that have died quickly.

Figure 12. Root disease crown symptoms are most severe in the tree on the left.

Douglas-fir with Phaeolus schweinitzii root and butt rot

This root and butt rot usually progresses slowly in Douglas-fir but a great deal of decay can result. The tree may show relatively few foliar symptoms until the disease is severe. Breakage usually occurs near the ground line either in main roots or the lower stem. Increasing lean and root movement often are detectable before failure occurs.

Figure 13. Phaeolus schweinitzii decay in both the main support roots and the lower butt caused this Douglas-fir to fail.

Root movement: Watch for ground heaving or root lifting within two or three feet of the butt. Trees with root movement are often very unstable.

Increasing lean: An uncompensated lean is an indication that movement is happening faster than the tree can compensate by correcting the angle of terminal growth.

Crown symptoms: As shown above, crown symptoms may develop slowly with P. schweinitzii, with particularly severe decay resulting.

Douglas-fir Beetle attack in Douglas-fir

Boring dust and pitch steamers may be an indication of active bark beetle attack. Such attacks may or may not be successful. A successful attack will result in tree death within a year. Normally, crowns of killed trees will turn dull green, then yellow and finally red in the spring of the year following the attack. In a dry year, crown symptoms may become visible in the fall of the same year they were attacked. The beetles (or more accurately, beetle larvae) may not be low enough on the tree stem to be seen without falling or climbing the tree. Though successfully attacked trees can not be saved, further bark beetle mortality can sometimes be thwarted using pheromone-mimics that confuse the attacking beetles.

Figure 14. Red-brown boring dust of Douglas-fir beetle is often evident in park cracks near the base of an attacked tree. The attack may be much higher in the crown.

Pitch steamers followed by boring dust are a good indication that the beetle has been successful.

Downed live trees are an important breeding ground for Douglas-fir beetle and with the high rate of tree failure from root disease in the surrounding stand, it is no surprise that there is evidence of Douglas-fir beetle activity in standing trees as well.

Tree mortality will be obvious if the Douglas-fir beetle attacks have been successful.

Tracking Monitoring Results

Monitoring follow-through is a critical part of hazard tree management. Each tree has a unique set of circumstances. Each identified tree should be checked annually with a permanent record of each exam maintained where it is accessible. Trees that were identified as possible bark beetle attacks may be removed from further monitoring if no additional symptoms are seen after one year.

Table 9 presents details on each of the trees we recommended for monitoring. Adding a row to the table after each tree (see the example for tree #2) with the monitoring year in the first column, allows for simple record keeping.

Factors which continue to be important for tree risk evaluation are:

- The importance (and permanence) of the target,
- The species of tree and attending susceptibility of that species to damage agents and wind breakage,
- And the combination of diseases, insects and physical conditions found in the assessment.

Table x. Ranger Station trees to be monitored.

Tree # (azimuth/ distance*)	Reference point	Sp.	dbh	Target	Defect description (Damage codes)	Monitor for:
2 (263° / 82')	Moose Cr. sign	DF	19.9	path	Probable *P. schweinitzii* root disease, slight lean. (1L)	Root movement, increase lean.
2009	*[Space for monitoring notes in 2009.]*					
3 (267° / 75')	Moose Cr. sign	DF	15.5	path	*P. schweinitzii* root disease, slight lean. (1L,2R)	Root movement, increase lean.
12 (280° / 85')	Moose Cr. sign	DF	19.3	Ranger shop	Possible Douglas-fir beetle. (1R,1L)	Death within a few months if DFB attack successful. Root failure from decay; watch for increasing lean.
19 (305° / 65')	Moose Cr. sign	DF	29.7	Ranger shop	Possible Douglas-fir beetle. (1L)	Death within a few months if DFB attack successful.
21 (91° / 20')	Moose Cr. sign	GF	51.8	Barn, RA	Annosus root disease and butt rot with 5" sound rind. (4D,3R)	This tree does not lean, watch for developing lean. Bore in 5 years to measure changes in rind.
22 (229° / 68')	Moose Cr. sign	DF	28.3	Corral	*P. schweinitzii* suspected with substantial lean. (2L,1R)	Increase lean, root movement.
30 (212° / 53')	NW corner warehouse	DF	28.1	Barn, corral	Advanced decay with 5" sound rind and stem cracking, root wounding with a slight lean.	Watch for progression of crack and bore in 5 years to measure changes in decay column.
31 (220° / 55')	NW corner warehouse	GF	32.6	Barn, warehse	Weeping stem crack associated with suspected butt rot. (2W)	Watch for progression of crack and increased weeping. Bore near base for sound rind if changes are noted.
36 (290° / 50')	NW corner warehouse	GF	28.3	RA	Leans away from target, but rot and weeping stem cracks. (3W, 1L, 1R)	Watch for progression of crack and increased weeping. Bore near base for sound rind if changes are noted.
37 (300° / 45')	NW corner warehouse	GF	33.1	RA	Substantial stem decay, slight lean. (2D, 1L, 1R)	Monitor for movement of cracks, weeping, increase lean. Bore if changes noted.
38 (305° / 45')	NW corner warehouse	GF	20.6	RA	Stem cracks indicate butt rot, root decay from annosus, slight lean. (1D, 1L, 1W, 1R)	Monitor for movement of cracks, weeping, increase lean
40 (315° / 50')	NW corner warehouse	GF	39.5	RA	Substantial lean and stem decay, cracking and root damage minor. (3D, 2L, 1W, 1R)	Watch for root movement, heaving. Increase lean or widening cracks with weeping. Bore if changes noted.
42 (358° / 80')	NW corner warehouse	DF	34.8	RA	*Armillaria* root disease confirmed, not leaning. (3R, 1W)	Death, deteriorating crown, root movement, develop lean.

* Measured or approximated from mapped tree position and measured points.
** See Appendix A for damage codes.

Table x. Ranger Station trees to be monitored (continued).

Tree # (azimuth/ distance*)	Reference point	Sp.	dbh	Target	Defect description (damage codes**)	Monitor for:
43 (169° / 64')	SE corner wash house	DF	21.1	RA	Poorly joined double top, lean, too far for broken top to strike, (3B, 2L, 1D, 1R)	Opening of joint at tops; increase in decay or root disease symptoms.
46 (175° / 65')		DF	15.5	RA	Possible bark beetle attack. (no codes)	Death within a few months if the attack was successful.
48 (180° / 60')		DF	16.2	RA or bath	Possible Douglas-fir beetle. (1R, 1W)	Death within a few months if the attack was successful.
54 (220° / 50')		GF	33.9	Bath	Stem cracks and catfacing indicative of butt/root rot. (2R, 2W)	Increase in crack diameter, weeping, decay between roots at butt.
61 (224° / 90')	Flag pole	DF	33.2	Cook shack	*P. schweinitzii* root disease/butt rot, compression crack, substantial lean away from target. (2R, 2L, 2W)	Increase in crack diameter, root movement, prevailing winds could change failure direction.
62 (230° / 95')	Flag pole	GF	37.6	Cook shack	Butt/root rot with crack through butt, cat-faces, rind 4.3, 5.5. (2R)	Crack instability, widening, lean or root movement. Bore at base in 5 years for decrease sound rind.
66 (309° / 73')	Flag pole	DF	35.9	Cook shack	Root disease probably *P. schweinitzii*, thin crown, weak. (4R, 2W)	Increasing crown symptoms of root decay. Watch for crack diameter increase, bore if needed.
69 (340° / 55')	NW corner Ranger House	GF	33.9	Ranger House	Weeping stem crack associated with suspected butt rot. (3R, 2B)	Watch for progression of crack and increased weeping. Changes in lean.
70 (345° / 50')	NW corner Ranger House	GF	34.6	Ranger House	Cat-faces indicating butt rot, leaning. (2R, 2L)	Watch for progression of crack and crown symptoms. Bore near base for sound rind if changes are noted.
76 (110° / 50')	NE corner Ranger Hse	PP	22.2	Ranger House	Crack on south side of bole may indicate decay. (2B-2)	Monitor for crack enlargement.
78 (120° / 60')	NE corner Ranger Hse	DF	20.0	Ranger house or shed	*Armillaria* root disease with resin at root crown. Possible Douglas-fir beetle attack. (3R)	Death within a few months if the attack was successful, slower death or developing lean and possible failure if only root disease is present.
79 (130° / 50')	NE corner Ranger Hse	DF	14.9	Ranger House	Root disease evident in poor crown. *Armillaria* or *P. schweinitzii*. (3R)	Watch for root movement, heaving or lean from rotting roots. Death likely.
80 (140° / 55')	NE corner Ranger Hse	GF	27.3	Ranger House	Crack on east side indicates butt rot (2W).	Crack enlargement, weeping.

* Measured or approximated from mapped tree position and measured points.
** See Appendix A for damage codes.

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