Forest Health Protection

Report 04-16 **December 2004**

CHANGES IN FIRE-KILLED WESTERN LARCH ON THE GLACIER VIEW RANGER DISTRICT (FLATHEAD NATIONAL FOREST), MONTANA

ESTABLISHMENT AND YEAR ONE REPORT

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INTRODUCTION

Important economic, ecological, and fire management questions will be answered with a better understanding of changes that take place in fire-killed western larch. Western larch is harvested for lumber, log homes, utility poles, and fuelwood (Keegan et al. 1995). Progressive changes in wood after trees are killed by fire affect the economic value and use of the wood, with fuelwood generally being of less value than other uses. Wildlife biologists have shown interest in learning more about changes in fire-killed larch and how these changes relate to wildlife use. Fire managers may find this study useful in projecting woody fuel loads on burned larch sites.

Research concerning changes in fire-killed western larch is limited. Hadfield and Magelssen (1996, 1997, 1998, 1999, 2000) conducted a 5-year study in eastern Washington, annually observing changes in trees killed by fires in 1994. They studied seven coniferous species and noted that a review of the literature prior to initiating their study showed no information in wood changes of fire-killed western larch. The Hadfield and Magelssen study provides information about the causes, types, and rates of wood changes following fire. They found that "western larch had no tree fall because there was almost no decay" during their 5 year study and "almost no loss of bark after five years even though it was loose on many trees." They also noted, "Bark loosening [partially due to wood borer feeding and woodpecker foraging] appeared to contribute to large numbers of cracks which caused the wood to become very dry." This dry wood likely decreased the potential for decay, but also contributed to cracking that affected almost 80 percent of the larch wood volume. Western larch was rated by Hadfield and Magelssen as one of the three species with the greatest snag durability of the seven species in their study. They concluded that western larch should be salvaged quickly for high-value lumber, but could still be salvaged for fuelwood after 5 years.

The Hadfield and Magelssen study provides good, but limited, information about changes of fire-killed western larch. The information is limited because of the small number of trees measured, limited number of large trees, and the short duration of the study. They began their study with 100 trees spread equally over 4 plots (25 trees per plot), with a d.b.h. (diameter at

breast height) range of 6.8 inches to 33.7 inches. Due to severe road damage, one plot could only be measured for the first 3 years of the study. A total of 15 trees were measured in that plot. Seventy-four of the 75 trees were measured in the other three plots. Although the plot measured for only 3 years had an average d.b.h. of 15.4 inches, the other three plots had an average (per plot) d.b.h. range of only 9.9-11.2 inches. Since there was almost no decay in larch at the end of the Hadfield and Magelssen study, a longer study period coupled with a greater number of large trees may provide more information about changes affecting wildlife habitat, fuel loading, and losses in high value merchantable volume early in the study and losses in fuelwood value in latter parts of the study.

This study will evaluate 320 trees (240 dissected), look at a large range (8-32 inches d.b.h.) of sizes, and evaluate fire-killed trees over an extended period of time (10 or more years). The data collected from this study in northwestern Montana will be compared to the data collected by Hadfield and Magelssen in eastern Washington to determine if fire-killed western larch changed similarly in these different geographic locations.

METHODS

In June 2002, 367 fire-killed western larch trees were selected at five sites with varying slope, aspect, and habitat types on the Glacier View Ranger District (RD) of the Flathead National Forest (NF) (Table 1 and Figure 1). Five sites were necessary to identify an adequate number of trees in each of the four size classes described below. The trees were killed by the Moose Fire that burned in northwestern Montana from mid-August through early October of 2001.

Table 1. Site Characteristics.

Site	No. of Trees[A]	Slope[B]	Aspect[C]	Habitat Type[D]	Elevation[E]
1	105	25% (0-54%)	West	ABLA/CLUN	3,880 (3760-3920)
2	28	20% (8-65%)	Southwest	ABLA/LIBO	3,880 (3840-4080)
3	65	14% (1-28%)	Variable[F]	ABLA/CLUN	3,840 (3840-4080)
4	89	35% (2-102%)	West	ABLA/CLUN	3,720 (3640-3800)
5	80	38% (12-68%)	Northeast	ABLA/MEFE	4,100 (3920-4280)

[A] Number of trees tagged at the site.

[B] Average percent slope across site. Within parentheses is the range of slope at the locations of all trees on that site.

[C] Predominant aspect at the site.

[D] Predominant habitat type (h.t.) as defined in Pfister et al. (1977). Site 1 has some trees that are in ABLA/XETE h.t., Site 2 has some ABLA/XETE h.t. and PICEA/CLUN h.t., and Site 5 has some in the ABLA/CLUN h.t.

[E] Elevation in feet at the geographic center of the site. Within parentheses is the range of elevation across the site.

[F] Mostly southwest and northeast.

Trees were identified, labeled with numbered aluminum tags, and marked with a band of orange tree paint. Their locations were recorded with a gps (global positioning system) unit and hand-drawn field maps. Data recorded at establishment included: d.b.h., tree height, spur loss, woodpecker activity, bark loss and insect activity. Crown scorch and basal scorch were

also estimated, but these data were unreliable due to reduced visibility caused by overcast weather conditions. Burn severity was generally high at the five sites (Figure 2). Four pictures were taken from the south side of each tree. These pictures are: (1) the crown, looking up from the base of the tree, (2) the bole from a distance of 6 feet, (3) the top half of the tree, and (4) the bottom half of the tree. These pictures are repeated immediately before the dissection of each tree.

Of the 367 tagged trees, 1 was eliminated from the study after it was identified as a Douglas-fir. Thirty-five trees were too close to water to be dissected, 20 had major defects such as basal scars or broken tops, and 14 showed green foliage—albeit very little—2 years after the fire. After 240 trees were selected for dissection during the first 10 years post-fire, remaining trees were categorized into four groups: (1) 57 useable trees that randomly were not selected for dissection, (2) 20 trees with observable defects, (3) 35 trees near water, and (4) 14 trees that were living 1 year after the fire. These four groups account for a total of 126 trees. Some of these trees may be used as replacements for trees lost to logging, firewood cutting, or other causes. Otherwise, some of them may be dissected at a later time or monitored continuously as longevity snags. Twenty trees will be identified in each size class as longevity snags to continue monitoring conk development and snag longevity. Depending on results of the 10-year dissections, these trees may be removed for measurements (e.g., year 15 or year 20) or may be left uncut for continued observation. Due to the limited number of trees of certain sizes, two trees with observable defects, one with a broken top and one with a basal scar, were included in the list of trees to be dissected.

Trees were placed into one of four size classes (8-11.9 inches d.b.h., 12-15.9 inches d.b.h., 16-19.9 inches d.b.h., and 20+ inches d.b.h.). Ten trees were randomly selected to be cut down in each size class during each dissection year.

Dissection years are 1, 2, 3, 5, 7, and 10 years after the fire. Prior to felling, the following data are collected: branch and bark retention, spur loss, presence of new woodpecker activity,

species of conks and locations on trees, top breakage, and natural tree falls. The felled trees are sawn into 8-foot lengths up to a 4-inch diameter. Diameter to the nearest one-eighth of an inch, char, checks, wood borers, wood stain, and decay are recorded in the field from approximately 2-inch thick cross-sectional disks taken at the stump and the top of each log. Char, wood stain, and wood decay are estimated as a percentage of each cross section's surface area. After all measurements have been recorded, extent of stain and decay are better clarified by dissecting the disks. Volume affected is estimated by calculating the volume of each log using Smalian's Formula for a paraboloid frustum as described by Husch et al. (1972) and multiplying the total volume of the log by the mean of percent area affected on the disk at each end of the log. Given we don't fully understand how the various stain and decay fungi colonize western larch, this seems to be a reasonable method for estimating the volume affected by these agents. Number and depth of peripheral checks and wood boring insect galleries are also measured on one surface of each cross section. Insects affecting deterioration during year 2 were collected for identification during a supplemental study that was initiated in April 2003 to trap adult wood-boring insects as they emerged. Ten-year growth increments are measured beginning from the outside and moving inward toward the center of the tree on each stump cross section. Tree age at time of death is estimated by counting annual rings at the stump and a photo is taken of the cross sections for future reference.

In addition to the measurement described above, a Forest Service certified scaler determines merchantable volume in each log using Cubic Scale Rules (USDA-Forest Service 1991) and Scribner Scale Rules (USDA-Forest Service 1985). Data is collected on the agents causing defects and the agents are divided into two categories (pre-existing and post-fire). “Pre-existing” defects were likely present when the trees were killed by fire and “post-fire” defects were likely initiated after trees were killed.

Decay and sapwood staining fungi were isolated from disks. Decay fungi were isolated on 2 percent malt agar (20 grams malt extract and 20

grams agar in 1 liter of distilled water), while stain fungi were isolated on 2 percent malt agar with 200 mg of cycloheximide added per liter. Decay isolates were sent to the Forest Products Laboratory in Madison, Wisconsin for identification and stain fungi were sent to the University of Montana for identification.

Year 1 Data Collection

In October 2002, 10 trees were identified in each size class for dissection. Two of the trees (one each at Site 3 and Site 4) had a small amount of green growth not detected during study establishment. Two replacement trees were selected and the live trees were left standing.

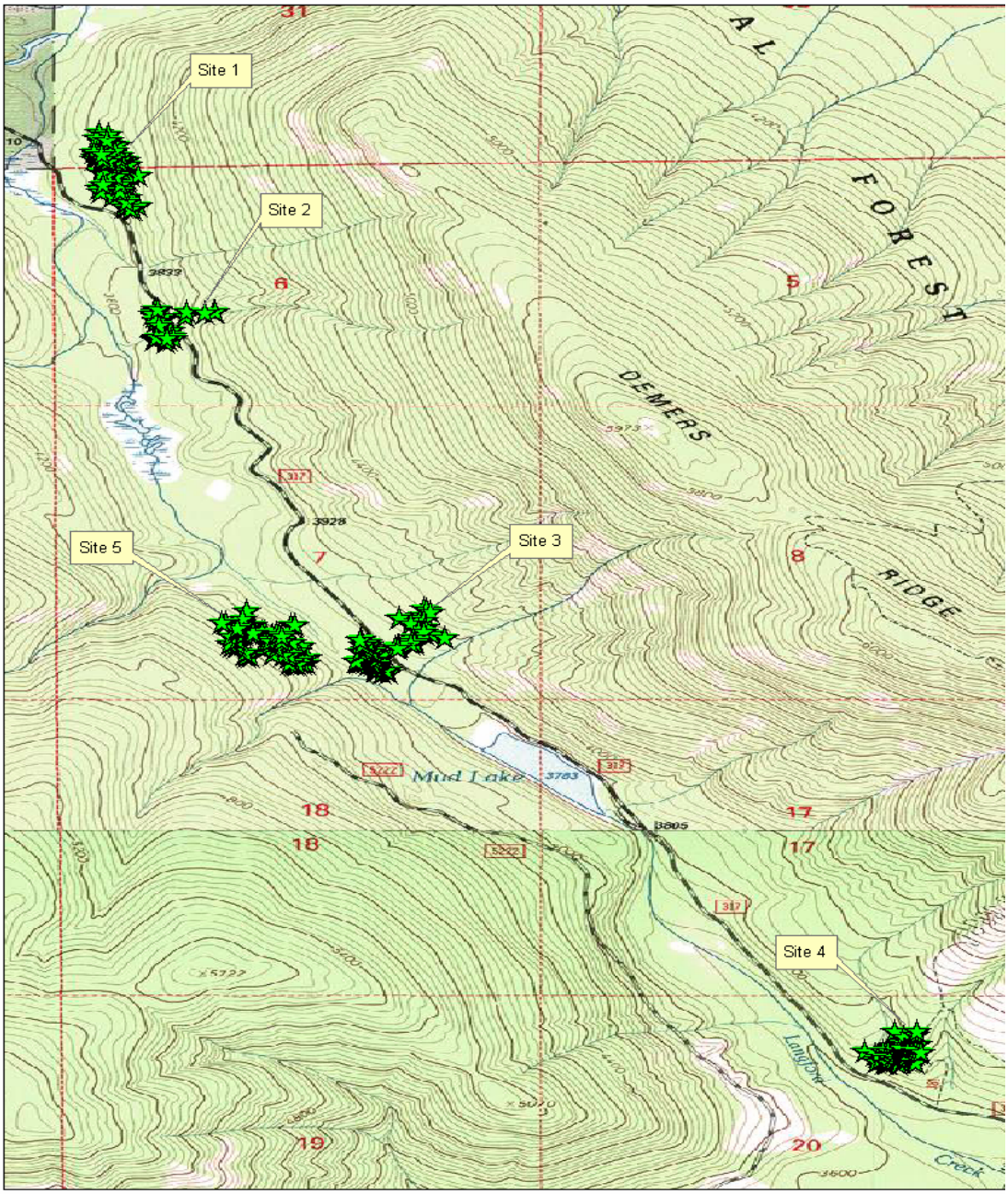
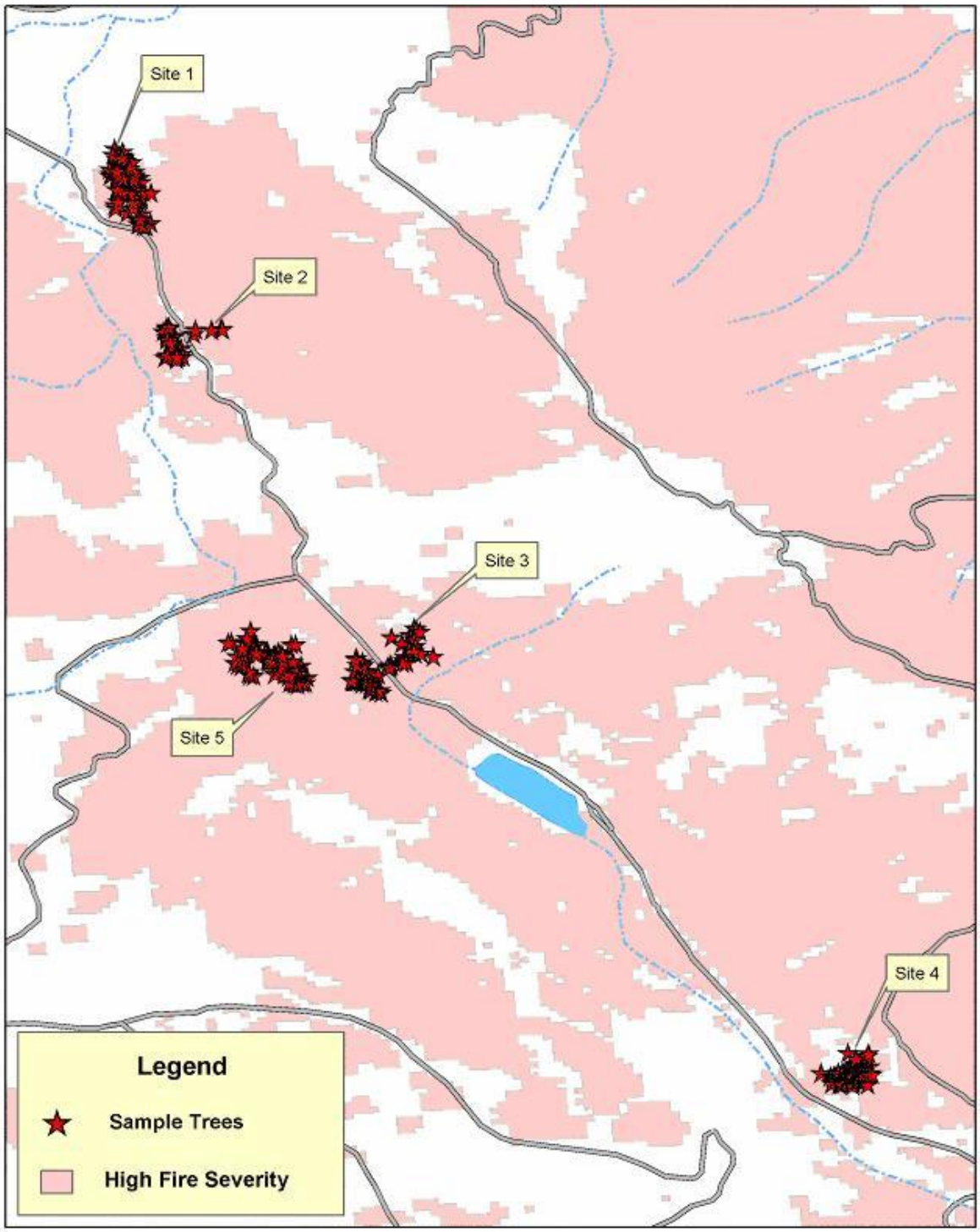


Figure 1. Site locations for fire-killed western larch on the Moose Fire.

Figure 2. Fire severity for the five sites on the Moose Fire.



RESULTS

One year after the fire, all bark was retained and no conks or snag falls were observed. The dissection results of this study are reported in two parts. "Agents" describes and quantifies the agents of change that were observed in the trees. Most of the agent data was derived from disk observations. Results of disk observations are summarized in Table 2. "Defects" describes and quantifies the agents, both pre-existing and post-fire, that reduced merchantable wood volume as determined by the scaler. Data generated by the scaler are summarized in Table 3.

Agents

Char. No char was observed on any disks.

Checks. Shake was the only type of crack seen. No peripheral checks were observed.

Decay. All observed decay was pre-existing, with most of it in the heartwood. Minimal sapwood decay was seen in only three trees (694, 696, and 784), all of it contiguous with white pocket rot of the heartwood. *Phellinus chrysoloma* (Fr.) Donk, a white pocket decay fungus, was isolated from white pocket rot in one tree. Other decay fungi isolated from heartwood included *Antrodia serialis* (Fr.:Fr.) Donk, *Fomitopsis cajanderi* (P. Karst.) Kotlaba & Pouzar, and a *Stereum* sp. Ten percent of the trees from 8-11.9 inches and 12-15.9 inches d.b.h. size classes had heartwood decay, while 50 percent of 16-19.9 inches d.b.h. size class and 70 percent of >20 inches d.b.h. size class had heartwood decay.

Wood Stain. Small amounts of sapwood stain were present across the size range of trees. A greater proportion of wood volume of 8-11.9 inches (2.7 percent) and 12-15.9 inches d.b.h. (3.0 percent) size classes were affected by stain than trees in the 16-19.9 inches (1.2 percent) and >20 inches d.b.h. (0.5 percent) size classes. Two isolates of *Ophiostoma minus* (Hedgcock) H. and P. Sydow, one with ostiolar hyphae and one without, and an isolate of *Ophiostoma huntii* (Robinson-Jeffrey) de Hoog and Scheffer were isolated from stained wood near wood borer holes (Figure 3).

Figure 3. Stain associated with wood borer holes.

Wood borers. Disk observations revealed that 75 percent of the trees were infested with wood borers. Cerambycid and Buprestid galleries were found in the wood, nearly all of them in the sapwood. No Buprestid larvae were found, but Cerambycid larvae remained in the wood. Most of the holes counted on each disk were believed to be caused by Cerambycid feeding. The average number of wood borer holes seen per disk in each tree varied from 0-5.8, without much variation between the size classes except the 16-19.9 inches d.b.h. size class had about 50 percent more holes than the others averaging 1.5 holes per disk.

New Woodpecker Activity. Approximately 63 percent of the trees showed some signs of woodpecker foraging since the trees were killed. Foraging was seen on 50 percent, 90 percent, 60 percent, and 50 percent of 8-11.9 inches, 12-15.9 inches, 16-19.9 inches, and greater than 20 inches d.b.h. size classes, respectively.

Defects

The scaler determined that there were 13,220 board feet or 2,287 ft.^{3} in the forty trees dissected (Table 3). Most defects appeared to be caused by heartwood decay, ring shake, massed pitch, and butt swell that were present prior to the fire. Pre-existing defects caused about 13 percent cubic volume and 17 percent board foot volume loss for the combined volume of the forty trees. Cubic volume losses from these pre-existing defects were 2.5 percent, 3.1 percent, 6.9 percent, and 20.9 percent of the

total volume of the 8-11.9 inch, 12-15.9 inch, 16-19.9 inch, and greater than 20 inch size classes, respectively. Board foot losses were 0 percent, 5.9 percent, 10.4 percent, and 25.3 percent of total board feet for the 8-11.9 inch, 12-15.9 inch, 16-19.9 inch, and greater than 20 inch size classes, respectively. Minor losses from wood borers were the only post-fire defects observed. Borers caused less than 1 percent cubic volume loss and about 0.2 percent board foot loss 1 year after the Moose Fire. Eight trees lost merchantable cubic volume to wood borers, with the greatest loss being about 26 percent of the total volume of one tree. Three trees lost board feet volume to wood borers, with the greatest loss being 10 percent of the total volume of one tree.

Table 2. Disk Data One Year After the Moose Fire - Summarized by Tree

Tree No.	D.B.H.[A] (inches)	Age[B] (Years)	Site[C]	Deepest Borers[D] (mm)	No. of Borer Holes[E]	Stain[F] (ft.^{3})	SW Decay[G] (ft.^{3})	Deepest Check[H] (mm)	No. of Checks[I]	HW Decay[J] (ft.^{3})
529	8.2	60	1	0	0	0	0	0	0	7.9
502	8.6	78	1	0	0	1.2	0	0	0	0
609	8.8	90	1	0	0	3.5	0	0	0	0
503	9.7	87	1	16	0.1	0	0	0	0	0
501	9.9	84	1	*[K]	0.1	2.8	0	0	0	0
606	10.2	94	1	40	2.4	6.1	0	0	0	0
527	10.5	70	1	30	1.1	2.5	0	0	0	0
637	10.8	90	1	30	1.4	4.8	0	0	0	0
603	11.2	84	1	*	1.9	2.5	0	0	0	0
555	11.9	87	1	31	1.4	3.8	0	0	0	0
MDC[L]	10.0	84.7	-	29.4	0.8	2.7	0	0	0	0.8
607	12.1	86	1	36	5.8	10.3	0	0	0	0
631	12.5	80	1	29	0.8	4.6	0	0	0	0
914	12.9	80	5	0	0	0.3	0	0	0	0
559	13.4	93	1	42	0.9	0.8	0	0	0	0
739	13.8	185	4	25	0.3	0	0	0	0	0.8
601	14.6	92	1	*	1.4	13.1	0	0	0	0
735	14.9	293	4	21	0.2	0	0	0	0	0
688	15.3	80	3	10	0.1	0.3	0	0	0	0
747	15.4	196	4	24	0.1	0.1	0	0	0	0
744	15.9	188	4	0	0	0	0	0	0	0
MDC	14.1	100.6	-	26.7	1.0	3.0	0	0	0	0.1
938	16.1	140	5	85	0.4	1.7	0	0	0	0.4
741	16.5	216	4	32	0.3	0.1	0	0	0	0
533	17.2	90	1	45	3.6	0.9	0	0	0	0
504	17.4	99	1	78	5.5	5.1	0	0	0	0
944	17.8	185	5	38	0.9	0.7	0	0	0	0.9
592	18.2	210	3	34	1.5	1.2	0	0	0	1.7
758	18.6	185	4	0	0	0	0	0	0	0
681	19.1	190	3	31	0.8	0.3	0	0	0	0.5
644	19.5	283	2	26	2.1	1.7	0	0	0	0.2
757	19.9	202	4	19	0.3	0.2	0	0	0	0
MDC	18.0	110.7	-	43.1	1.5	1.2	0	0	0	0.4
667	20.9	208	3	20	0.2	0.2	0	0	0	3.1
696	21.2	220	3	39	1.8	3.0	0.2	0	0	4.6
770	22.2	155	4	0	0	0	0	0	0	<0.1
563	23.2	180	2	26	2.1	0.3	0	0	0	0
694	24.1	190	3	0	0	0.2	3.0	0	0	24.0
778	25.1	190	4	0	0	0	0	0	0	0
697	26.2	213	3	18	0.4	0.1	0	0	0	<0.1
695	27.2	207	3	38	1.2	0.1	0	0	0	<0.1
643	28.3	226	2	39	3.5	0.7	0	0	0	0
784	30.2	226	4	0	0	0	2.7	0	0	17.2
MDC	24.9	123.4	-	30	0.9	0.5	0.7	0	0	4.9

[A]Diameter at breast height. Measured at 4.5 feet above ground level.

[B]Age - Estimated by counting the annual rings at the stump.

[C] Tree location (see Figure 1).

[D]Distance of wood borer hole that was furthest from the edge of the wood on any disk from the tree.

[E]Average number of wood borer holes per disk.

[F]Estimated cubic volume percent affected by sapwood stain. Estimated by calculating the volume of each log using Smalian's Formula for a paraboloid frustum and multiplying the total volume of the log by the mean of the percent area affected by sapwood stain on the disk at each end of the log. The total stain volume in the tree is then divided by the total tree volume.

[G]Estimated cubic volume percent affected by sapwood decay. Estimated by calculating the volume of each log using Smalian's Formula for a paraboloid frustum and multiplying the total volume of the log by the mean of the percent area affected by sapwood decay on the disk at each end of the log. The total sapwood decay volume in the tree is then divided by the total tree volume.

[H]Depth of the deepest check found on all disks from tree.

[I]Ratio of peripheral checks to total number of disks on that tree.

[J]Estimated cubic volume percent affected by heartwood decay. Estimated by calculating the volume of each log using Smalian's Formula for a paraboloid frustum and multiplying the total volume of the log by the mean of the percent area affected by heartwood decay on the disk at each end of the log. The total heartwood decay volume in the tree is then divided by the total tree volume.

[K]Data not taken.

[L]MDC - Mean for the diameter class. This is the mean for the 10 values in the diameter class, except wood borer depth means include only trees where wood borers were found.

Table 3. Scaled Log Data One Year After the Moose Fire - Summarized by Tree

			Scribner Rule (Board Feet)				Cubic Rule (Cubic Feet)			
Tree No.	D.B.H.[A] (inches)	Age[B]	Pre-existing Defect[C]	Post-Fire Defect[D]	Total Scaler Defect[E]	Gross Scaler Vol.[F]	Pre-existing Defect[G]	Post-Fire Defect[H]	Total Scaler Defect[I]	Gross Scaler Vol.[J]
529	8.2	60	0	0	0	50	2.1	0	2.1	11.7
502	8.6	78	0	0	0	40	0	0	0	10.6
609	8.8	90	0	0	0	50	0.3	0.5	0.8	12.8
503	9.7	87	0	0	0	40	0.4	0	0.4	12.6
501	9.9	84	0	0	0	60	0	0	0	17.0
606	10.2	94	0	0	0	60	0	1.6	1.6	16.8
527	10.5	70	0	0	0	60	0	0	0	16.0
637	10.8	90	0	0	0	60	1.3	0	1.3	19.2
603	11.2	84	0	0	0	90	0	0	0	21.2
555	11.9	87	0	0	0	110	0	0	0	23.9
MDC[K]	10.0	84.7	0	0	0	62	0.4	0.2	0.6	16.2
607	12.1	86	10	10	20	100	1.2	5.8	7	22.0
631	12.5	80	20	0	20	130	1.6	0	1.6	28.0
914	12.9	80	0	0	0	140	0	0	0	26.8
559	13.4	93	20	0	20	110	0.5	0.3	0.8	24.7
739	13.8	185	30	0	30	210	7.2	0	7.2	41.2
601	14.6	92	0	0	0	210	0	0	0	40.5
735	14.9	293	0	0	0	240	0	0	0	45.3
688	15.3	80	0	0	0	220	0	0	0	40.6
747	15.4	196	20	0	20	240	0.4	0	0.4	45.3
744	15.9	188	10	0	10	270	0.6	0	0.6	51.5
MDC	14.1	100.6	11	1	12	187	1.2	0.6	1.8	36.6
938	16.1	140	0	0	0	290	1.1	0	1.1	50.7
741	16.5	216	20	0	20	330	1.8	0	1.8	58.9
533	17.2	90	0	0	0	260	0	2.8	2.8	49.1
504	17.4	99	40	10	50	240	3.0	3.0	6	44.3
944	17.8	185	20	0	20	370	1.6	0	1.6	62.8
592	18.2	210	20	0	20	360	3.4	0	3.4	61.6
758	18.6	185	50	0	50	510	4	0	4	85.6
681	19.1	190	60	10	70	380	9.9	2	11.9	66.0
644	19.5	283	40	0	40	290	3.4	0	3.4	52.9
757	19.9	202	120	0	120	520	14.2	0	14.2	85.9
MDC	18.0	110.7	37	2	39	355	4.2	0.8	5.0	61.8
667	20.9	208	100	0	100	440	13.8	0	13.8	73.1
696	21.2	220	170	0	170	530	17.1	0	17.1	86.9
770	22.2	155	90	0	90	530	14.2	0	14.2	86.7
563	23.2	180	140	0	140	400	16.5	0	16.5	87.8
694	24.1	190	290	0	290	560	42.3	0	42.3	91.1
778	25.1	190	50	0	50	800	4.8	0	4.8	125.3
697	26.2	213	130	0	130	740	18.9	0	18.9	117.5
695	27.2	207	20	0	20	900	0.6	0	0.6	138.6
643	28.3	226	170	0	170	920	22.3	1	23.3	140.2
784	30.2	226	660	0	660	1360	87.8	0	87.8	194.4
MDC	24.9	123.4	182	0	182	718	23.8	0.1	23.9	114.2
Total	-	-	2300	30	2330	13220	296.3	17	313.3	2287.1

[A]Diameter at breast height. Measured at 4.5 feet above ground level.

[B]Age - Estimated by observing the annual rings at the stump.

[C]Number of board feet deducted from tree volume due to pre-existing defects such as crook, heart shake, heartwood decay, etc.

[D]Number of board feet deducted from tree volume due to wood borer galleries.

[E]Total number of board feet deducted from tree volume due to both pre-existing and post-fire defects.

[F]Total number of board feet in the tree at time of dissection.

[G]Cubic volume deducted from tree due to pre-existing defects such as crook, heart shake, heartwood decay, etc.

[H]Cubic volume deducted from tree due to wood borer galleries.

[I]Cubic volume deducted from tree due to both pre-existing and post-fire defects.

[J]Total cubic volume in tree at time of dissection.

[K]MDC - Mean for the diameter class.

DISCUSSION

Agents of change. There are many similarities and a striking difference in the changes of fire-killed western larch reported in eastern Washington (Hadfield and Magelssen 1996) as compared to this report on the Moose Fire. Hadfield and Magelson found wood stain in 95 percent of the western larch they observed in eastern Washington 1 year post-fire. Also, a high number of trees, 78 percent, were found here to contain stain 1 year after the Moose Fire. Ten percent of Washington larch contained sapwood decay 1 year after the fire and none of the larch they sampled 2 years post-fire contained sapwood decay. The only decay found in sapwood after the first year of this study appeared to be an extension of pre-existing heart rot into sapwood. All of their larch were infested with wood borers 1 year post-fire and this study found 75 percent infested based on disk observations. The greatest difference between the eastern Washington study and the Moose Fire results thus far concern peripheral checks. Hadfield and Magelssen reported cracks in 65 percent of their trees 1 year post-fire while this study reports no peripheral checks after 1 year. Hadfield (2004) noted that they found no cracks 1 year post-fire in ABLA habitat series plot, but most trees at the 3 PSME habitat series plots were cracked 1 year after the fire. The difference in peripheral checking may be due—at least in part—to greater moisture on ABLA habitat series on Montana sites and the one eastern Washington site as compared to drier PSME habitat series reported at the other three eastern Washington sites.

Loss in merchantable volume. Pre-existing defects, such as heartwood decay, increased with increasing size classes. This may be associated with greater average ages seen with increasing size classes. Trees that have been on the landscape for longer periods of time are perhaps more likely to experience broken tops or other injuries that could provide entries for decay-causing fungi. Western larch forests are generally considered more susceptible to heartwood decay as they become overmature (Carlson, et al. 1995). Wood borers—the only post-fire agent that produced defect—caused minimal losses in merchantable volume 1 year after the Moose Fire. The scaler measured less wood borer-caused defect in the >20 inches d.b.h. size class, but this may be a product of small sample size. Although stain was observed, it does not reduce merchantable volume and therefore is not considered a volume defect (Danielson 2002).

Wildlife. Fire-killed larch provides important foraging and cavity nesting sites for various forms of wildlife. About 63 percent of the fire-killed larch showed signs of woodpecker foraging for insects 1 year after the fire. Since woodpecker foraging was observed on 4 of the 10 trees that didn't show wood borer activity in the disks, disk observations may have underestimated wood borers. As may be expected, the two size classes with the greatest average number of wood borer holes, 12-15.9 inches d.b.h. and 16-19.9 inches d.b.h., also had more woodpecker foraging than the smallest and largest size classes. About 13 percent of dissected trees contained substantial columns of pre-existing decay, perhaps future cavity-nesting sites.

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ACKNOWLEDGEMENTS

My thanks to Heidi Trechsel, Silviculturist on the Hungry Horse and Glacier View Ranger Districts, for helping identify field sites and providing a great deal of local support.

I also thank Jessie Micales, of the Forest Products Laboratory in Madison, WI for identifying the decay fungi, and Diana Six, Associate Professor of Integrated Forest Entomology/Pathology at the University of Montana, for identifying the stain fungi mentioned in this report. Thanks also go to Skip Danielson, of the Clearwater National Forest, for scaling the logs and Larry Stipe, of the Forest Health Protection field office in Missoula, for preparing the maps and providing other GIS/GPS support. Reviews and constructive comments provided by Gregg DeNitto, of the Forest Health Protection field office in Missoula, Skip Danielson, and Jim Hadfield, of the Forest Health Protection-Wenatchee Service Center, are greatly appreciated.