APPENDIX B
Fire Plot Monitoring

Appendix B

Kootenai National Forest 1994 Post Fire Monitoring Project

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Introduction

Lightning-ignited fires burned approximately 53,000 acres on the Kootenai National Forest in the summer of 1994. Following the fires and based on a recommendation from the 1994 Fire Assessment, the Forest Management Team approved a long term, permanent monitoring project. The first objective of this project was to refine predictive guidelines for estimating conifer mortality of fire-affected trees previously developed by Forest Service personnel **(Appendix A)**. The second objective was to determine trends in succession of vegetation. Although initially considered as a third objective, the meaningful analysis of vegetation response to different harvest practices required a much larger sample size than time and budget would allow and was not realized. This project intended to establish baseline information regarding conifer mortality, vegetative succession and accumulation of fuels. Thirty-eight plots have been established to date. Although initially intended to be sampled on a one, two, three, five and ten year schedule, budget and time constraints limited the sampling to four years following the fires (1994 to 1997). Data collected at year five would have allowed a complete comparison of the post fire tree mortality estimation matrix. Since the fifth year sampling did not occur, adjustments will not be made to the matrix (**Appendix A**).

This report intends to clarify methods and the summarize plots installed. The summary includes both second and fourth year results for fire effects as related to tree mortality. The summary then covers the second year results for the succession phase of this effort.

Sample Design: Pre-field Plot Stratification and Installation

Initially termed Ecological Land Units (ELUs) and renamed Vegetative Response Units (VRUs), as described in the Forest Assessment of 1994 Major Fires (USDA 1994), are the basis for plot distribution. Initial stratification by ELU (VRU) assured adequate sampling across a variability of environmental gradients. Plots were placed in order to sample the dominant habitat group within the ELU (VRU).

District Tree Mortality (TM) determinations were used for further stratification. TM defines the percent of trees scorched or consumed by fire over a given area. Districts made TM delineations from aerial photos and ground-truthing. A TM of one indicates 70 to 100 percent of tree crowns scorched or consumed. A TM of two indicates 30 to 70 percent. A TM of three indicates one to 30 percent. Representing all thirteen ELUs (VRUs), at all levels of burn intensity would have required 96 plots. Limited by funding and time constraints, we assigned priority to TM 2 and those ELU (VRU)/TM combinations with the largest burned acreage. TM two and three are of particular interest because of questionable tree and vegetative response to moderate and low burn levels. **Table 1a** and **Table 1b** illustrate the distribution of plots as of fall 1995.

Plots placement typified TM for the dominant habitat group by ELU (VRU). Verification of tree mortality, habitat type and group, landtype and aspect occurred in the field. Most plots are at least 300 feet from roads or ecotones to reduce edge effect. We avoided existing or proposed harvest units.

A map and table listing plot locations are in **Appendix C**. Fire plots are being monitored in the following 1994 fires: (1) China Basin, (2) Douglas Hill, (3) Fowler, (4) Pillick, (5) Quartz Three, (6) Scenery, (7) Seventeen Mile, (8) Tenmile Prescribed Burn, (9) Webb, and (10) Willard. Mean elevation of the plots is 4350 feet with a range from 2225 to 6305 feet. All fires except Tenmile ignited in the summer of 1994. Tenmile burned in the spring of 1995.

ELU (VRU)	TM 1	TM 2	TM 3	TOTAL ELUs
1-30n (TE01)	1	0	0	1
1-30s (TE01)	0	0	2	2
2-25s (TE02S)	0	1	2	3
2-30s (TE02S)	2	2	1	5
2-35s (TE02S)	0	1	1	2
3-30s (TE03)	0	1	0	1
5-35n (TE05N1)	1	6	2	9
5-35s (TE05S1)	2	0	2	4
6-35r (TE06)	1	1	1	3
7-35s (TE07S)	0	0	1	1
9-40lr (TE09)	2	2	3	7
TOTAL TM	9	14	15	**PLOTS = 38**

Table 1a. Number of plots per ELU (VRU)* and Tree Mortality (these plots are ordered according to the Regional VRU classification scheme)

To be consistent with the Region, ELUs (VRUs) were converted from Kootenai National Forest Habitat designations to the Regional convention. See **Appendix B.*

ELU	TM 1	TM 2	TM 3	TOTAL E.LUs
a-30s	1	0	2	3
b-25s	0	1	2	3
b-30s	1	2	0	3
b-35s	0	1	0	1
c-30s	1	0	1	2
c-35n	0	0	1	1
d-30s	0	1	0	1
d-35n	2	5	3	10
d-35s	1	1	1	3
e-35n	0	0	1	1
f-35r	1	1	1	3
h-40lr	2	2	3	7
TOTAL TM	9	14	15	**PLOTS = 38**

Table 1b: Number of plots per ELU and Tree Mortality (these plots are ordered according to the Kootenai National Forest classification scheme)

Community Vegetation at the Plot Level and Fire Effects Monitoring Methods

Data collection followed the Ecosystem Inventory and Analysis methodology, ECODATA, (USDA 1992) with exception of measuring fire effects on individual trees. Modifications were made to the Fire Effects Data Form to better capture burn effects on individual trees. ECODATA forms used include: Comments Data, Location Linkage, Plant Composition, General Form, Down Woody Debris, and the modified Fire Effects (**Appendix D**). Macroplots are one-tenth acre in size with a variable radius plot used for Fire Effects tree data. Down woody transects circumnavigate the plot. Detailed field methods are in **Appendix E**.

We entered most data into the Data General ECODATA database and then extracted it to a Paradox database for easier manipulation. For the modified Fire Effects form, we entered data directly into Paradox. We used both Paradox and Quattro-Pro software for analysis.

Preliminary (First year) Results and Discussion

Three hundred thirty-nine trees associated with 38 macroplots are designated and can be permanently monitored. The sample of trees includes nine species with a wide range of size classes (**Table 2**). Ideally, all baseline measurements would have been collected shortly after fires. We succeeded in installing nineteen plots shortly after the 1994 fires and an additional three plots in the Tenmile prescribed burn that burned early the summer of 1995. The following summer (1995), an additional 17 plots were installed in the 1994 burns.

Species	1994	1995	Total trees	Avg. dbh	Min. dbh	Max. dbh
Abies lasiocarpa	15	13	28	11	6.3	16.6
Larix occidentalis	16	11	27	17	8.6	39.1
Picea engelmannii	03	07	10	18	8.3	25.0
Pinus contorta	23	36	59	9.3	4.9	16.8
Pinus monticola	13	03	16	20	6.9	40.0
Pinus ponderosa	21	11	32	18	7.0	30.6
Pseudotsuga menziesii	40	62	102	17	5.2	48.0
Thuja plicata	12	17	29	18	7.2	38.0
Tsuga heterophylla	18	15	33	18	8.0	35.0
Burned	00	03	03	13	10.0	17.4

Table 2. Summary of tree species sampled for individual tree fire effects monitoring with minimum, maximum, and average dbh indicating the range in size classes.

The type of fire and surface burn severity was collected for the macroplot. These designations provide a detailed view of how the fire moved through the plot and how severely the soil and duff on the macroplot are affected (**Appendix F and G**). Out of the nine plots installed in Tree Mortality 1, all but one has a significantly greater percentage of moderate severity surface burn than high severity surface burn. High levels of crown fire rarely correlated with high severity surface burn. As we defined surface burn severity, very few of the fires we sampled had severe impacts on soils, although impacts to overstory and understory vegetation varied greatly.

Individual Tree Fire Effects

Individual trees were measured to monitor tree response to various fire injuries over time. These measurements will be used to validate or improve the tree mortality prediction matrix developed in the fall of 1994. See **Appendix A**. Fire effects measurements include: bole char, deep bole char, height of bole char, root char, and crown scorch (underline indicates data collection attributes defined in Appendix G). These measurements will not change over time. However, live crown ratio and dead cambium are measurements that will change. These variables will indicate the vigor and status of the tree over time, i.e., alive or dead. See **Appendix G** for detailed explanations. **Figures 1 - 4** illustrate sampled fire effects for the species ponderosa pine (*Pinus ponderosa*), which is considered resistant to fire, and western redcedar (*Thuja plicata*), which is considered moderately intolerant of fire. Figures for other species are in **Appendix H**. Secondary effects such as insect and disease will be very important to monitor and could contribute significantly to individual tree mortality. Had data been collected at year five, there would have been enough information to recommend changes or refinement in the tree mortality guide. Elaboration on other species will wait until further data is collected.

Second Year Summary

Of the ponderosa pine sampled that have a crown ratio greater than 30 percent and a dbh greater than 12 inches, bole char is 25 to 100 percent, but none show any dead cambium (**Figure 1**). High bole char compared to zero dead cambium illustrates the insulative and resistant properties of ponderosa pine bark. These trees experienced predominately hot surface fires and creeping ground fires with very little crowning and torching (**Table 3**). Ponderosa pine that had high levels of crown scorch did not fare as well. Plots two and thirty-five were associated with understory vegetation that facilitated torch and crown types of fires (**Table 3**). Most trees represented in **Figure 2** have 75 to 100 percent crown scorch, which is highly related to low live crown ratios and high levels of dead cambium.

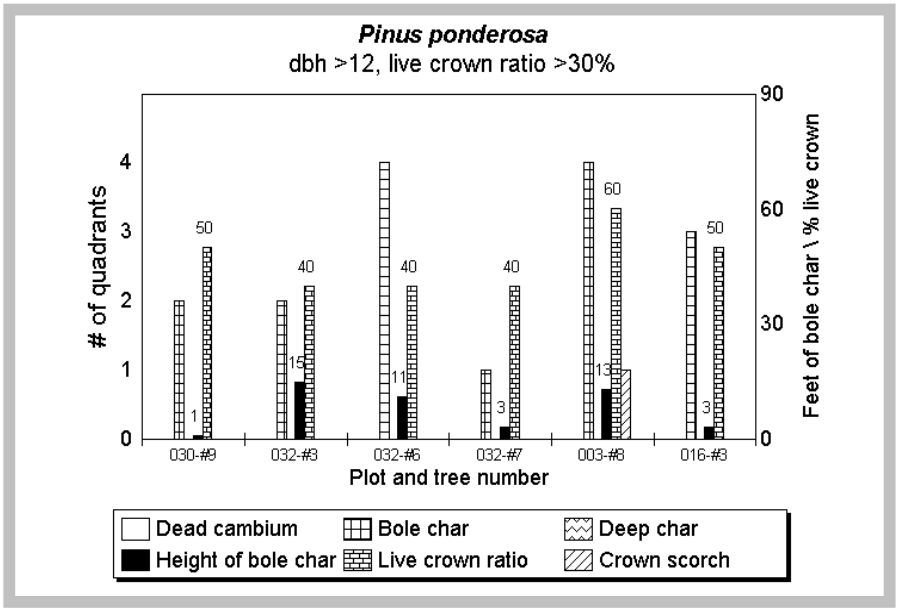


Figure 1. Ponderosa pine with dbh >12 and live crown >30% from 1994 and 1995 fire plots. Dead cambium and live crown ratios represent 1995 measurements.

Macroplot Identification Data				Percent of Macroplot that experienced each Type of Fire				Percent of Macroplot Surface with each of the following Burn Severity Classes			
plt #	habitat group	tree mortality	ft^2 / acre	crown	torch	hot surface	creeping ground	no burn	low	mod	high
2	2	1	180	0	30	70	0	0	20	70	10
3	2	3	160	0	0	98	0	1	10	80	10
16	2	2	100	0	25	75	0	0	0	90	10
30	2	2	110	0	3	10	80	1	60	30	1
32	2	3	100	0	0	10	80	3	80	10	1
35	2	2	180	30	10	0	40	20	3	70	3

Table 3. General burn characteristics and severity of surface burn for plots with ponderosa pine over 12 inches in dbh. See **Appendix G** for detailed description of fields.

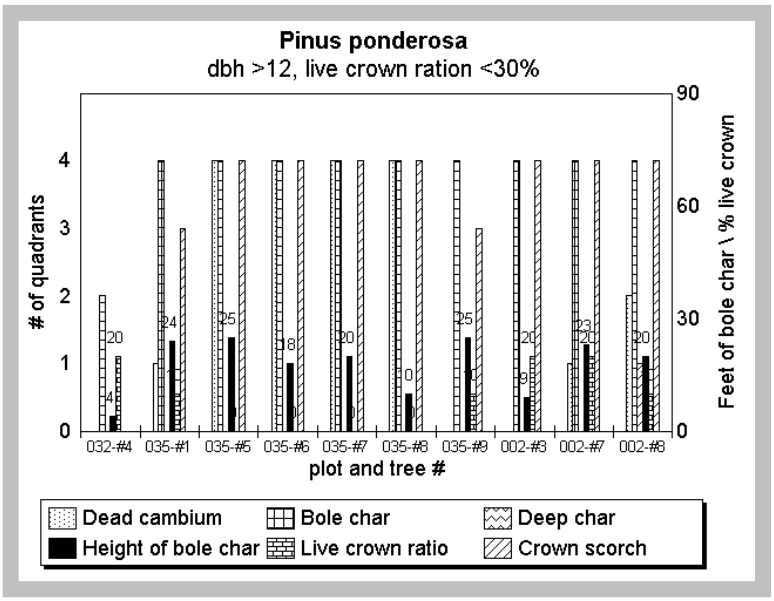


Figure 2. Ponderosa pine with dbh >12 and live crown <30% from 1994 and 1995 fire plots. Dead cambium and live crown ratios represent 1995 measurements.

Of the ponderosa pine in **Figures 1 and 2**, four trees have died to date, and all are associated with high crown scorch. High bole char is also indicated, but none of the trees sampled that are greater than 12 inches have deep char. Cambium death or tree death, is more related to high crown scorch and low levels of live crown ratio than to bole char. From the data collected to date, crown variable appears to be a better predictor of tree death in ponderosa pine greater than 12 inches dbh than bole char. Western redcedar on the other hand, is more susceptible to bole damage.

Western redcedar, represented in **Figures 3 and 4**, was sampled in three plots representing a riparian influence. The exception was plot six. This plot was placed within vegetation representing a terrestrial composition. Plots representing redcedar had a high percent of hot surface and creeping ground type fires with very little torching (**Table 4**). This is not surprising considering sampled sites that have western redcedar generally have higher duff levels, are moist to wet, and generally have less understory vegetation to serve as ladder fuels. Burn severity class designations for these plots were generally moderate to low. Plot #six had a greater percentage of high severity burn (**Table 4**).

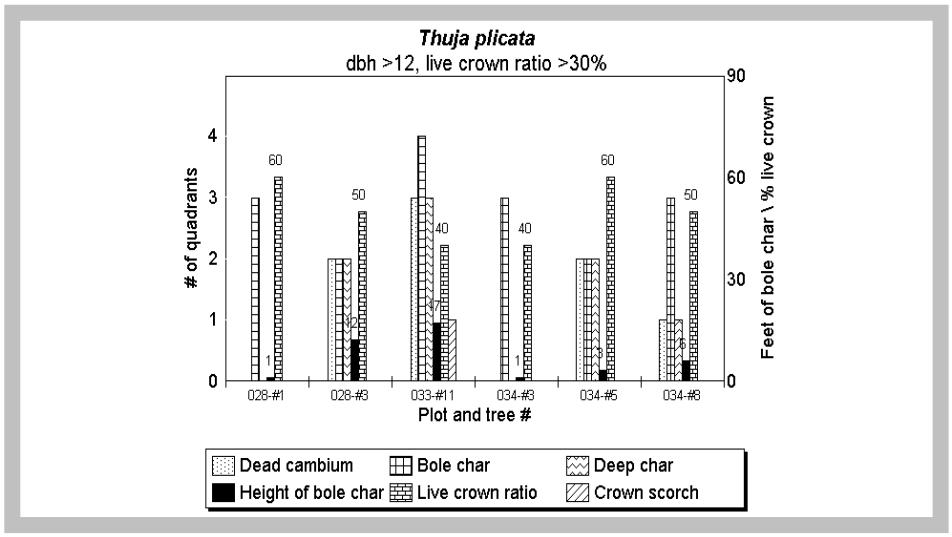


Figure 3. All western redcedar with dbh >12 and live crown ratio >30 %. Dead cambium and live crown ratios represent 1995 measurements.

Macroplot Identification Data				Percent of Macroplot that experienced each Type of Fire				Percent of Macroplot Surface with each of the following Burn Severity Classes			
plt #	habitat group	tree mortality	ft^2/ acre	crown	torch	hot surface	creeping ground	no burn	low	mod	high
6	5	2	260	0	0	50	50	20	10	50	20
28	6	2	180	0	20	35	45	10	10	80	0
33	5	2	220	0	3	60	40	1	40	60	3
34	5	3	200	0	3	20	70	3	80	20	1

Table 4. General burn characteristics and severity of surface burn for all plots with western redcedar over 12 inches dbh. See **Appendix B** for more detailed descriptions of these fields.

Preliminary data indicate that deep char is a reliable measure of total dead cambium for western redcedar, whereas bole char is not. For most of the trees in **Figure 3 & 4** dead cambium correlated with deep char, but not with bole char. Only tree 028-#4, **Figure 4**, has greater cambium death than deep char. This is likely attributed to the high level of crown scorch, not bole damage. Further measurements can determine what factors result in mortality or survival and will be used to refine the post fire tree mortality guide **(Appendix A**.)

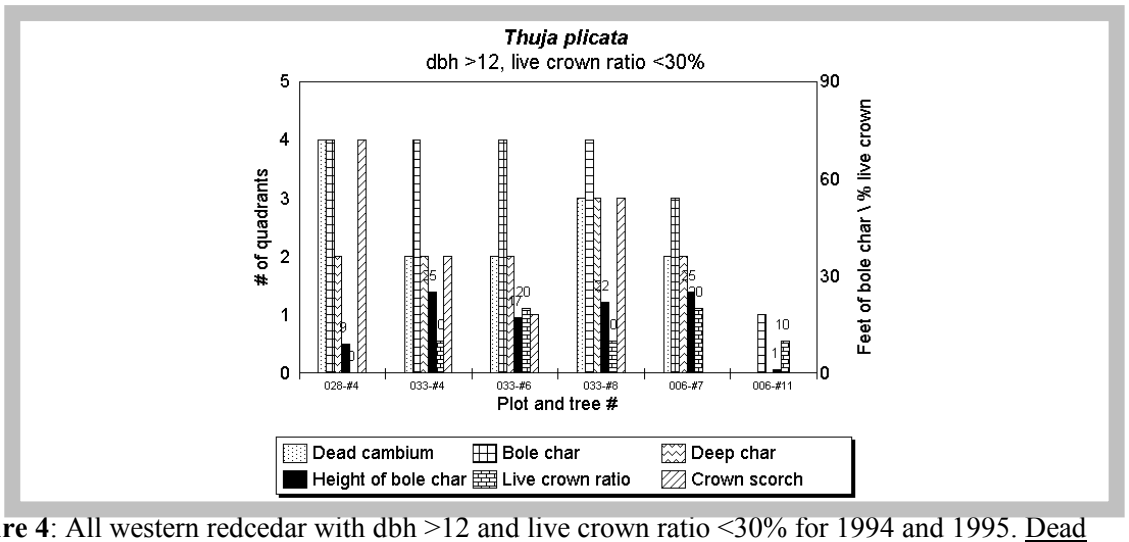


Figure 4: All western redcedar with dbh >12 and live crown ratio <30% for 1994 and 1995. Dead cambium and live crown ratios represent 1995 measurements.

Fourth Year Summary of Fire Effects and Mortality

This summary analysis focused on the following species: lodgepole pine, Douglas-fir, ponderosa pine, western redcedar, western hemlock, western larch, and subalpine fir. We felt this would cover a cross-section of seral and non-seral, shade tolerant and intolerant species. Most plots were sampled for 4 successive years (1994 to 1997).

The attributes live_crown_ratio, crown_scorch, bole_char, and dead_cambium (both bole and root) are used in this summary. These are the attributes most similar to those used in the "Conifer Tree Mortality (Fire Damaged) Estimator" (1995) developed by a group of silviculturists (with guidance from scientific literature and observations) following the 1994 fires in order to assist forest managers in predicting whether conifers damaged by wildfire will live or die. The same document included a "Guide to Post-Fire Tree Mortality Estimation" that served as marking guides for prescriptions used during post-fire tree management activities.

Comments based on observation following implementation of prescriptions indicate more trees were marked than actually died. The purpose of this summary is to determine what burn attributes are likely to lead to the death of a tree following a fire and to compare actual, sampled tree mortality with predicted mortality. In addition, this summary can refine the "Guide to Post-Fire Tree Mortality Estimation Guide" prior to prescription implementation for the 2000 post fire activities.

Summary Methods

Since each species responds differently to fire, the first step in this summary was to separate different species. To determine what burn attributes would eventually lead to the death of a tree, we needed to know which trees died and which lived. After dividing each tree of each species into dead and alive, we further subdivided into trees less than 12 inches DBH and trees greater than 12 inches DBH. Some trees were snags before the fires and therefore eliminated from further consideration because the fires did not directly cause the mortality. Once organized into these groups, we plotted into the following attributes: live_crown_ratio, crown_scorch, bole_char, burn_through_bark, bole_dead_ cambium, and root_dead_cambium. Mean and median values were also calculated for each attribute.

The summary consists of graphs of each attribute in each category; tables of the mean and median values; and a summary of observations for each species.

Douglas-fir

Mean and Median Values for Live Douglas-fir				
	DF < 12" DBH		DF > 12" DBH	
Count	14		45	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	24.36	20.00	37.78	40.00
Bole Dead Cambium	0.00	0.00	7.21	0.00
Root Dead Cambium	0.00	0.00	8.70	0.00
Crown Scorch	14.50	0.00	8.70	0.00
Bole Char	65.64	88.00	74.38	88.00
Burn Through Bark	0.00	0.00	2.87	0.00

Mean and Median Values for Dead Douglas-fir				
	DF < 12" DBH		DF > 12" DBH	
Count	11		19	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	1.10	0.00	18.47	10.00
Bole Dead Cambium	35.20	0.00	33.16	13.00
Root Dead Cambium	6.50	6.50	30.81	13.00
Crown Scorch	77.64	88.00	56.79	88.00
Bole Char	83.45	88.00	78.79	88.00
Burn Through Bark	0.00	0.00	8.74	0.00

Discussion: In comparing mean and median values between live and dead trees, we can see some major differences. Overall, the live crown ratio (LCR) is higher in live trees. Root and bole dead cambium is slightly higher in dead trees. Crown scorch is much higher in dead trees. Bole char and burn through bark, on the other hand are basically the same between live and dead trees. This seems to indicate that Douglas-fir are more sensitive to crown scorch and not to bole char. Live crown ratio is highly variable between the live and dead trees. In live trees >12", LCR ranges from 10 to 80% whereas in dead trees LCR ranges from 0 to 60%. The mean value for LCR in dead trees is considerably lower than live trees due to the fact that out of a total 19 dead trees, 7 were killed outright by the fire and had an LCR of 0. Due to the variability, LCR may not be a reliable attribute to determine mortality.

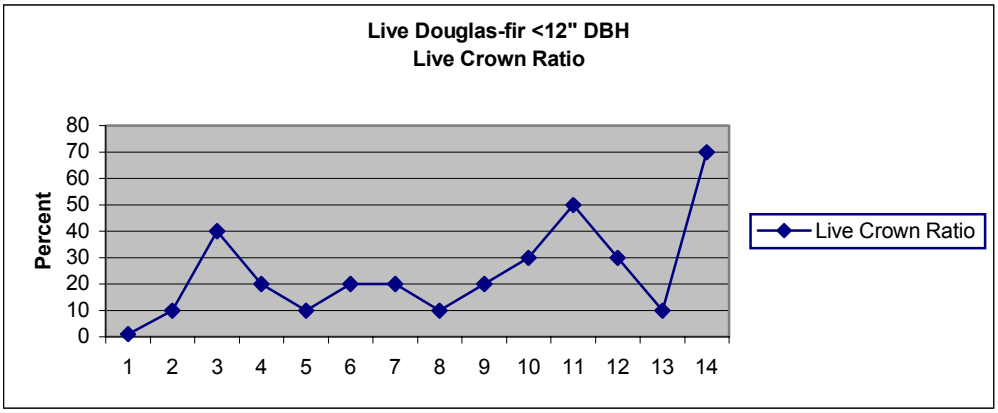
Another consideration in live trees is to see if the LCR has been declining, indicating that the tree is fading. The graphs show LCR has decreased by 20% or more in only 7 trees >12" and 1 tree <12". Most of the live trees are either maintaining or increasing their LCR's. I only looked at those trees that had a change in LCR by 20% or more because a 10% change could easily be attributed to differences in field measurements (i.e., different people collecting data year after year).

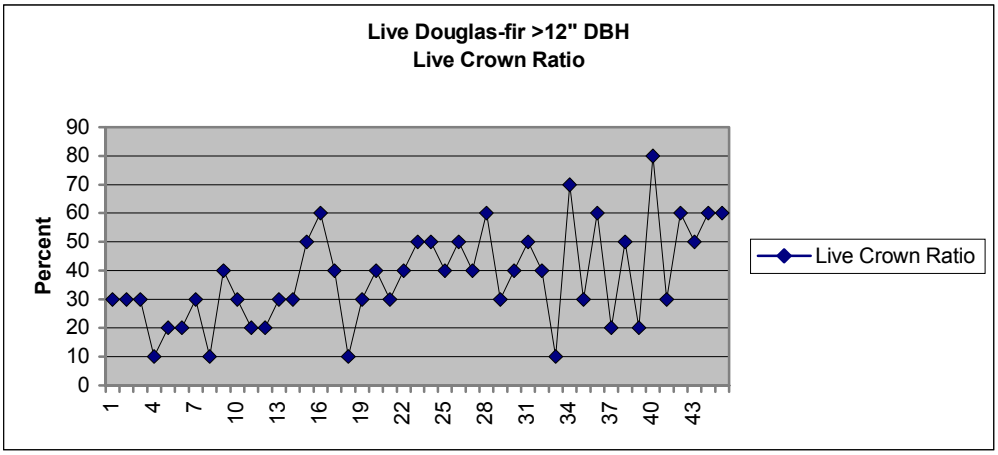
The crown scorch graphs show very different patterns. Live trees, both small and large, sustained very little crown scorch, mostly under 13% (or 1-25% category). Most of the dead trees had crown scorch greater than 25%. The mean and median figures reflect these major differences. However, there are always exceptions. Two out of 45 live trees >12" and 1 out of 14 live trees <12" had very high crown scorch. Eight out of 19 dead trees >12" and 2 out of 11 dead trees <12" had crown scorch less than 25%. Most of the 8 dead trees >12" had some burn through bark. Other factors such as VRU or fire severity may have to be investigated to explain these exceptions.

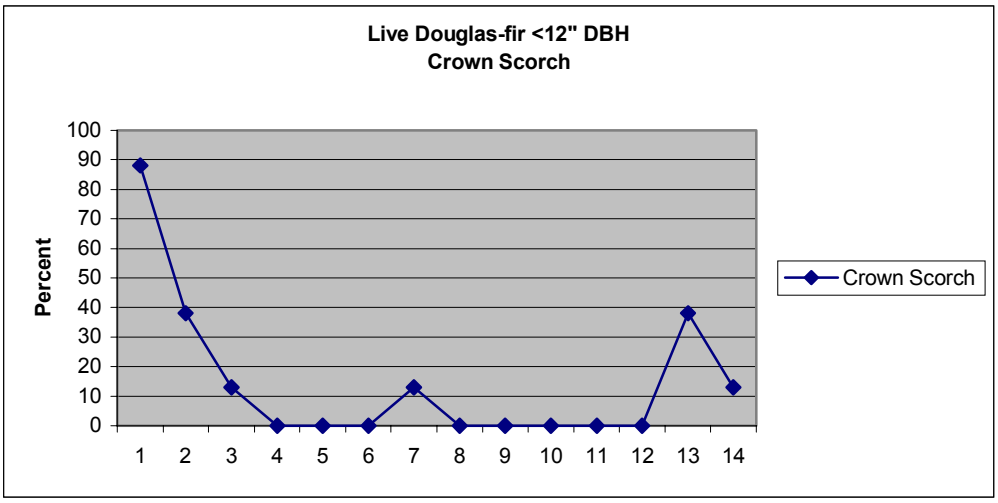
Both live and dead trees have sustained very high bole char and very little to no burn through bark. Dead cambium values are slightly higher in dead trees. However, the values are highly variable so it is difficult at this point to make any generalizations.

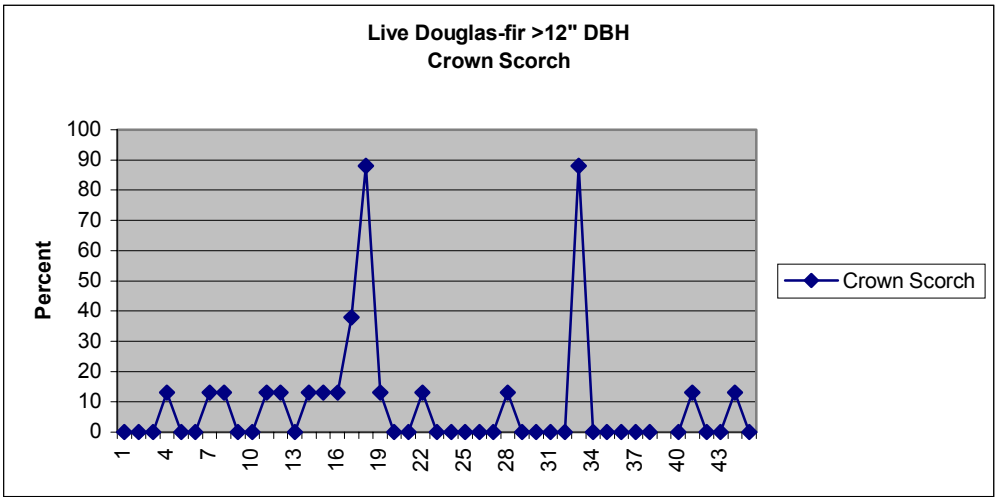
Summary Observations for Douglas-fir

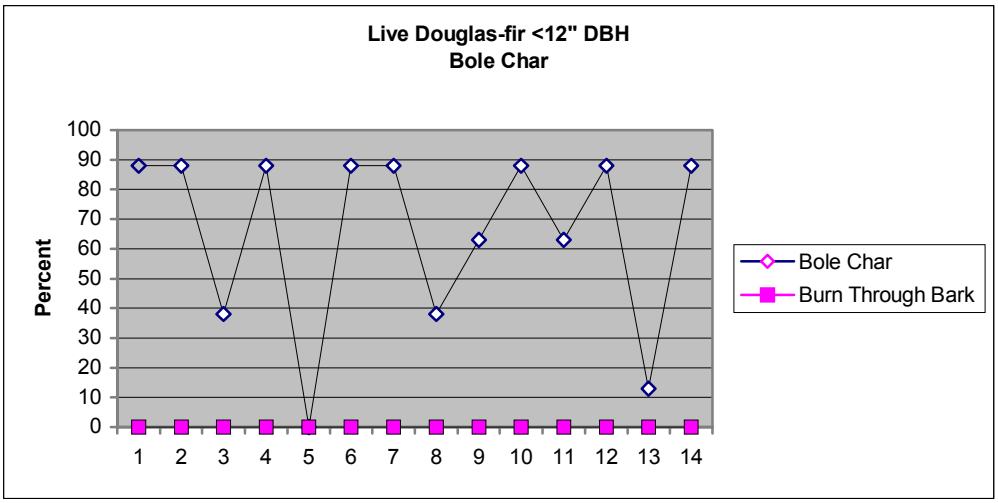
Douglas-fir seems to be more sensitive to crown scorch than to bole char. In general, Douglas-fir appears to survive if crown scorch is less than 25%. Douglas-fir can survive with up to 100% bole char. Live crown ratio values appear to be too variable to be used an indicator of mortality. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:

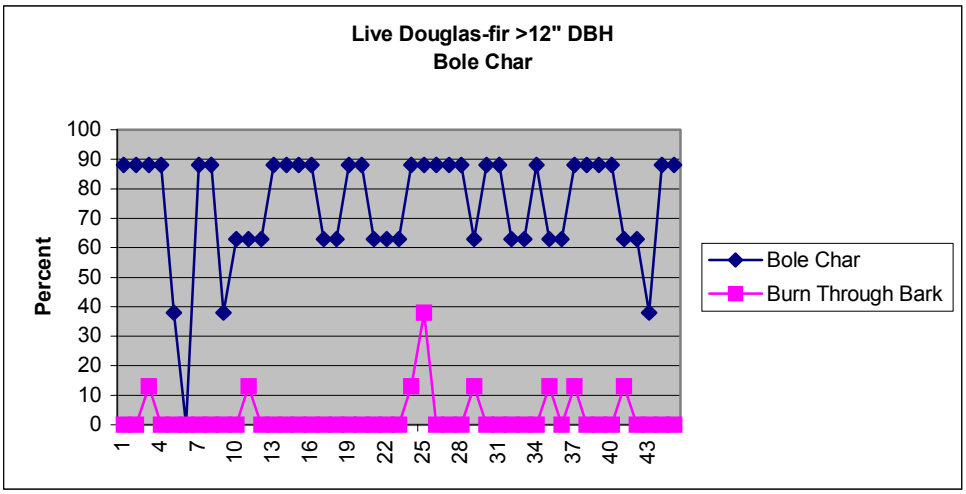


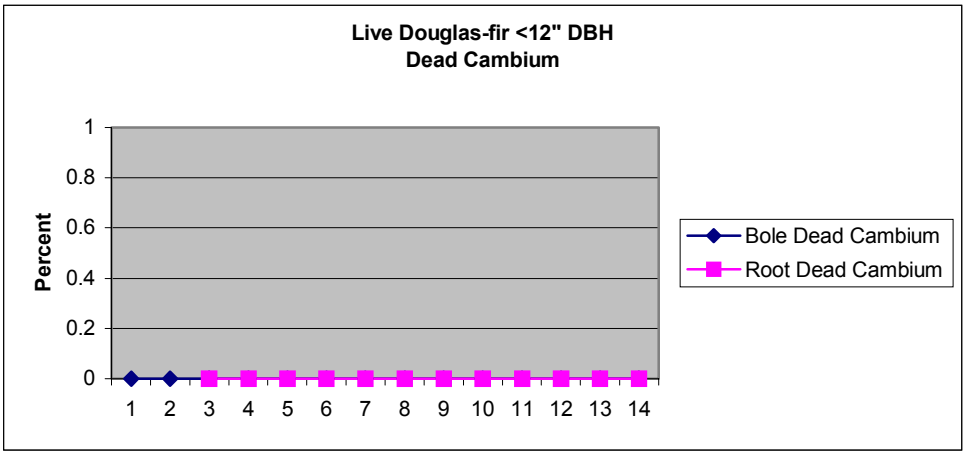


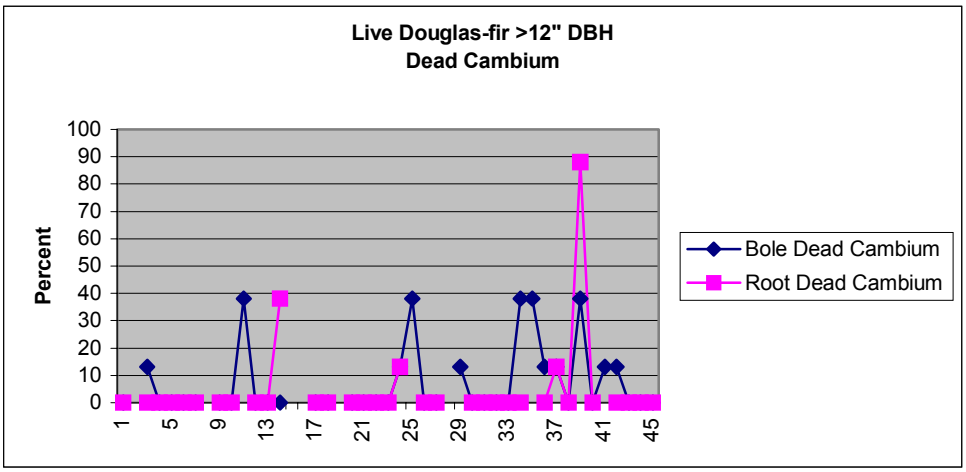

Live Douglas-fir <12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Crown Scorch


Live Douglas-fir >12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43
Crown Scorch


Live Douglas-fir <12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Bole Char
Burn Through Bark


Live Douglas-fir >12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
Bole Char
Burn Through Bark


Live Douglas-fir <12" DBH
Dead Cambium
Percent
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Bole Dead Cambium
Root Dead Cambium


Live Douglas-fir >12" DBH
Dead Cambium
Percent
100
90
80
70
60
50
40
30
20
10
0
1
5
9
13
17
21
25
29
33
37
41
45
Bole Dead Cambium
Root Dead Cambium

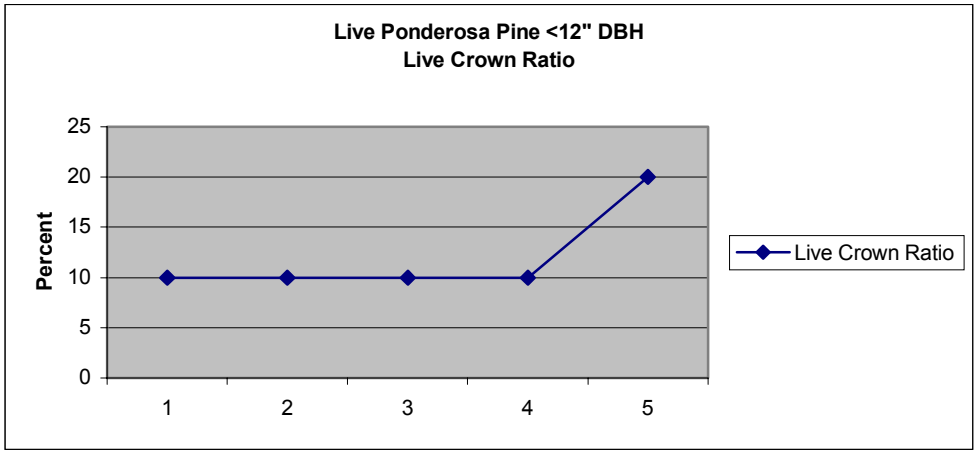
Ponderosa Pine

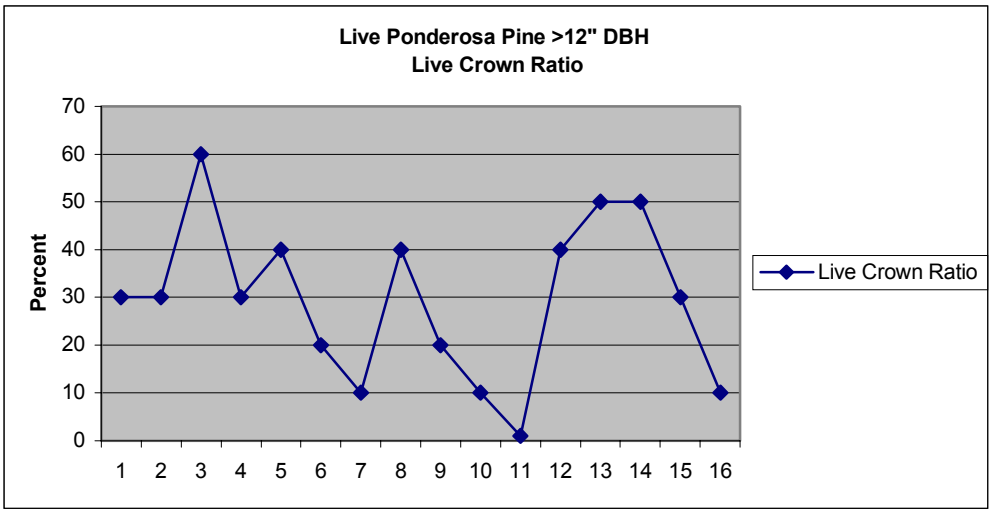
Mean and Median Values for Live Ponderosa Pine				
	PP < 12" DBH		PP > 12" DBH	
Count	5		16	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	12.00	10.00	29.44	30.00
Bole Dead Cambium	0.00	0.00	4.25	0.00
Root Dead Cambium	0.00	0.00	0.00	0.00
Crown Scorch	50.40	63.00	21.31	0.00
Bole Char	88.00	88.00	67.69	88.00
Burn Through Bark	0.00	0.00	2.38	0.00

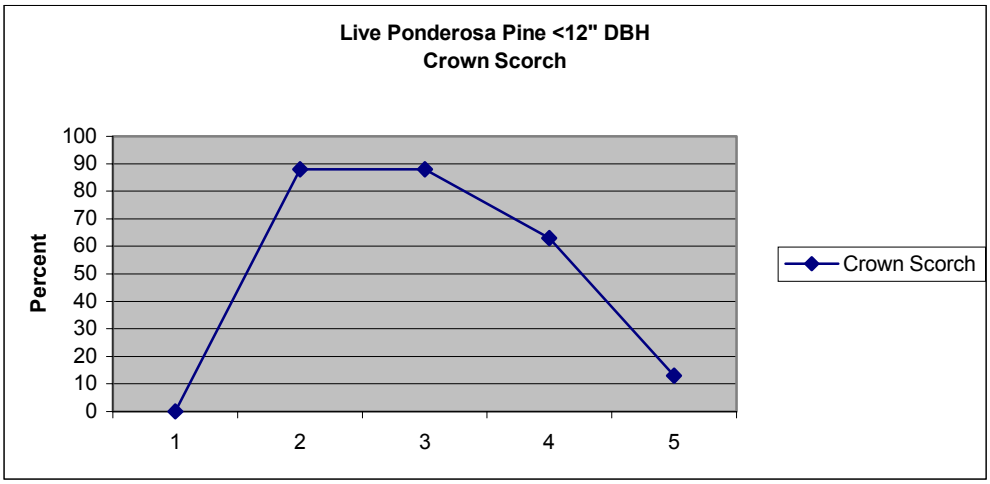
Discussion: Only live trees were looked at since there were only 6 dead trees of which 2 were killed by mountain pine beetle. The remaining 4 were killed outright by fire and had very high bole char, very little burn through bark and no LCR. Ponderosa pine appear to survive even when their LCR is fairly low (10%). In general, LCR values increased or remained the same throughout the 3-year period, which means that none of the trees were fading up to this point. PP also seem to handle a high amount of crown scorch, but generally less than 75%. The larger trees on average had less crown scorch than the smaller trees although they both ranged from 0 to 88%. Bole char was generally very high although burn through bark was minimal.

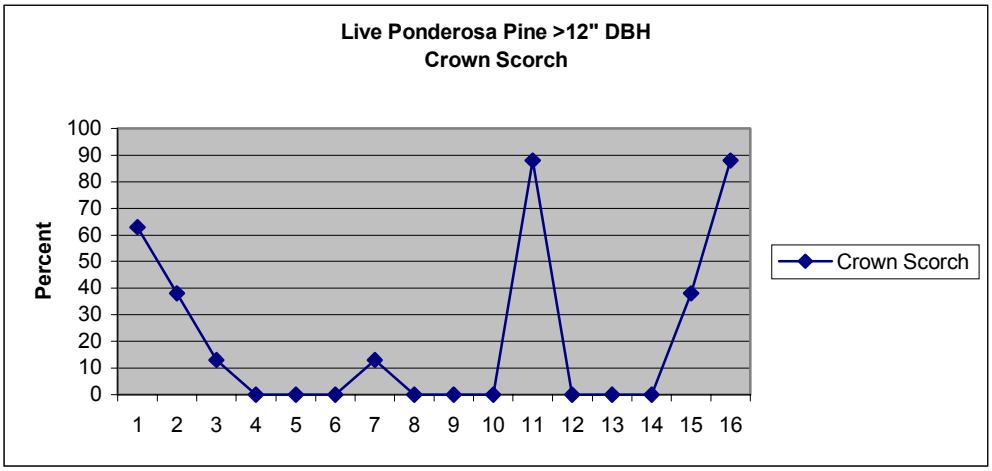
Summary Observations for Ponderosa Pine

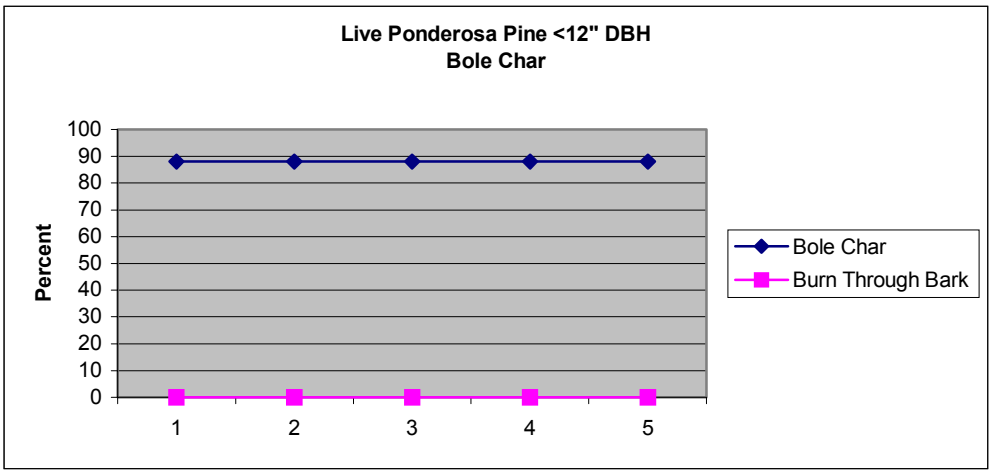
These data seem to indicate ponderosa pine can survive even with high crown scorch (up to 75% and very high bole char (up to 100% of tree bole circumference). Ponderosa pine requires a severe and intense burn to die by fire. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:

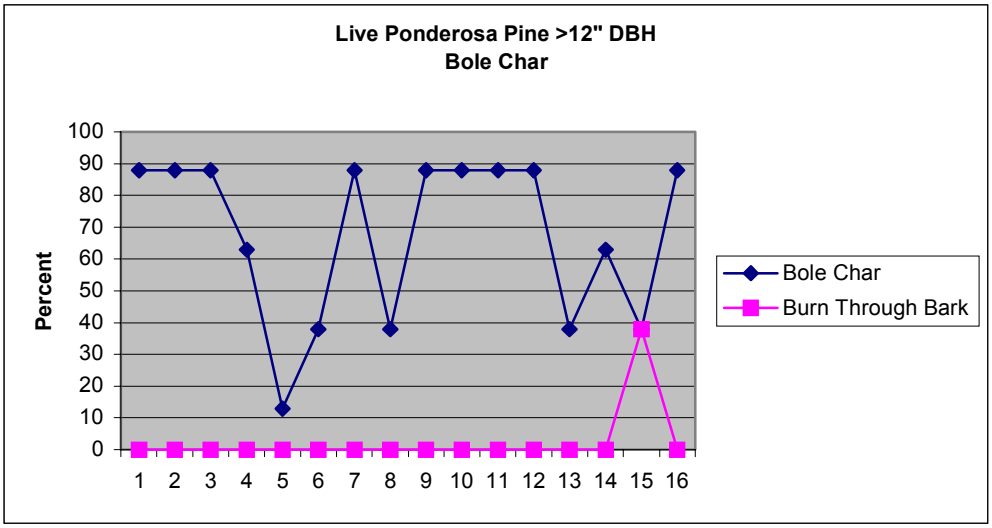



Live Ponderosa Pine >12" DBH
Live Crown Ratio
Percent
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Live Crown Ratio


Live Ponderosa Pine <12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5
Crown Scorch


Live Ponderosa Pine >12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Crown Scorch



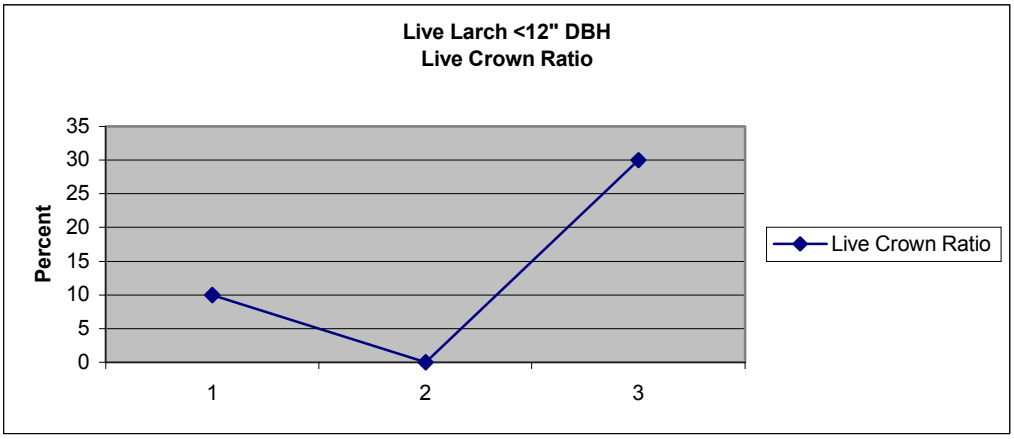


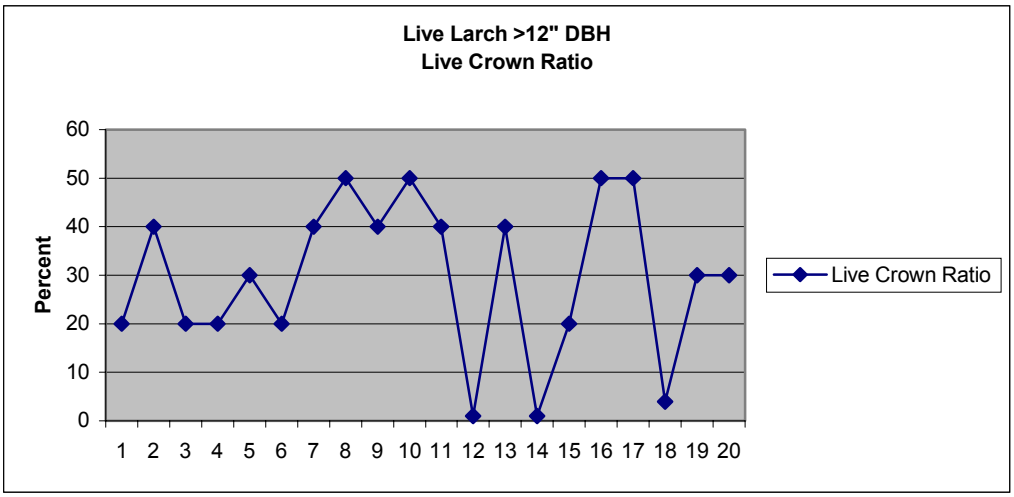
Western Larch

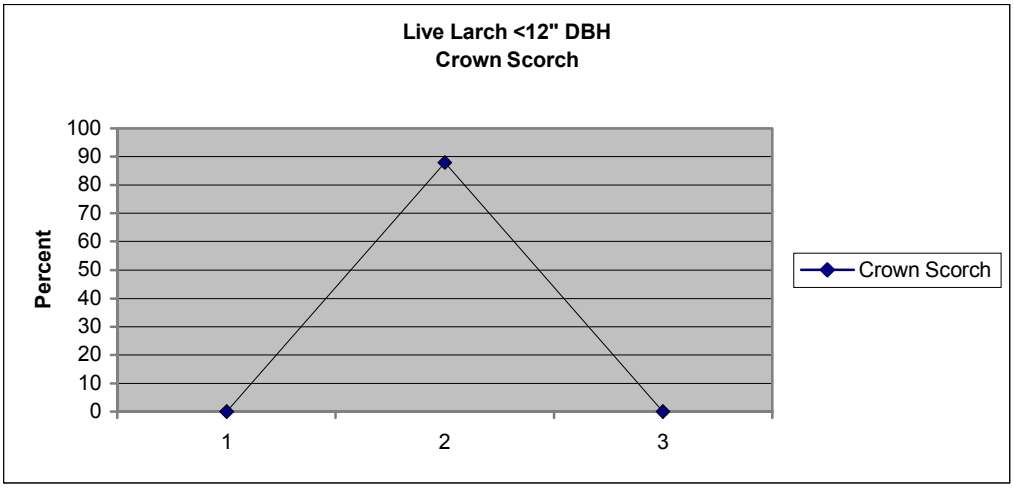
Mean and Median Values for Live Larch				
	Larch < 12" DBH		Larch > 12" DBH	
Count	3		20	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	13.33	10.00	29.80	30.00
Bole Dead Cambium	0.00	0.00	6.68	0.00
Root Dead Cambium	0.00	0.00	1.00	0.00
Crown Scorch	29.33	0.00	12.68	0.00
Bole Char	88.00	88.00	83.00	88.00
Burn Through Bark	12.67	0.00	11.40	0.00

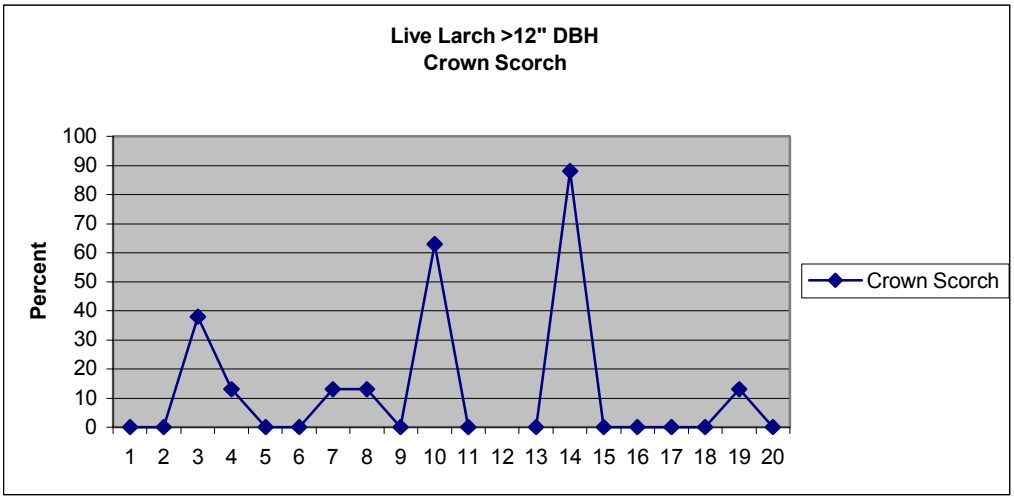
Summary Observations for Western Larch

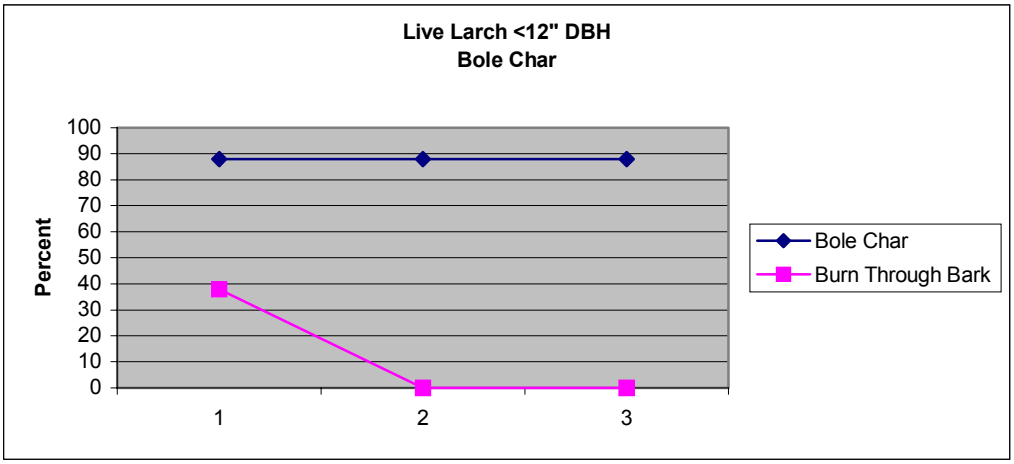
Discussion: Only two larch of all trees sampled were killed by the 1994 fires. The general trends for ponderosa pine appear to apply to larch. However, larch may be less tolerant to crown scorch than ponderosa pine since only 2 out of 20 large larch had crown scorch greater than 50%. Larch appears to survive with very high bole char (up to 100% of tree bole circumference) and moderate crown scorch (up to 50%). The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:

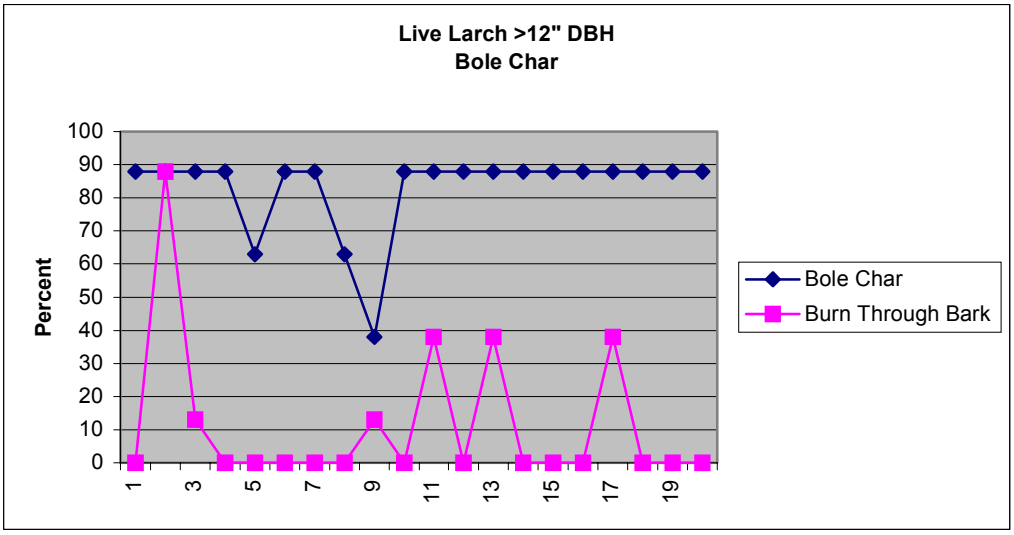





Live Larch <12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
Crown Scorch


Live Larch >12" DBH
Crown Scorch
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Crown Scorch


Live Larch <12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
Bole Char
Burn Through Bark



Lodgepole Pine

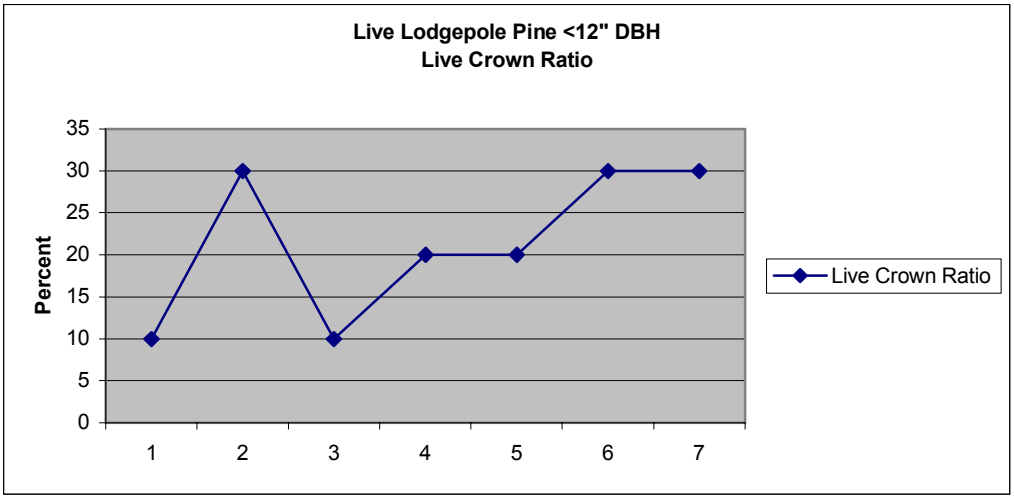
Mean and Median Values for Live Lodgepole Pine				
	LP < 12" DBH		LP > 12" DBH	
Count	7		4	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	21.43	20.00	35.00	35.00
Bole Dead Cambium	12.57	0.00	3.25	0.00
Root Dead Cambium	2.60	0.00	3.25	0.00
Crown Scorch	5.57	0.00	31.50	19.00
Bole Char	36.00	13.00	37.75	31.50
Burn Through Bark	1.86	0.00	0.00	0.00

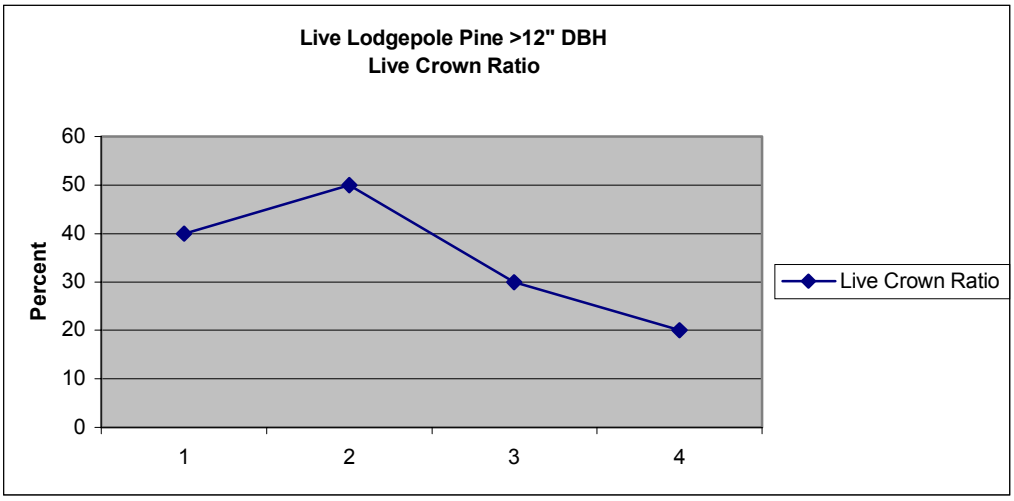
Mean and Median Values for Dead Lodgepole Pine				
	LP < 12" DBH		LP > 12" DBH	
Count	28		9	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	2.00	0.00	5.00	0.00
Bole Dead Cambium	81.71	88.00	73.88	88.00
Root Dead Cambium				
Crown Scorch	92.00	100.00	80.00	75.50
Bole Char	85.32	88.00	81.75	88.00
Burn Through Bark	70.50	88.00	36.25	25.50

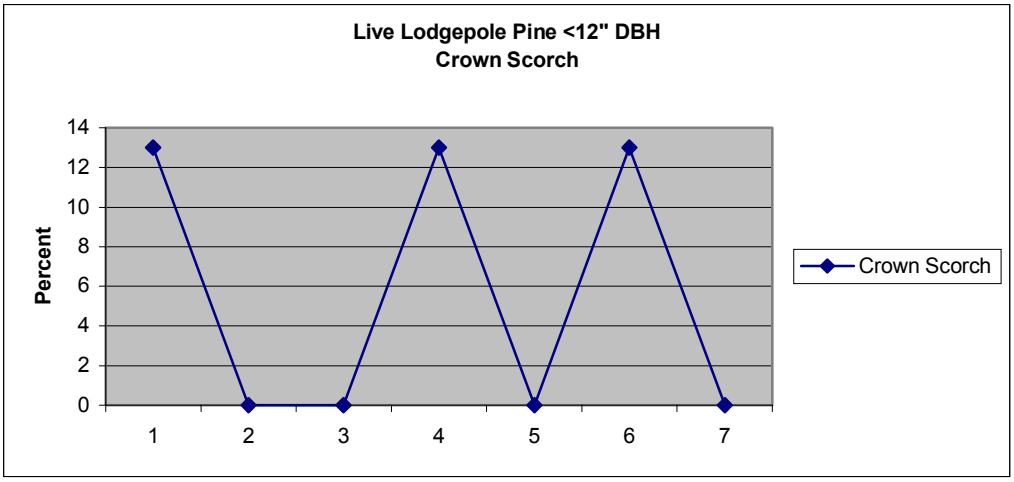
Discussion: A comparison between live and dead LP trees is difficult since most of the trees were either severely burned and killed by fire or hardly burned and survived the fire. Most of the dead trees were killed by fire with complete crown scorch, crowns consumed by fire, and no LCR. Live trees, in general, hardly burned. LCR in live trees ranged from 10 to 50%. Most trees appear to be maintaining their LCR although 1 tree >12" and 1 tree <12" appear to be fading. Both trees started with a LCR of 30%. One tree <12" (#4) may be dead, but the data is unclear and therefore will not be part of the discussion. All of the small live trees sustained less than 25% crown scorch and variable bole char, ranging from 0 to 100%. Large live trees had variable crown scorch and bole char (0 to 88%).

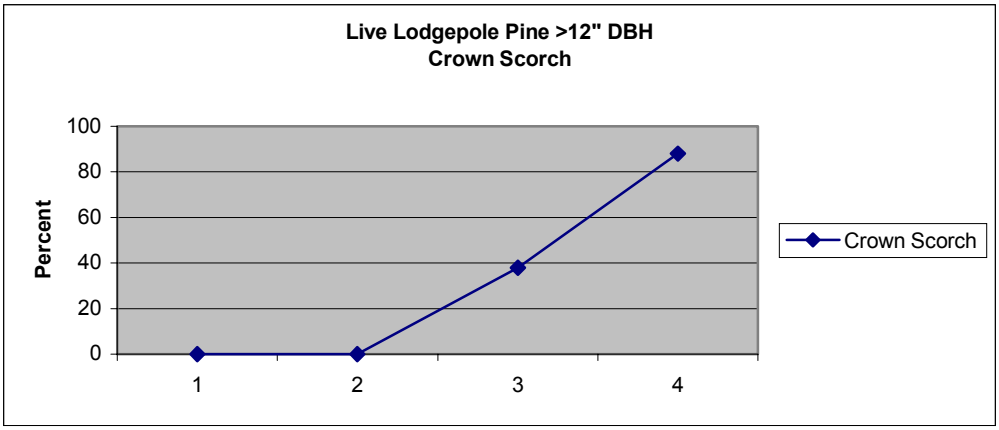
Summary Observations for Lodgepole Pine

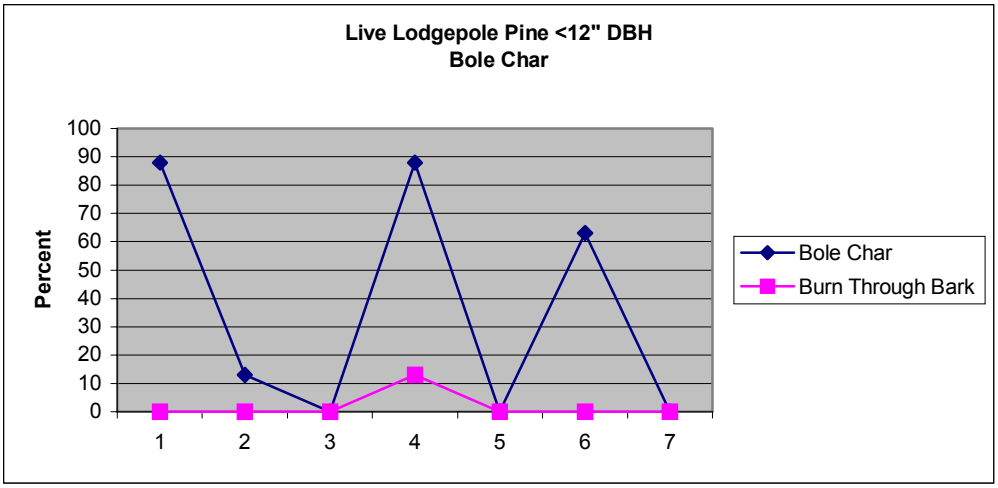
Out of all lodgepole pine sampled (37 total), few (11 total) survived the 1994 fires. Most of the dead trees burned severely. Most of the live trees had minor fire impacts. This indicates high fire severity in burned lodgepole pine stands. Survival of lodgepole pine appears to be linked to fire severity. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:

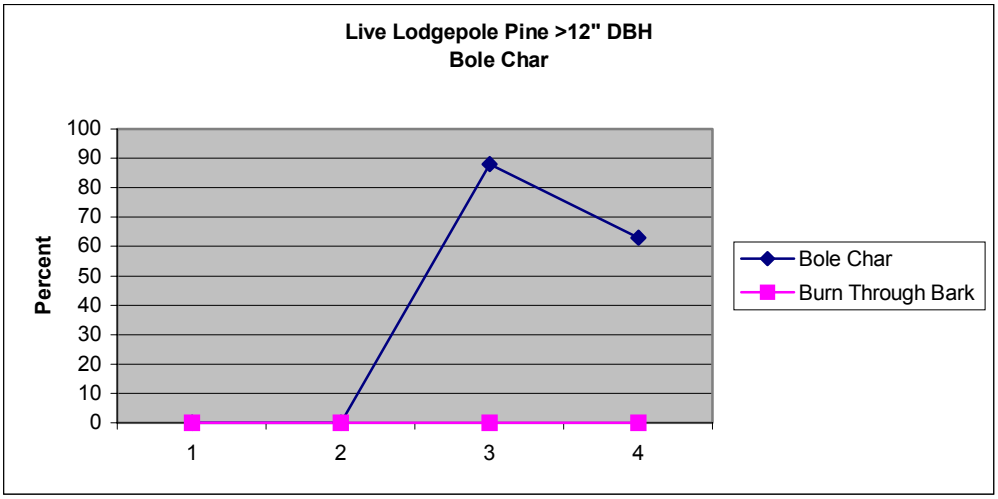


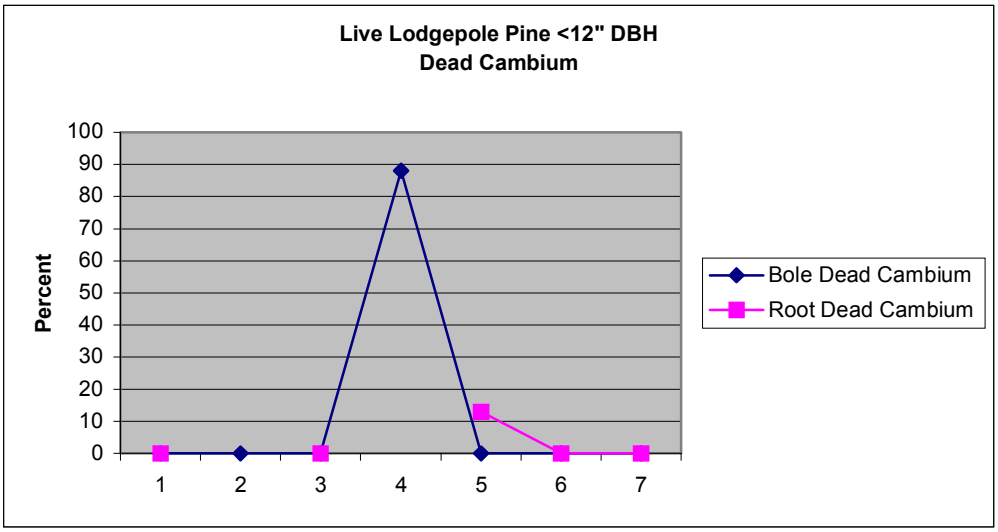


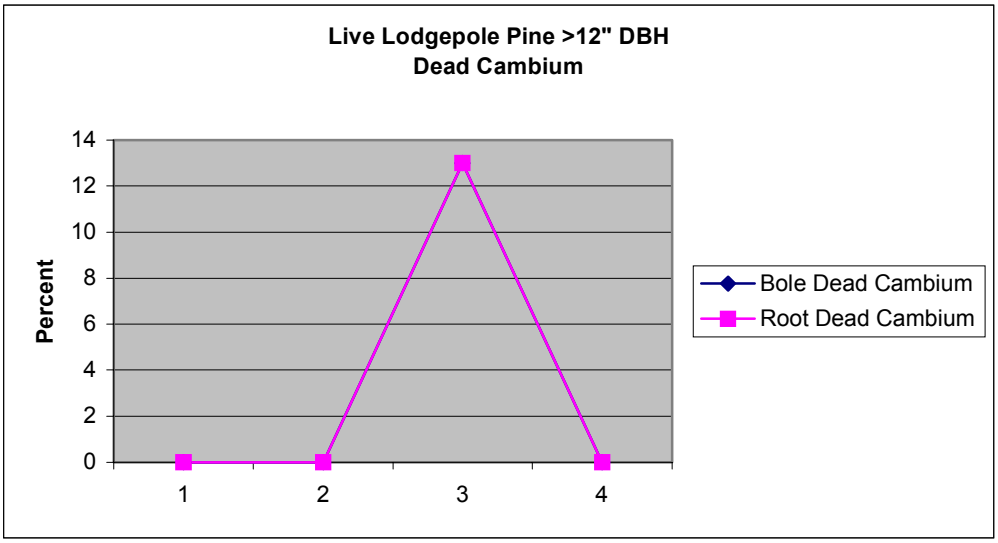

Live Lodgepole Pine <12" DBH
Crown Scorch
Percent
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
Crown Scorch


Live Lodgepole Pine >12" DBH
Crown Scorch
Percent
100
80
60
40
20
0
1
2
3
4
Crown Scorch


Live Lodgepole Pine <12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
Bole Char
Burn Through Bark


Live Lodgepole Pine >12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
Bole Char
Burn Through Bark


Live Lodgepole Pine <12" DBH
Dead Cambium
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
Bole Dead Cambium
Root Dead Cambium


Live Lodgepole Pine >12" DBH
Dead Cambium
Percent
14
12
10
8
6
4
2
0
1
2
3
4
Bole Dead Cambium
Root Dead Cambium

Western Redcedar

Mean and Median Values for Live Cedar				
	Cedar > 12" DBH		Cedar > 12" DBH	
Count	3		14	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	26.67	20.00	39.29	40.00
Bole Dead Cambium	17.00	13.00	18.00	13.00
Root Dead Cambium	31.50	31.50	19.10	13.00
Crown Scorch	0.00	0.00	1.18	0.00
Bole Char	29.67	38.00	43.29	38.00
Burn Through Bark	4.33	0.00	16.92	6.50

Mean and Median Values for Dead Cedar				
	Cedar < 12" DBH		Cedar > 12" DBH	
Count	3		9	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	0.00	0.00	13.33	10.00
Bole Dead Cambium	54.67	63.00	54.00	63.00
Root Dead Cambium	58.67	88.00	19.00	6.50
Crown Scorch	100.00	100.00	31.63	13.00
Bole Char	88.00	88.00	88.00	88.00
Burn Through Bark	38.00	38.00	39.50	38.00

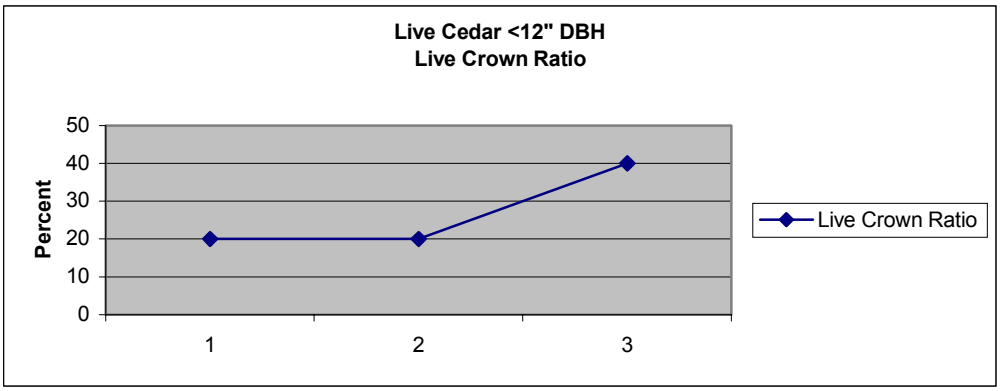
Discussion: (Sample sizes for small cedar both dead and alive are so small they will not be part of this discussion.) Live trees generally have higher LCR's, lower dead cambium, lower crown scorch, lower bole char, and lower burn through bark. LCR's in live trees ranged from 10% to 80% and 0% to 40% in dead trees. Most of the live trees had a LCR greater than 30%; only 4 out of 14 had a LCR less than 30%. Of the dead trees, only 1 had a LCR > 30% and 1 had a LCR = 30%. The remaining 7 dead trees had a LCR < 30%.

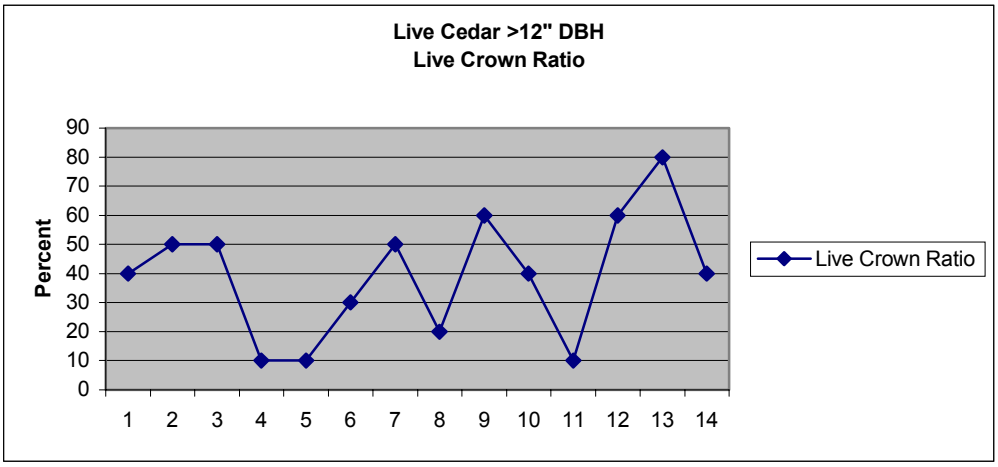
Only 1 live tree had any crown scorch, which was 13% (1-25% category). In dead trees, crown scorch ranged from 0 to 100%. However, only 2 of the dead trees had a crown scorch greater than 50 % (100% and 63%). Bole char in live trees was variable, ranging from 0 to 88%. All of the dead trees had very high bole char (88%). Burn through bark ranged from 0 to 63% in both live and dead trees; however, mean values in dead trees were higher.

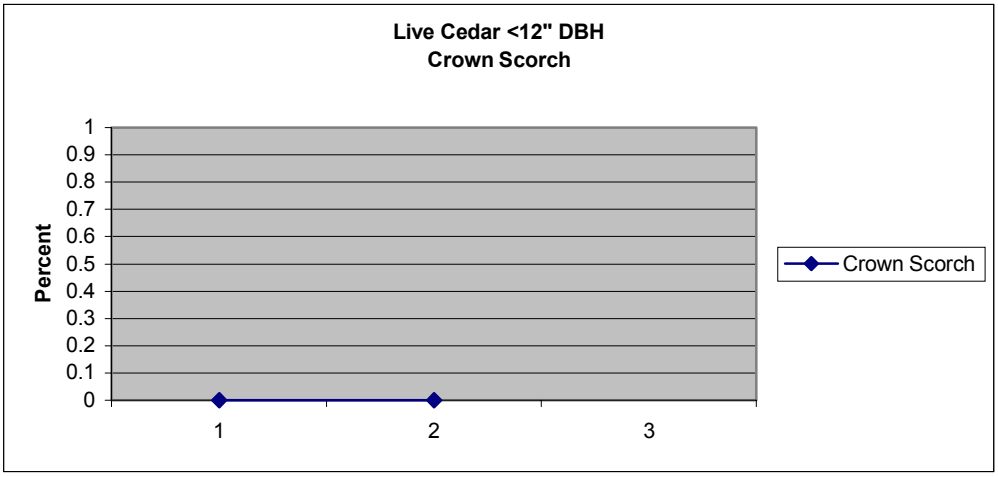
Both live and dead trees had variable dead cambium values. In live trees, both root and bole dead cambium values ranged from 0 to 63%. In dead trees, the range was 0 to 88%. Due to the variability, dead cambium (other than complete dead cambium) may not be a good predictor for mortality.

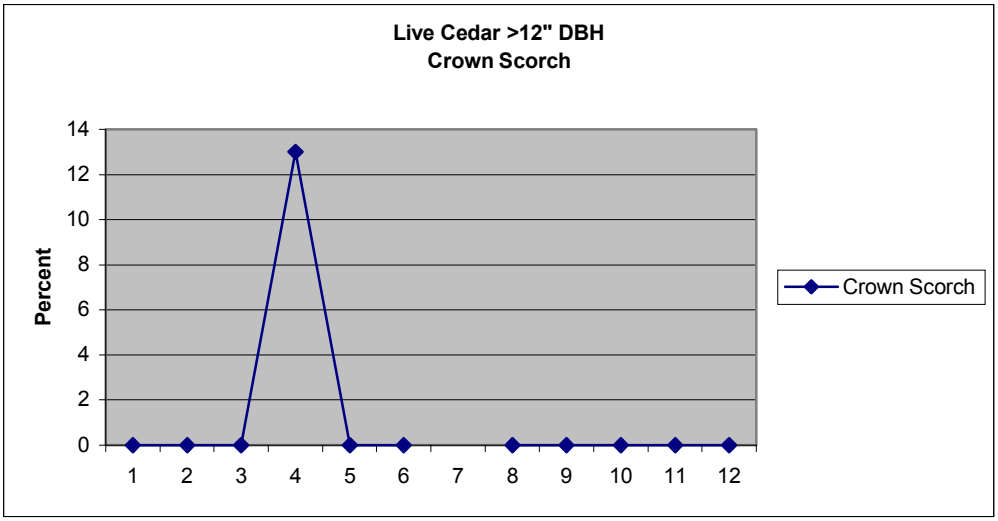
Summary Observations for Western Redcedar

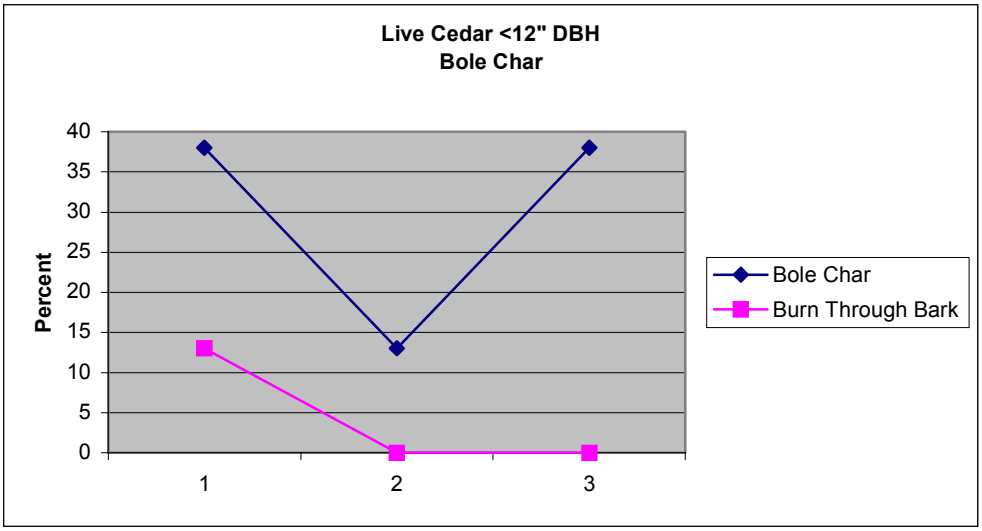
Live crown ratio may need to be greater than 30% for a tree to survive. Cedar seems to be very sensitive to crown scorch. More than 25% crown scorch on a cedar may be lethal. Cedar is also somewhat sensitive to bole char. However, if a tree has greater than 30% live crown ration and less than 25% crown scorch, it may survive complete bole char around the circumference and even some burn through bark. In general, cedar appears to survive if bole char is less than 75% and burn through bark is less than 50%. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:

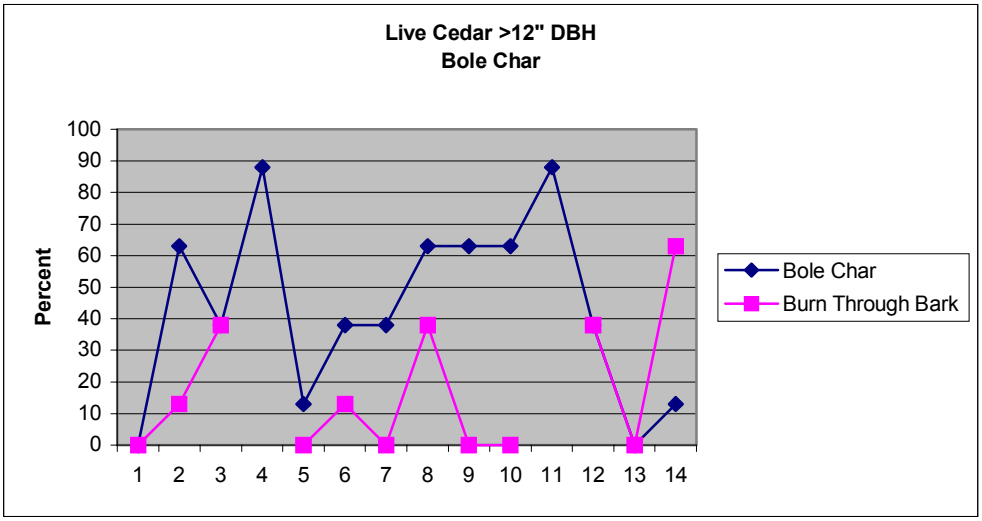

Live Cedar <12" DBH
Live Crown Ratio
Percent
50
40
30
20
10
0
1
2
3
Live Crown Ratio


Live Cedar >12" DBH
Live Crown Ratio
Percent
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Live Crown Ratio


Live Cedar <12" DBH
Crown Scorch
Percent
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
Crown Scorch


Live Cedar >12" DBH
Crown Scorch
Percent
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12
Crown Scorch


Live Cedar <12" DBH
Bole Char
Percent
40
35
30
25
20
15
10
5
0
1 2 3
Bole Char
Burn Through Bark


Live Cedar >12" DBH
Bole Char
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Bole Char
Burn Through Bark

Hemlock

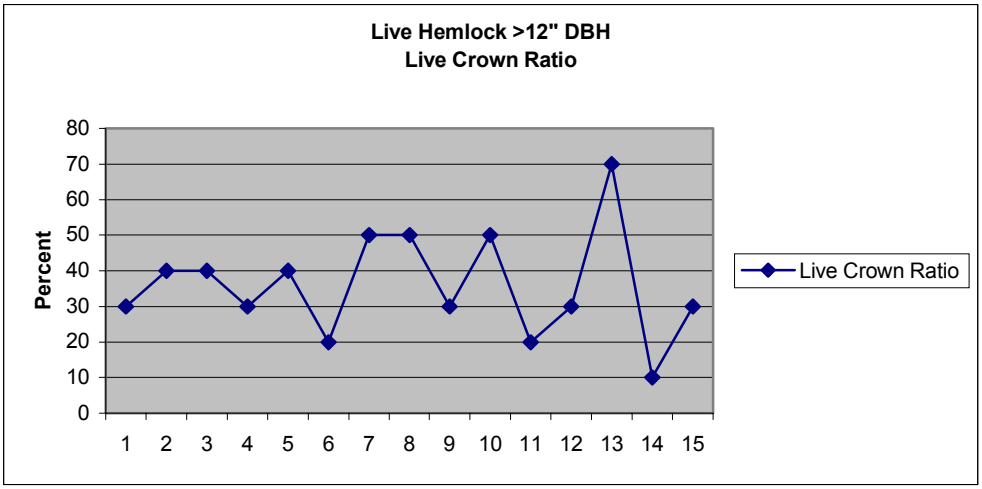
Mean and Median Values for Live Hemlock				
	Hemlock < 12" DBH		Hemlock > 12" DBH	
Count	0		15	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio			36.00	30.00
Bole Dead Cambium			12.67	0.00
Root Dead Cambium			34.55	38.00
Crown Scorch			6.36	0.00
Bole Char			49.60	38.00
Burn Through Bark			6.91	0.00

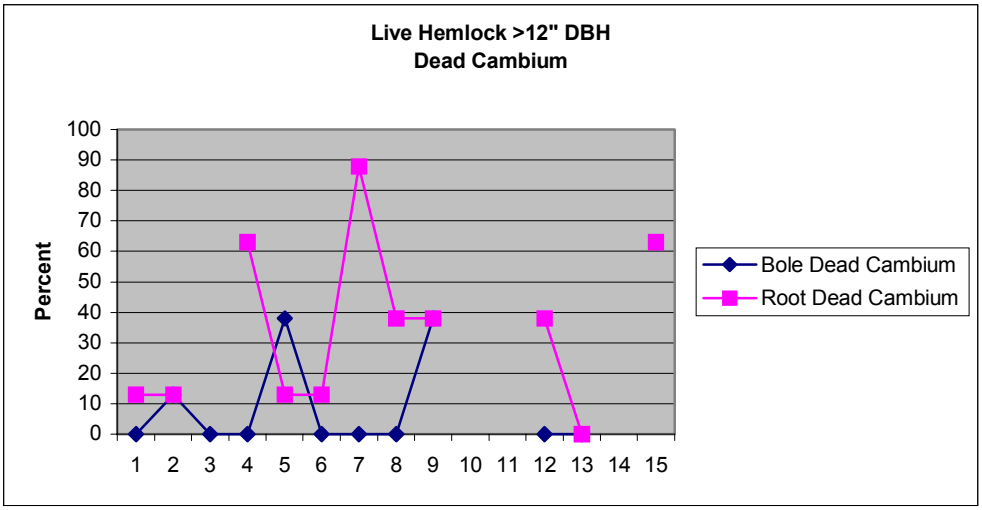
Mean and Median Values for Dead Hemlock				
	Hemlock < 12" DBH		Hemlock > 12" DBH	
Count	4		13	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	0.00	0.00	22.22	30.00
Bole Dead Cambium	88.00	88.00	37.83	25.50
Root Dead Cambium	61.33	88.00	44.20	38.00
Crown Scorch	100.00	100.00	29.73	13.00
Bole Char	88.00	88.00	71.33	88.00
Burn Through Bark	25.50	25.50	18.54	13.00

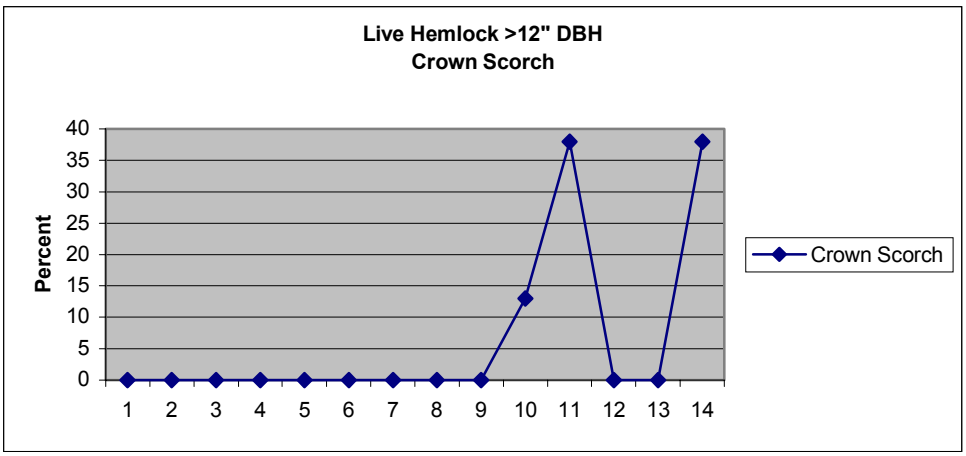
Discussion: Due to the small sample sizes of small trees, only the large trees will be discussed. LCR and root dead cambium values were similar between live and dead trees. Crown scorch was only slightly higher in dead trees. Bole dead cambium, bole char and burn through bark values were all higher in dead trees.

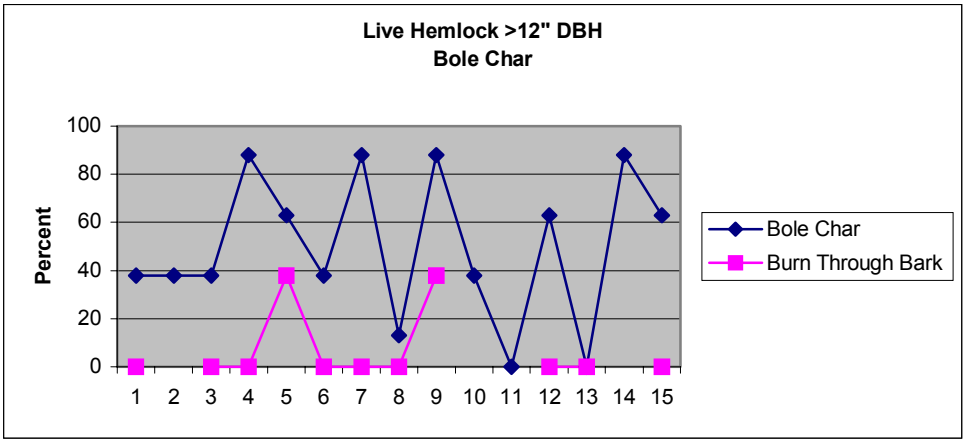
Summary Observations for Western Hemlock

It is difficult to generalize observations since each attribute shows so much variability. It appears a live crown ration can be greater than or equal to 30% with no crown scorch and no burn through bark for a hemlock to survive. It appears the tree would survive 100% bole char while meeting these conditions. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:


Live Hemlock >12" DBH
Live Crown Ratio
Percent
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Live Crown Ratio


Live Hemlock >12" DBH
Dead Cambium
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Bole Dead Cambium
Root Dead Cambium


Live Hemlock >12" DBH
Crown Scorch
Percent
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Crown Scorch



Subalpine fir

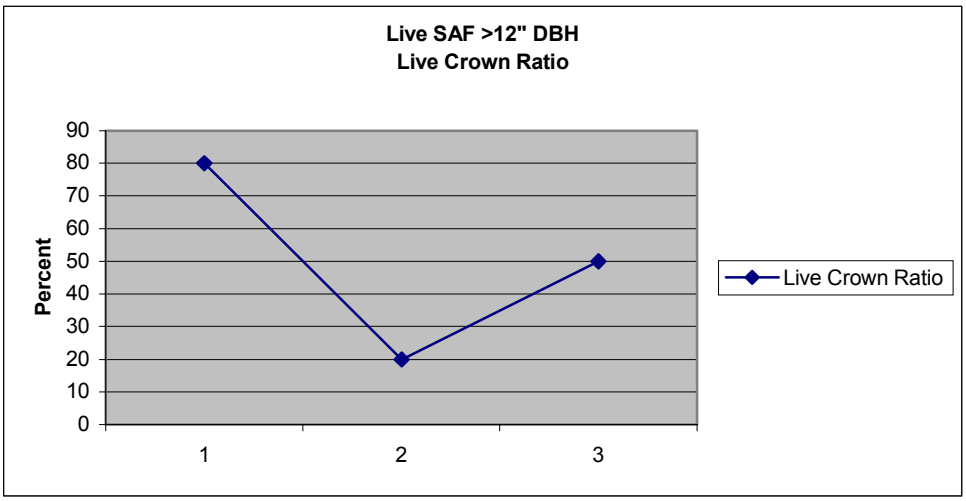
Mean and Median Values for Live Subalpine fir				
	SAF < 12" DBH		SAF > 12" DBH	
Count	0		3	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio			50.00	50.00
Bole Dead Cambium			0.00	0.00
Root Dead Cambium			0.00	0.00
Crown Scorch			8.67	13.00
Bole Char			4.33	0.00
Burn Through Bark			0.00	0.00

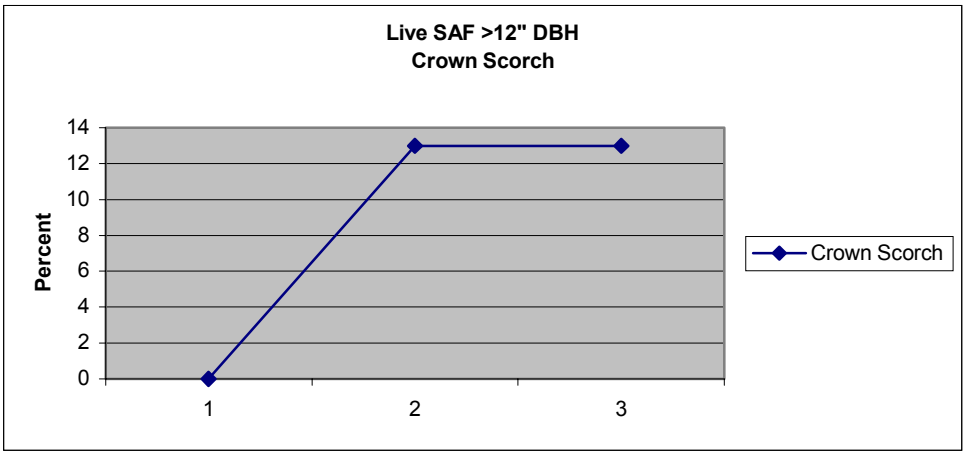
Mean and Median Values for Dead Subalpine fir				
	SAF < 12" DBH		SAF > 12" DBH	
Count	15		8	
ATTRIBUTE	Mean	Median	Mean	Median
Live Crown Ratio	2.14	0.00	8.57	0.00
Bole Dead Cambium	65.47	88.00	70.75	88.00
Root Dead Cambium	53.82	88.00	79.00	88.00
Crown Scorch	83.47	100.00	79.88	100.00
Bole Char	71.33	88.00	75.50	88.00
Burn Through Bark	43.73	38.00	55.13	63.00

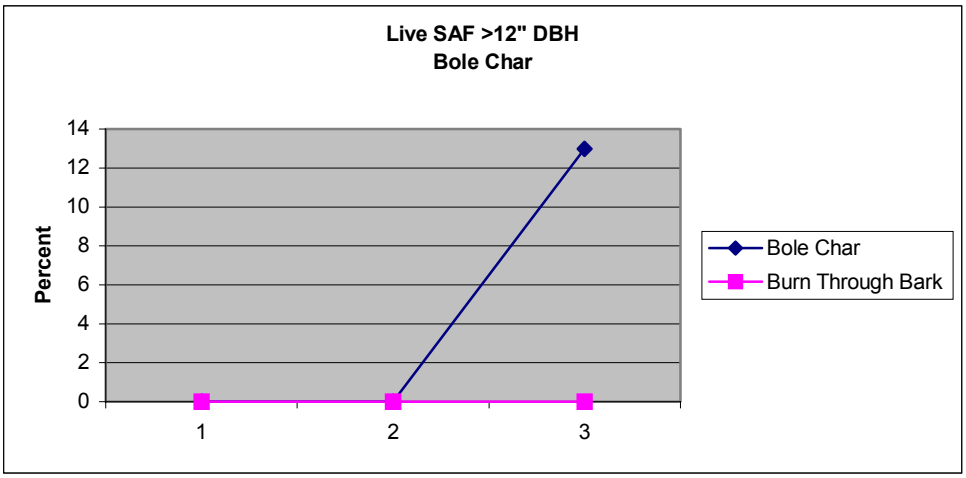
Subalpine fir

Summary Observations for Subalpine Fir

Sample size was small. Generalizations only represent the few trees sampled. Similar to lodgepole pine, most of the dead subalpine fir burned severely and subsequently died due to intense fire effects. Most of the live trees hardly burned. This indicates fire severity was high in stands of subalpine fir. The following charts summarize fire effects data collected from 1994 to 1997. The X axis on the charts indicate the tree number for each tree for each species – *not* the number of trees. The Y axis indicates percent of each attribute:


Live SAF >12" DBH
Live Crown Ratio
Percent
90
80
70
60
50
40
30
20
10
0
1
2
3
Live Crown Ratio


Live SAF >12" DBH
Crown Scorch
Percent
14
12
10
8
6
4
2
0
1
2
3
Crown Scorch


Live SAF >12" DBH
Bole Char
Percent
14
12
10
8
6
4
2
0
1
2
3
Bole Char
Burn Through Bark

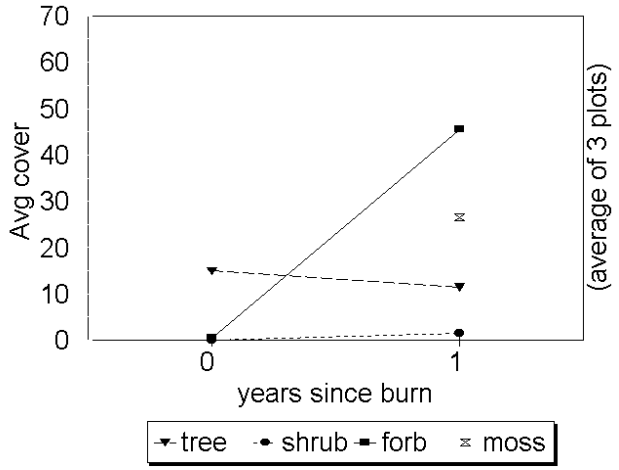
Second Year Succession Summary

The following figures illustrate the change in species composition following the second growing seasonand the current dominant vegetation for 13 plots placed in habitat group five, ELU 5-35n (VRU TE05S1)and
5-35s (VRU TE05N1). This moderately cool and moist habitat group was chosen for illustration because there are multiple plots in all three burn intensities. All 13 plots in group five are cedar/clintonia or hemlock/clintonia habitat types. The diversity of principal cover species revealed in **Tables 5, 6 and 7** are largely a result of the tree mortality and severity. Species listed are currently dominant. With time we expect principal cover species will change.

Nearly all plots in habitat group five, regardless of burn intensity, had high fireweed *(Epilobium angustifolium*) and liverwort (*Marchantia polymorpha*) coverage one year after fire. Firemoss *(Funaria hygrometrica*) is also a common colonizer post fire. We identified it in many plots, particularly those with lower burn intensities. As remonitoring continues we will be looking for changes in moss cover in addition to forbs and shrubs.

Figure 5 illustrates change in coverage by life form for those plots in tree mortality one habitat group five. Western redcedar and western hemlock were prefire principal species components. Post fire dead canopy coverage ranged from 10 - 40 percent for these species on two plots, while the third was a lodgepole seral phase of hemlock/clintonia. In all three of the plots there was no forb, shrub, grass, or moss coverage immediately following the fire.

Figure 5: Vegetation cover by lifeform for tree mortality one habitat group five.
5



Species	Pesent	>1% Cover	>15% Cover	Max Cover%
		number of plots		
Picea engelmannii	1	1	0	3
Larix occidentalis	2	2	1	20
Spirea betulifolia	2	1	1	20
Rosa woodsii	1	1	0	3

Paxistima myrsinites	1	1	0	3
Cornus stolonifera	1	1	0	3
Chimaphila umbellata	1	1	0	3
Ceanothus sanguineus	1	1	0	3
Marchantia polymorpha (liverwort)	2	1	1	30
Carex geyeri	2	1	1	20
Calamagrostis rubescens	2	2	1	20
Viola orbiculata	1	1	0	3
Geranium bicknellii	2	1	0	10
Epilobium minutum	1	1	0	3
Epilobium angustifolium	3	3	1	30
Apocynum androsaemifolium	1	1	0	3

Table 5: Principal cover species on three plots in tree mortality one habitat group five in 1995, one year after the fire. (Principal cover species are those species with >1% cover on at least one of the three plots).

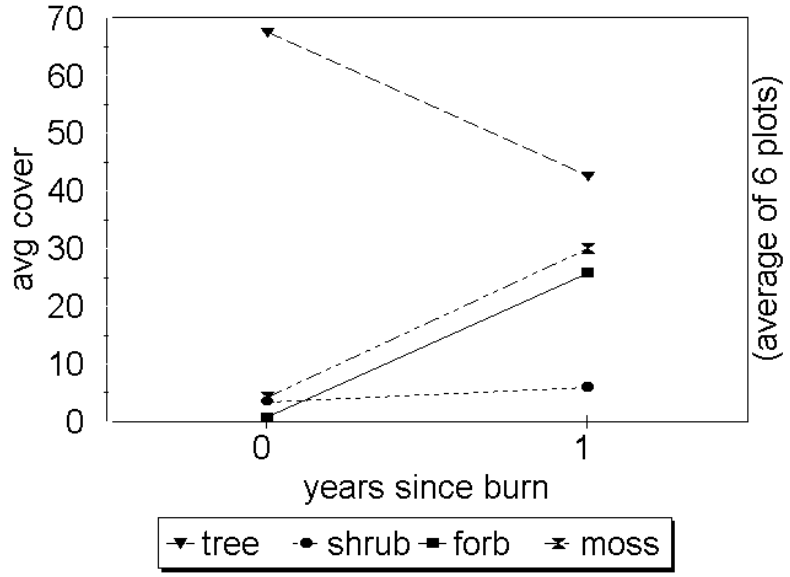


Figure 6: Vegetation cover by lifeform for Burn Intensity two habitat group five.

Species	Present	>1% cover	>15% cover	Max cover %
		number of plots		
Tsuga heterophylla	6	6	2	40
Thuja plicata	6	5	3	20
Pseudotsuga heterophylla	2	2	1	30
Picea engelmannii	1	1	0	10
Larix occidentalis	2	2	1	20
Abies lasiocarpa	2	2	0	3
Menziesia ferrugines	1	1	0	3
Linnaea borealis	2	2	0	10
Rhytidiopsis robusta (moss)	3	2	1	2
Marchantia polymorpha (liverwort)	5	5	3	20
Funaria hygrometrica (moss)	3	3	1	10
Usnea (lichen)	2	1	0	3
Bryori (lichen)	1	1	0	3
Viola orbiculata	4	1	0	10
Tiarella trifoliata	3	1	0	3
Hieracium albertinum	4	1	0	3
Epilobium angustifolium	6	6	5	30

Table 6: Principal cover species on six plots in tree mortality two habitat group five in 1995, one year after the fires. (Principal cover species are those species with >1% cover on at east one of the six plots).

All plots showed an increase in forbs and mosses the year following the fire. Greatest predominance of shrubs was on those plots with unburned remnants. Fireweed, the liverwort *Marchantia polymorpha*, and firemoss were again the most common species present.

Burn intensity three had greater cover of shrubs and forbs immediately following the fire. Forb cover increased as we had seen in other burn intensities (predominantly an increase in fireweed). The decrease in shrub cover illustrated in **Figure 6** is due to a decrease in alder (*Alnus sinuata*) cover on one of the four plots in this group. In all other cases total shrub cover had insignificant change between 1994 and 1995.

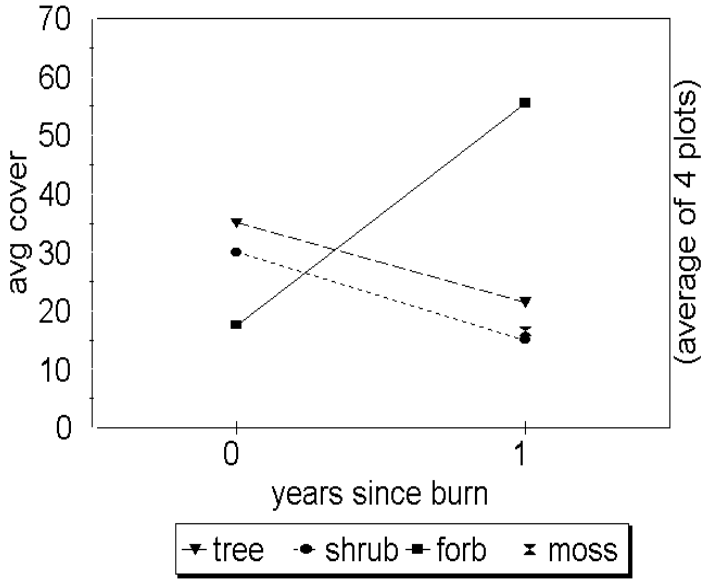


Figure 7: Vegetation cover by lifeform for tree mortality three habitat group five.

There are fewer plots in the other habitat groups that have only one year of data collected, and therefore, we did not think they were as illustrative of overall patterns or trends. Some patterns visible in habitat group five will likely be true of other habitat groups as well. These include: marked increase in forb coverage - predominantly fireweed, change in moss coverage, and greater loss of tree canopy with higher intensity burns. We expect species composition will show stronger differentiation between habitat groups as time progresses. Those patterns we have illustrated based on two years (or often one year) worth of data will become more apparent as time progresses.

Species	Present	>1% cover	>15% cover	Max cover %
		number of plots		
Tsuga heterophylla	3	2	0	10
Thuja plicata	2	2	1	20
Pseudotsuga menziesii	1	1	1	20
Pinus monticula	1	1	0	3
Pinus contorta	1	1	1	20
Picea engelmannii	3	1	0	10
Larix occidentalis	2	2	1	20

Vaccinium occidentalis	1	1	0	3
Menziesia ferruginea	1	1	0	10
Cornus canadensis	1	1	0	3
Chimaphila umbilatum	1	1	0	3
Alnus sinuata	1	1	0	3
Rhytidiopsis robusta (moss)	2	1	0	3
Polytrichum juniperinum (moss)	3	1	0	3
Marchantia polymorpha (liverwort)	4	2	1	20
Funaria hygrometrica (moss)	3	1	0	10
Carex concinnoides	1	1	0	3
Xerophyllum tenax	1	1	1	20
Hieracium albiflorum	3	2	0	10
Geranium	3	1	0	3
Epilobium angustifolium	4	4	2	20
Pteridium aquilinum	1	1	1	30
Apocynum androsaemifolium	1	1	0	3

Table 7: Principal cover species on four plots in tree mortality three habitat group five in 1995, one year after the fire. (Principal cover species are those species with >1% cover on at least one of the three plots.)

Conclusion

To accurately represent post fire tree mortality and succession for the Kootenai National Forest, it is important that plots continue to be established and monitored as new wildfires and prescribed burns occur. This is especially important for under-represented ELUs (VRUs) (Kessell and Fischer, 1981). Weather conditions for any particular year will affect soil moisture, drought stress, insect and disease patterns and burn characteristics of each individual fire. (Crane and Fisher 1986). It would be inappropriate to make strict predictions or generalizations about tree mortality and vegetation succession based solely on species' response measurements after the 1994 fires. But as information continues to be acquired, all will help describe existing and pre-existing conditions for fires in habitat groups and improve our confidence level in predicting tree mortality and succession.

We also recommend a group of interdisciplinary specialists meet together and discuss these results and apply to mortality guides, marking guides, or wherever appropriate in our assessment, analysis, and implementation processes.

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NOTE: There are eight appendices to this report which were not appropriate for Adobe Acrobat. If you need copies of these appendices, please contact the KNF Supervisors' Office.