Wildfire and Prescribed Fire Scenarios in the Columbia River Basin in Relationship to Particulate Matter and Visibility

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INTRODUCTION

Increases of prescribed fire activity appear in most of the alternatives within the Eastside and Upper Columbia River Basin Environmental Impact Statements. The CRBSUM model can be used to determine approximations of total smoke outputs associated with wildfire and prescribed fire for the alternatives, but the approximations are based on a yearly, or series of yearly totals. The problem with this system is that wildfires and prescribed fires do not occur evenly spaced throughout the year, but in a pattern more likely defined as episodes.

For wildfires, a combination of weather conditions and ignition sources (usually lightning) need to occur. When weather associated with both intense fire behavior and multiple ignitions occurs, the result can be multiple, large fires. These large fires result in the majority of all acres burned due to wildfire.

With prescribed fire, weather is a primary factor in determining if an area can be burned under conditions that will meet the objectives of this management activity. When the weather conditions become favorable for prescribed fire, the area affected is usually large resulting in episodes when large amounts of prescribed fire are occurring.

The CRBSUM model is not responsive to these episodes of fire activity, neither wildfire nor prescribed. To more realistically model the impacts of smoke production from these episodes of high activity, a different modeling scheme was developed. This scheme considered the impact of various levels of wildfire and prescribed fire activity on National Ambient Air Quality Standards for particulate matter (PM_{10} and $PM_{2.5}$) and Air Quality Related Value (AQRV) of visibility on a Aregional@ scale, across the entire project area.

With assistance from the U.S. Environmental Protection Agency (EPA) to supply weather data (MM4 data for 1990) and aid in the modeling concept, the U.S. Forest Service, Portland, OR let a contract to Earth Tech of Concord, MA, utilizing CALPUFF non-steady-state dispersion model (Scire and others 1995a). The Forest Service supplied the data for smoke emission factors and the scenario designs of acres burned by vegetation type.

METHODS

Scenario Development-Wildfire

To obtain a realistic estimate of spatial placement, size, and acres burned per day for wildfires, daily records kept at Northwest Coordination Center were used (records used were ICS-209 forms and daily situation reports). Only those wildfires 100 acres and larger were used in this analysis since the availability of the data was more consistent and available for fires of this size and these few, larger fires make up the vast majority of the wildfire acres burned. The origin of the fire was used to place the fire for modeling purposes. An eight day period was used to track how many acres burned per day for an estimate of the cumulative impacts of emissions. Eight days were selected to fit the analysis within budget. Weather data from the MM4 model for August 6 to 13 were used to model all wildfire scenarios. This time period was used because it represented a weather scenario when wildfires took place in the project area in 1990, the year of the weather data set.

Wildfire scenarios were selected from actual eight day events that took place. There were three wildfire episodes modeled B August 6-13, 1990; July 27-August 3, 1994; and August 20-27, 1994. All three of these scenarios represented an active wildfire scenario with over 150,000 acres burned in the eight days. To make an estimate of emissions for wildfire scenarios that weren't so active (i.e., fewer acres burned during an eight day period), each of the three wildfire scenarios listed above was reduced by 50 percent and 25 percent of acres burned during the eight days (Table 1). To bring the 1990 scenario below 200,000 acres and provide some variability between the data sets one fire, Pine Springs Basin, which burned 65,000 acres during this period was dropped from modeling. This fire was arbitrarily selected because it was large and only one fire needed to be dropped from the data to provide a significant departure from the other wildfire scenarios which were dropped from the data set to provide a significant departure from the other two scenarios which were both well over 200,000 acres.

Wildfires included in this analysis included all agency fires (State and Federal).

Table 1.--Modeled Acres Burned Per Day by Wildfire.

Scenarios	# of Fires	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Total
Aug 6-13, 1990	34	2,650	4,346	26,055	25,754	78,763	21,922	7,021	4,669	171,180
50% of Aug 6-13	34	925	2,173	13,028	12,877	39,382	10,961	3,511	2,335	85,192
25% of Aug 6-13	34	463	1,087	6,514	6,439	19,691	5,481	1,755	1,167	42,595

July 27-Aug 3, 1994	45	36,455	37,282	83,256	47,518	22,061	29,795	11,956	5,082	273,405
50% of July 27-Aug 3	45	18,288	18,641	41,628	23,756	11,129	14,898	5,978	2,541	136,799
25% of July 27-Aug 3	45	9,144	9,321	20,814	11,880	5,515	7,449	2,989	1,271	68,351
Aug 20-27, 1994	34	38,989	34,218	26,699	35,310	31,381	21,205	19,211	31,821	238,834
50% of Aug 20-27	34	19,495	17,109	13,350	17,655	15,691	10,603	9,606	15,911	119,420
25% of Aug 20-27	34	9,747	8,555	6,675	8,828	7,845	5,301	4,803	7,955	59,709

Scenario Development-Prescribed Fire

To make an estimate of a baseline that matched the weather that was available for modeling (the 1990 MM4 weather data set), a count of all the prescribed fires in 1990 from all federal agencies in the project area was obtained. Unfortunately, not all agencies kept the locations of the prescribed fires in latitude and longitude and in some cases locations are missing entirely. However, work done by Janice Peterson in 1989 provided an insight on what proportion of prescribed fires were done by vegetation types (Table 2). Each prescribed fire reported was coded as to the type of burn, e.g. pile, underburn, or broadcast. Since we didn't have good locations for these prescribed fires, but we did have a reasonable idea of what vegetation type they burned in, by using Peterson's 1989 data, the prescribed fires were spatially placed by randomly selecting locations by vegetation type. Each vegetation type was then allocated a number of prescribed fires by their proportion to the total

Table 2.--Percentage of Prescribed Fires by Vegetation Type.

Vegetation Type	Spring Prescribed Fire % by Vegetation Type	Fall Prescribed Fire % by Vegetation Type
Grass	13	1
Shrub	19	8
Ponderosa Pine	5	7
Mixed Conifer	62	84

Tables 3a through 3h show how many prescribed fire units, unit sizes, and total acres burned by vegetation type for Spring for each management scenario modeled.

Table 3a.--Baseline for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire units	Burn Type	Average Unit Size	Number of units	Acres
Grass	11.5	Underburn	20	9	182

Shrub	14.4	Underburn	21	11	229
Ponderosa Pine	6.8	Broadcast	22	5	108
	3.2	Pile	17	3	50
Mixed Conifer	1.6	Underburn	26	1	26
	20.4	Pile	13	25	323
	42.1	Broadcast	32	21	668
Totals	100%		21	75	1,586

Table 3b.--Baseline + 100% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	3	317
	6	Underburn	200	1	190
	4	Underburn	500	0	127
Ponderosa Pine	20	Underburn	30	21	634
	12	Underburn	100	34	381
	8	Underburn	250	1	254
Mixed Conifer	25	Pile	25	32	793
	15	Broadcast	30	16	476
Totals	100%		41	78	3,172

Table 3c.--Baseline + 200% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	5	476
	6	Underburn	200	1	285

	4	Underburn	500	0	190
Ponderosa Pine	20	Underburn	30	32	952
	12	Underburn	100	6	571
	8	Underburn	250	2	381
Mixed Conifer	25	Pile	25	48	1,190
	15	Broadcast	30	24	714
Totals	100%		41	117	4,758

Table 3d.--Baseline + 300% for Prescribed Fires Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	6	634
	6	Underburn	200	2	381
	4	Underburn	500	1	254
Ponderosa Pine	20	Underburn	30	42	1,269
	12	Underburn	100	8	761
	8	Underburn	250	2	508
Mixed Conifer	25	Pile	25	63	1,586
	15	Broadcast	30	32	952
Totals	100%		41	156	6,344

Table 3e.--Baseline + 500% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	250	5	1,190

	7.5	Underburn	500	1	714
	5	Underburn	1000	0	476
Ponderosa Pine	25	Underburn	35	68	2,379
	15	Underburn	150	10	1,429
	10	Underburn	500	2	952
Mixed Conifer	15	Pile	25	57	1,427
	10	Broadcast	30	32	952
Totals	100%		54	175	6,344

Table 3f.--Baseline + 750% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	250	7	1,685
	7.5	Underburn	500	2	1,011
	5	Underburn	1000	1	674
Ponderosa Pine	25	Underburn	35	96	3,370
	15	Underburn	150	13	2,022
	10	Underburn	500	3	1,384
Mixed Conifer	15	Pile	25	81	2,022
	10	Broadcast	30	45	1,384
Totals	100%		54	248	13,481

Table 3g.--Baseline + 1000% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	250	9	2,181
	7.5	Underburn	500	3	1,308
	5	Underburn	1000	1	872
Ponderosa Pine	25	Underburn	35	125	4,362
	15	Underburn	150	17	2,617
	10	Underburn	500	3	1,745
Mixed Conifer	15	Pile	25	105	2,617
	10	Broadcast	30	58	1,745
Totals	100%		54	321	17,446

Table 3h.--Baseline + 1500% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	500	6	3,172
	7.5	Underburn	1000	2	1,903
	5	Underburn	2000	1	1,269
Ponderosa Pine	30	Underburn	70	109	7,613
	18	Underburn	300	15	4,568
	12	Underburn	1000	3	3,045
Mixed Conifer	10	Pile	25	102	2,538
	5	Broadcast	30	42	1,269
Totals	100%		91	280	25,376

Table 4a.--Baseline for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire units	Burn Type	Average Unit Size	Number of units	Acres
Grass	0		0	0	0
Shrub	2.4	Underburn	81	18	1,464
Ponderosa Pine	0.1	Underburn	23	1	23
	11.8	Pile	19	89	1669
	0.5	Broadcast	17	4	70
Mixed Conifer	0.3	Underburn	38	2	76
	79.6	Pile	16	600	9,355
	5.3	Broadcast	31	40	1,226
Totals	100%		18	754	13,883

Table 4b.--Baseline + 100% for Prescribed Fires Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	28	2,777
	6	Underburn	200	8	1,666
	4	Underburn	500	2	1,111
Ponderosa Pine	20	Underburn	30	185	5,553
	12	Underburn	100	33	3,332
	8	Underburn	250	9	2,221
Mixed Conifer	25	Pile	25	278	6,942
	15	Broadcast	30	139	4,165
Totals	100%		41	682	27,766

Table 4c.--Baseline + 200% for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	42	4,165
	6	Underburn	200	12	2,499
	4	Underburn	500	3	1,666
Ponderosa Pine	20	Underburn	30	278	8,330
	12	Underburn	100	50	4,998
	8	Underburn	250	13	3,332
Mixed Conifer	25	Pile	25	416	10,412
	15	Broadcast	30	208	6,247
Totals	100%		41	1,023	41,649

Table 4d.--Baseline + 300% for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	10	Underburn	100	56	5,553
	6	Underburn	200	17	3,332
	4	Underburn	500	4	2,221
Ponderosa Pine	20	Underburn	30	370	11,106
	12	Underburn	100	67	6,664
	8	Underburn	250	18	4,443
Mixed Conifer	25	Pile	25	555	13,883
	15	Broadcast	30	278	8,330
Totals	100%		41	1364	55,532

Table 4e.--Baseline + 500% for Prescribed Fires, Spring Scenarios.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	200	52	10,412
	7.5	Underburn	500	12	6,247
	5	Underburn	1000	4	4,165
Ponderosa Pine	25	Underburn	35	595	20,825
	15	Underburn	150	83	12,495
	10	Underburn	500	17	8,330
Mixed Conifer	15	Pile	25	500	12,495
	10	Broadcast	30	278	8,330
Totals	100%		54	1541	83,298

Table 4f.--Baseline + 750% for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	250	74	14,751
	7.5	Underburn	500	18	8,850
	5	Underburn	1000	6	5,900
Ponderosa Pine	25	Underburn	35	843	29,501
	15	Underburn	150	118	17,701
	10	Underburn	500	24	11,801
Mixed Conifer	15	Pile	25	708	17,701
	10	Broadcast	30	393	11,801
Totals	100%		54	2183	118,006

Table 4g.--Baseline + 1000% for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	200	95	19,089
	7.5	Underburn	500	23	11,453
	5	Underburn	1000	8	7,636
Ponderosa Pine	25	Underburn	35	1091	38,178
	15	Underburn	150	153	22,907
	10	Underburn	500	31	15,271
Mixed Conifer	15	Pile	25	916	22,907
	10	Broadcast	30	509	15,271
Totals	100%		54	2825	152,713

Table 4h.--Baseline + 1500% for Prescribed Fires, Fall Scenario.

Veg Type	% of Total Rx Fire Acres	Burn Type	Average Unit Size	Number of units	Acres
Shrub	12.5	Underburn	500	56	27,766
	7.5	Underburn	1000	17	16,660
	5	Underburn	2000	6	11,106
Ponderosa Pine	30	Underburn	70	952	66,638
	18	Underburn	300	133	39,983
	12	Underburn	1000	27	26,655
Mixed Conifer	10	Pile	25	889	22,213
	5	Broadcast	30	370	11,106
Totals	100%		91	2448	222,128

Figures 1,2,and 3 show the change graphically between management scenarios for a number of prescribed fire units, and acres burned, and average unit size for each management scenario modeled.

Figure 1. Acres Burned by Prescribed Fire
Spring and Fall Scenarios

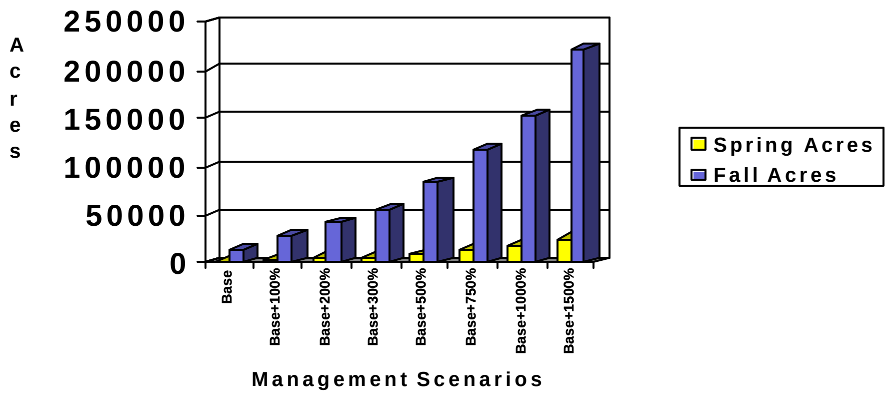


Figure 2. Number of Prescribed Fires Burned
Spring and Fall Scenarios

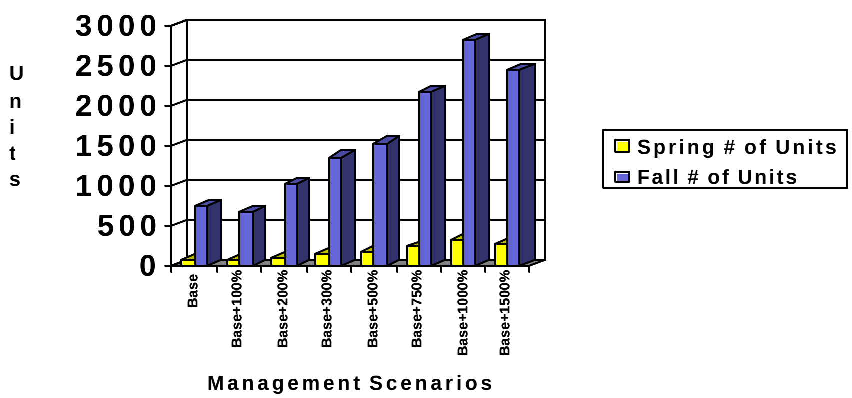
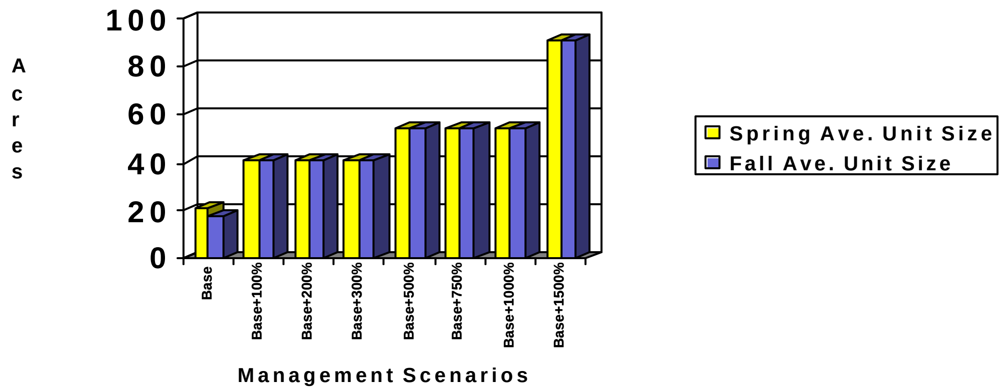


Figure 3. Average Unit Size of Prescribed Fires Burned Spring and Fall Scenarios



Smoke Production

The factors essential for determining smoke production are: (1) fuel loading, (2) area burned, (3) fuel consumption, and (4) emission factors (Peterson 1988). These are the factors that were used in developing the smoke production for each day of the prescribed fire and wildfire scenario runs. Recent research in the Pacific Northwest and the Intermountain Regions has led to improved fuel consumption models and emission characteristics; these have improved the ability to estimate smoke production and inventory emissions (Keane and others 1994, Ottmar and others 1993, Ward and Hardy 1991).

The fuel loadings (volume of downed woody material by size classes, litter, and duff) used were averages of surface fuel loading averaged by vegetation type (Huff and others 1995). The distribution of fires by vegetation type is discussed in the scenario development for wildfire and prescribed fire sections (see above).

Acres burned were obtained by the processes determined in the scenario development for wildfire and prescribed fire sections (see above).

Ottmar used the CONSUME model to estimate fuel consumption (Ottmar and others 1993). Most of the model inputs were held constant except moisture for large fuels (7.6 to 22.9 centimeter-in-diameter woody material), time of ignition (for prescribed fires), and fuel loading among the different vegetation types. For all estimates of fuel consumption derived by the model, a constant wind speed of 4.8 kilometers/hour, a slope of 20 percent, and 12 percent fuel moisture for 0.64 to 2.54 centimeter-in-diameter woody material was used.

The emission factors were assigned as a fire-average factor for prescribed fires corresponding to each set of fuels and fire behavior data. Emission factors were defined as the amount of particulate matter (in grams) less that 10 microns in size (PM_{10}) emitted per kilogram of fuel consumed. Most current smoke emissions regulation is based on PM_{10} standards. The PM_{10} emission factors for prescribed fires are values inferred from real measurements collected for all particulate matter and for particulate matter less than 2.5 microns ($PM_{2.5}$). So we also had available emission factors for $PM_{2.5}$. Forested fuels emission factors ranged from 12.5 to 10.2 grams/kilogram (Ward and Hardy 1991). Shrub fuels were assigned an emission factor of 10.6 grams/kilogram, approximating either chaparral or sagebrush. Patches

dominated by grass were assigned the emission factor of 10.0 grams/kilogram (U.S. Environmental Protection Agency 1991).
For wildfire emissions, a ratio derived by an average of 14.9 grams/kilogram, as calculated by Hardy and others (1992), divided by the prescribed fire emission factor for Douglas-fir/hemlock (the fuel type closest to that of the wildfire). This ratio was then multiplied by each emission factor to determine a wildfire emission factor, except for grass and shrub vegetation types.

To determine smoke emission production derived by the CONSUME model, the amount of fuel consumed was multiplied by the total area burned to determine total smoke emission produced. In addition, heat release rates resulting from the prescribed fire and wildfire scenarios were derived using the Emissions Production Model (EPM). This data was needed to determine the height of plume development.

ANALYSIS

The analysis of the impact of the various management scenarios for prescribed fire and scenarios for wildfire was contracted to Earth Tech, Concord, MA. The contract was to provide a regional air quality modeling study to the Columbia River Basin. The dispersion modeling to assess the air quality impacts of prescribed and wildfire was done using CALPUFF non-steady-state dispersion model (Scire and others 1995a). For an in-depth review of the analysis process refer to Scire and Tino (1996).

RESULTS

The National Ambient Air Quality Standard (NAAQS) for PM_{10} is 150 Fg/m^3 for a twenty-four hour average. There is no currently established standard for $PM_{2.5}$, but we have used an assumed threshold of 60 Fg/m^3 for a twenty-four hour average. For all the scenarios modeled, only the wildfire scenarios produced predicted concentrations above either of these threshold values. The predicted concentrations for the prescribed fire scenarios are substantially lower for several reasons: (1) the acreage burned with the prescribed fires are generally lower; (2) dispersion conditions during the spring and fall prescribed burn episodes are better, (3) there are larger numbers and a larger spatial distribution of prescribed fires. A compensating factor though is the larger buoyancy and potentially higher plume rise of the wildfire plumes compared to the smaller prescribed fire plumes. The wildfire plumes may start out higher, but they eventually mix to the ground and result in higher ground level concentrations of PM_{10} and $PM_{2.5}$.

For the regional modeling analysis, a modeling domain covering 1300 km x 1060 km was gridded into 65 x 53 20-km cells. This domain includes all of the Columbia River Basin and an appropriate buffer zone around the edges of the area of interest to allow for the effects of recirculating wind flows and boundary effects to be accounted (Scire and Tino 1996). The number of grid cells with a 24-hour average concentration above the threshold values is shown in table 5a through 5f. There were no exceedances of the threshold values for any of the prescribed burn simulations. Wildfire scenario two has the highest number of exceedances of the PM_{10} threshold value (190 for the 100% emissions case). Wildfire scenario one has the largest number of grid cells exceeding the $PM_{2.5}$ threshold (443 for the 100 percent emissions case). All of the nine wildfire scenarios had at least some exceedances of the threshold values for PM_{10} and $PM_{2.5}$.

Table 5a.--Summer Wildfire Scenario #1.
Number of Grid Cells with PM_{10} Concentrations above 150 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	0	0	0
8/7/90	0	0	0
8/8/90	2	0	0
8/9/90	5	1	1
8/10/90	25	6	3
8/11/90	49	36	15
8/12/90	28	4	0
8/13/90	1	0	0

Total	110	47	19

Table 5b.--Summer Wildfire Scenario #1.
Number of Grid Cells with $PM_{2.5}$ Concentrations above 60 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	0	0	0
8/7/90	0	0	0
8/8/90	5	2	1
8/9/90	41	4	2
8/10/90	65	24	9
8/11/90	130	75	42
8/12/90	157	100	29
8/13/90	45	2	0
Total	443	207	83

Table 5c.--Summer Wildfire Scenario #2.
Number of Grid Cells with PM_{10} Concentrations above 150 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	1	0	0
8/7/90	1	0	0
8/8/90	12	4	0
8/9/90	55	20	1
8/10/90	56	16	3
8/11/90	29	0	0
8/12/90	26	5	0
8/13/90	10	0	0
Total	190	45	4

Table 5d.--Summer Wildfire Scenario #2.
Number of Grid Cells with $PM_{2.5}$ Concentrations above 60 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	1	0	0
8/7/90	1	0	0
8/8/90	12	4	0
8/9/90	49	17	1
8/10/90	40	16	2
8/11/90	24	0	0
8/12/90	24	4	0
8/13/90	9	0	0
Total	160	41	3

Table 5e.--Summer Wildfire Scenario #3.

Number of Grid Cells with PM_{10} Concentrations above 150 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	2	1	1
8/7/90	8	2	0
8/8/90	6	1	0
8/9/90	5	1	0
8/10/90	25	5	1
8/11/90	14	1	0
8/12/90	14	0	0
8/13/90	7	2	1
Total	81	13	3

Table 5f.--Summer Wildfire Scenario #3.
Number of Grid Cells with $PM_{2.5}$ Concentrations above 60 Fg/m^3

	Scenario		
Day	100%	50%	25%
8/6/90	2	1	1
8/7/90	8	2	0
8/8/90	6	1	0
8/9/90	5	1	0
8/10/90	25	5	1
8/11/90	14	1	0
8/12/90	14	0	0
8/13/90	7	2	1
Total	81	13	3

To determine the effect of smoke production of the various scenarios upon visibility, a haziness index expressed in deciviews was used (Pitchford and Malm 1994). A change in one deciview corresponds to an approximate 10 percent change in extinction coefficient, which is considered a small, but perceptible change in visibility. When considering the impacts of smoke production upon visibility, a person should understand that if the visibility of an area is quite high a relatively small amount of smoke can be perceptible, while if the area has relatively poor visibility, a greater amount of smoke would need to be produced to create a perceptible change.

The number of grid cells where the change in haziness (or visibility) exceeded one deciview was computed for each simulation. Tables 6a through 6c contain the analyses of the prescribed burn scenarios on the regional domain. The regional grid, as noted previously, contains 3,445 grid cells (65x53) with a grid spacing of 20 km. Up to 4.5 percent, 7.2 percent, and 32 percent of the domain was predicted to have a perceptible change in visibility with the highest emission scenario on at least one of the days in early spring, late spring, and fall episodes, respectively. The results of the wildfire simulations are tabulated in Table 6e. Up to 75 percent of the grid cells have a perceptible change in visibility during the highest emission scenario.

Table 6a.--Early Spring Episode.
Number of Grid Cells with ? dv $ 1 - Regional Domain

Emission Scenario	3/27	3/28	3/29	3/30	3/31
Base	21	17	17	5	12
Base + 100%	21	33	27	16	20
Base + 200%	28	38	59	46	28
Base + 300%	46	42	64	37	44
Base + 500%	46	65	72	42	51
Base + 750%	84	84	112	79	81
Base + 1000%	149	92	147	133	125
Base + 1500%	154	132	183	197	127

Table 6b.--Late Spring Episode.
Number of Grid Cells with ? dv $ 1 -Regional Domain

Emission Scenario	5/4	5/5	5/6	5/7	5/8	5/9	5/10
Base	11	13	9	12	16	14	13
Base + 100%	20	52	22	39	40	23	0
Base + 200%	44	61	33	35	50	15	0
Base + 300%	56	52	38	68	58	15	9
Base + 500%	71	114	72	87	129	26	0
Base + 750%	108	112	80	100	107	64	7
Base + 1000%	119	138	106	145	218	88	10
Base + 1500%	142	249	158	128	210	131	136

Table 6c - Fall Episode

Number of Grid Cells with ? dv $ 1 -Regional Domain

Emission Scenario	10/14	10/15	10/16	10/17	10/18	10/19
Base	109	40	76	80	64	147
Base + 100%	162	111	158	149	121	231
Base + 200%	295	166	248	224	241	355
Base + 300%	399	320	332	334	312	476
Base + 500%	510	477	612	502	423	623
Base + 750%	707	700	886	751	609	844
Base + 1000%	782	805	1176	941	729	1038
Base + 1500%	792	836	1307	1239	680	1099

Table 6d.--Summer Episodes

Number of Grid Cells with ? dv $ 1 -Regional Domain

Episode	Emission Scenario	8/6	8/7	8/8	8/9	8/10	8/11	8/12	8/13
#1	25%	9	103	107	281	432	685	910	1061
#1	50%	19	215	242	470	737	1080	1314	1597
#1	100%	26	322	402	757	1077	1541	1900	2238
#2	25%	88	551	636	792	768	1043	1194	1443

#2	50%	104	735	1040	1434	1363	1543	1820	2089
#2	100%	130	914	1327	1859	1807	2092	2305	2570
#3	25%	82	471	767	878	808	979	1186	1468
#3	50%	109	599	976	1177	1075	1294	1723	2155
#3	100%	159	720	1121	1408	1350	1735	2383	2437

Similar analysis was also completed for a fine scale analysis area (2500 grid cells in a 50 x 50 grid with a spacing of 4 km). This area took in the northern end of the Blue Mountains in northeast Oregon and extended into southwest Idaho and into southeast Washington. This area showed similar patterns of effect as did the Regional Domain analysis, but at a lesser scale of impacts. The fine scale analysis did not give a good representation of wildfire effects for either particulate matter impacts or visibility impacts as the modeling process used did not include impacts from outside this smaller area and little fire activity occurred in this area in the days used for the wildfire analysis. The fine scale analysis at this point seems of very little value.

CONCLUSION

Fire is a part of the natural processes of the Columbia River Basin and vital in maintaining ecosystem functions in this region. The use of prescribed fire as a tool to return fire to the ecosystem is very likely to increase in most of the alternatives considered in the Environmental Impact Studies for the Columbia River Basin. This modeling effort indicates that prescribed fire could be used at intense levels of activity (such as 220,000 + acres in a six day period) with little chance of producing impacts to National Ambient Air Quality Standards for particulate matter (PM_{10}). The modeling would also indicate that perceptible changes in visibility (or haziness) can result over a large portion of the basin from the most intense use of prescribed fire.

Huff and others (1995), concluded (and we feel it pertinent to this study also) that:

> One of the most important tradeoffs to consider is the substantial increase in smoke production from wildfires versus prescribed fire. Wildfires occur when fuels are dry, fuel consumption is greater, and the fuels are consumed during the less efficient smoldering stage, which nets about twice as much PM_{10} when compared to prescribed fire. If prescribed fire can be used to restore or maintain fire-adapted ecosystems, yet reduce the potential of wildfire, PM10 production from landscape burning could be reduced considerably. In addition, prescribed fires are planned in advance, and four mitigation techniques are available to further reduce air quality impacts. Managed ignitions can be planned for situations when (1) smoke will disperse quickly, (2) smoke will avoid sensitive airsheds, (3) less fuel will be consumed more efficiently and produce less smoke, and (4) fuels have been removed or reduced, thereby eliminating the need to burn. In cases where specific objectives are to be met, some of these mitigation techniques may not be employed to the fullest extent possible.

Wildfires are not planned; therefore, there is little opportunity to employ mitigation techniques except to suppress the fire as quickly as possible. The smoke generated will be directed and concentrated according to the prevailing wind and atmospheric stability. This will often occur during the summer months when fuel moisture is low, fuel consumption and smoke production are high, and stable atmospheric conditions may persist. Wildfire does have one advantage over prescribed fire: it might not occur. Will the public be willing to accept smoke from prescribed fires spread over a period of years or find it preferable to gamble that a catastrophic wildfire, which sends out large amounts and greater concentrations of smoke in a few months, will not occur?

It is commonly noted that if we do not prescribe burn now, wildfire may soon do the job in a much less acceptable way, from both ecosystem and air quality standpoints. This premise will not be accepted by society and cannot be used as an excuse for not providing quality information about potential impacts of prescribed burning for forest health.

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TABLE CAPTIONS

Table 1. Modeled acres burned per day by wildfire.

Table 2. Percentage of prescribed fires by vegetation type.

Table 3a. Baseline for prescribed fires, spring scenarios.

Table 3b. Baseline + 100 percent for prescribed fires, spring scenarios.

Table 3c. Baseline + 200 percent for prescribed fires, spring scenarios.

Table 3d. Baseline + 300 percent for prescribed fires, spring scenarios.

Table 3e. Baseline + 500 percent for prescribed fires, spring scenarios.

Table 3f. Baseline + 750 percent for prescribed fires, spring scenarios.

Table 3g. Baseline + 1000 percent for prescribed fires, spring scenarios.

Table 3h. Baseline + 1500 percent for prescribed fires, spring scenarios.

Table 4a. Baseline for prescribed fires, fall scenarios.

Table 4b. Baseline + 100 percent for prescribed fires, fall scenarios.

Table 4c. Baseline + 200 percent for prescribed fires, fall scenarios.

Table 4d. Baseline + 300 percent for prescribed fires, fall scenarios.

Table 4e. Baseline + 500 percent for prescribed fires, fall scenarios.

Table 4f. Baseline + 750 percent for prescribed fires, fall scenarios.

Table 4g. Baseline + 1000 percent for prescribed fires, fall scenarios.

Table 4h. Baseline + 1500 percent for prescribed fires, fall scenarios.

Table 5a. Summer wildfire scenario number one, number of grid cells with PM10 concentrations above 150 µg/m3.

Table 5b. Summer wildfire scenario number one, number of grid cells with PM2.5 concentrations above 60 µg/m3.

Table 5c. Summer wildfire scenario number two, number of grid cells with PM10 concentrations above 150 µg/m3.

Table 5d. Summer wildfire scenario number two, number of grid cells with PM2.5 concentrations above 60 µg/m3.

Table 5e. Summer wildfire scenario number three, number of grid cells with PM10 concentrations above 150 µg/m3.

Table 5f. Summer wildfire scenario number three, number of grid cells with PM2.5 concentrations above 60 µg/m3.

Table 6a. Early spring episodes, number of grid cells with change in deciviews greater than or equal to one - Regional Domain.

Table 6b. Late spring episodes, number of grid cells with change in eciviews greater than or equal to one - Regional Domain.

Table 6c. Fall episodes, number of grid cells with change in deciviews greater than or equal to one - Regional Domain.

Table 6d. Summer episodes, number of grid cells with change in deciviews greater than or equal to one - Regional Domain.

FIGURE CAPTIONS

Figure 1. Acres burned by prescribed fire, spring and fall scenarios.

Figure 2. Number of prescribed fires, spring and fall scenarios.

Figure 3. Average unit size of prescribed fires, spring and fall scenarios.