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A Database for Spatial Assessments of Fire Characteristics, Fuel Profiles, and PM10 Emissions

Colin C. Hardy

Robert E. Burgan

Roger D. Ottmar

John E. Deeming

AUTHORS

COLIN C. HARDY and ROBERT E. BURGAN are research foresters, U.S.D.A. Forest Service, Intermountain Research Station, Missoula, MT.

ROGER D. OTTMAR is a research forester, , U.S.D.A. Forest Service, Pacific Northwest research Station, Seattle, WA.

JOHN E. DEEMING is a wildland fire management consultant, Bend, OR.

INTRODUCTION

Consideration of the role and relative impacts of fire is essential in landscape-scale scenario development and in the assessment of management alternatives. Fire-related considerations include wildfire hazard and fire potential as well as immediate fire effects such as biomass consumption and smoke emissions. The Fire-Fuels-Emissions Database provides 28 fire- and fuels-related attributes for the broadscale scientific assessment of the Interior Columbia River Basin (CRB). The attribute values in the database relate to three general areas: 1. fire weather, fuel moisture, and fire characteristics; 2. fuel loading and fuel consumption; and 3. PM10 smoke emissions.

For the broadscale CRB assessment, this database is linked to the CRBSUM historic or current potential vegetation data through a series of crosswalks, beginning with a direct link to the CRB Current Covertype Map (McNicoll and others 1996). There are 46 vegetation cover types in Version 1.0 of the Current Covertype Map--43 wildland vegetation types and three other types—water, barren ground, and agriculture (Menakis and others 1996).

Fire probability is not included in this database. The database provides estimates of fire, fuels, and emissions characteristics for any classification category, pixel or polygon within which a fire (wildfire or prescribed fire) may occur. The database is designed to provide estimates for any of three unique fire-weather scenarios: wet, normal, and dry. The effects from a specific fire type (prescribed versus wildfire) are determined by triggering one of two subsets of this database, with wildfires triggering the “*Dry Scenario*” data subset, and prescribed fire triggering the “*Normal Scenario*” data subset. These weather-dependent subsets are further explained later in this description.

The individual activities comprising the development process for this database are diagrammed in figure 1. There are as many as seven potential structural development stages for each of the 46 cover type categories, which, when combined with the three weather scenarios, results in a 966-cell matrix. Each cell could thereby be populated with a unique set of fire, fuels, and emissions characteristics.

METHODS

There are many interdependencies within the database. These dependencies are generally illustrated by the dashed lines in the diagram of activities shown in figure 1. The fire weather and fire characteristics (behavior) were determined first (right-side column of figure 1). These data were then used in the fuel consumption calculations (middle column of figure 1), which ultimately were used to derive estimates of smoke emissions production (left-side column of figure 1).

Each of the procedures used in the development of the Fire-Fuels-Emissions Database for the broadscale CRB assessment are discussed in the following sections. Throughout the discussion, reference will be made to individual elements of the detailed process-flow diagram shown in figure 3, where numbers for the elements relating to emissions or fuels are prefaced by the letters ‘E’ or ‘F’, respectively.

Fuel Moisture and Fire Characteristics

Two distinct sets of fuels attributes were developed for the database: 1. stylized fuel models for determining fire characteristics such as wildfire hazard; and 2. fuels attributes for calculating fuel consumption and smoke emissions. The stylized fuel models represent only biomass in the upper duff, surface litter, and vertically oriented vegetation within about six feet of the ground. They are not appropriate for estimating smoke production that results from long term fuel consumption behind the fire front. The following discussion is limited to the first set of fuels attributes (the stylized fuel models). Fuels attributes relating to fire effects such as fuel consumption and smoke emissions will be discussed in another section.

Stylized fuel models—Fuel models are a set of numbers that describe vegetation characteristics in terms that are required by mathematical fire models for computing fire potential. There are two fuel model sets that have been in use for many years -- those used in the National Fire Danger Rating System, called the "1978 NFDR" models (Deeming and others 1977), and those used in the fire behavior system (Albini 1976). Each fuel model set is specifically designed for the system in which it is used. Thus there was an initial choice to be made between using fire behavior fuel models and fire danger fuel models. The NFDR fuel model set was selected because it has two more fuel components than the fire behavior fuel model set--one more dead fuel component and one more live fuel component. These extra fuel components improve the capability to portray seasonal fire potential variation. The NFDR fuel model parameters are: 1) dead fuel loads by size class, 2) live herbaceous and shrub loads, 3) fuel bed depth, 4) fuel heat content, and other parameters not directly related to biomass.

Ten of the twenty standard 1978 NFDR fuel models were used to represent fire characteristics in the database (table 1). However, these ten do not provide enough resolution to represent all the required vegetation cover type/structure stage combinations for the CRB assessment. Therefore, we used an expanded set of the 1978 NFDR fuel models produced by both increasing and decreasing the mass (loading) assigned to each live and dead fuel class by one-third. Fuel bed depth was adjusted to maintain a constant packing ratio (pounds of fuel per cubic foot of fuel bed) and a characteristic surface area-to-volume ratio to mitigate the potential of producing an aberrant fuel model. These fuel models were labeled to indicate low, medium and high loadings of the original NFDR fuel models. The two-letter model designations are of the form ***model-load***; that is, the model letter precedes the loading level, as in "CL”, “CM”, and “CH" where the letter "C" defines the NFDR fuel model, and "L", "M", and "H" represent 1/3 less than the original load (low), the original load (medium), and 1/3 more than original load (high), respectively. The resulting 25 “scaled-NFDR” fuel models for the CRB are described in table 2. They were then linked to each vegetation cover type/structural stage combination on the basis of the fuel model descriptions and expert knowledge.

Fire-weather scenarios—It is assumed that climatology and site conditions over the last several hundred years have defined the geographic location of the various vegetation types within the CRB and that individual weather stations can represent the vegetation types within which they occur. Weather data from National Fire Danger Rating System (NFDRS) weather stations were used because these data provide measures of all the inputs required by the NFDRS processor (Deeming and others 1977). Weather data sets from 17 NFDRS fire weather stations identified as being among the best agency-operated weather stations in California, Oregon, Idaho, and Washington provided the base data for the CRB analysis area (figure 2). The period July 1 through August 31 for the years 1978 through 1992 defined the temporal scope of the analysis. The weather data were analyzed with respect to fire potential using a predicted NFDRS index called the energy release component (ERC) which provides a measure of energy release -- BTUs released per unit area burned within the fire front. The analysis was based on ERC because it is largely a function of fuel load and moisture, and is not influenced by wind speed (wind speed estimates would be rather meaningless for the large scale analysis). It was determined that fuel moistures for the wet, normal, and dry fire-weather scenarios would be derived from median weather data for which the percentile ERCs were 10, 50, and 90, respectively. For those models that have a small ERC range (AL, AM, AH), another NFDRS index (burning index, or BI) was used to provide a larger range from which to select fuel moistures.

Processing of the weather data to derive fire- and fuels-related attributes was done using the programs *pcFIRDAT* and *pcSEASON* (California Department of Forestry and Fire Protection 1994), which are adaptations of the original *FIREFAMILY* set of historical fire danger analysis programs (Main and others 1990). The program *pcFIRDAT* was used to calculate fuel moistures and NFDRS indices and components (Deeming and others 1977). The resulting output file was processed using *pcSEASON* to delineate the median values of the lowest 20 percent, middle 20 percent, and highest 20 percent daily ERC. These median values were also the 10th, 50th, and 90th ERC percentiles.

National fire danger rating weather stations are always located in the open because they are meant to monitor "near worst case" conditions. It was therefore necessary to adjust the fuel moistures for the effect of shading by forest canopies. No shading adjustment was made for shrub or grass vegetation types. A fixed increase of 4.0 percent was made for all the dead fuel moisture classes to adjust the moistures for shaded conditions. Also, the 20 foot wind speeds were adjusted to account for differences between CRB cover types and the NFDRS fuel model-dependent wind reduction factors. The adjusted fuel moistures and associated NFDRS indices (heat per unit area, fireline intensity, flame lengths) occurring at the 10th, 50th, and 90th percentile ERCs for each CRB vegetation cover type/structural stage combination were then used to populate the database for the wet, normal, and dry fire-weather scenarios (figure 3, elements F2, F3).

Fuel Attributes for Fuel Consumption

Fuel loading—Seven attributes were used to describe the fuel loading characteristics of each vegetation cover type/structural stage combination. The loading attribute data were parsed from an existing matrix of predetermined fuel condition classes (FCC) developed for a Fire Emissions Tradeoff Model (FETM) used in another study (Schaaf 1996). For that study, a team of fuel specialists, fire managers, and research personnel developed the fuel profiles assigned to each FCC. The resulting 188 FCCs represent nine general vegetation types, four age classes, three levels of fuel loading, and nine harvest and/or fuel management activities. Each FCC has nine fuel loading components--two live, six dead and downed woody, and duff. Since these included all of the attributes needed for the CRB assessment, it was thereby possible to link appropriate FCC classes to each broadscale CRB vegetation cover type/structural stage combination. These loading estimates were only used to predict first-order fire effects such as fuel consumption and emissions production, and the values are not necessarily comparable to the stylized NFDR fuel loadings.

Fuel consumption—The fuel loading attributes and respective fuel moisture values for each weather scenario (figure 3, elements F1, F2, F3) were used with the First Order Fire Effects Model (FOFEM) to calculate fuel consumption, by fuel component, for each unique fuels/weather combination (figure 3, element F4).[1] Table 3 shows how the consumption values for the eight FOFEM fuels components were consolidated into five components for the CRB assessment (figure 3, element F5). For each of the three weather scenarios, each vegetation cover type/structural stage combination in the database was then attributed with the respective set of fuel consumption values.

PM10 EMISSIONS

Aggregating the data by emissions group—Many of the vegetation cover type/structural stage combinations shared common emissions characteristics. The NFDR fuel model assignments were used to key the database into three groupings of the original 10 base NFDR fuel models from table 1 (figure 3, element E1). The three groupings are referenced by their dominant vegetation: “conifers” (NFDR models G,H,R,U); “shrubs”

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[1] Keane, R.E.; Reinhardt, E.D.; Brown, J.K. FOFEM User’s Guide. [manuscript in preparation]. U.S.D.A. Forest Service, Intermountain Research Station, Missoula, Montana.

(NFDR models F,T); and “grasses” (NFDR models A,C,L,S).

Emission factors—Emission factors for smoke from wildland fires are strongly related to the fire conditions associated with the combustion of a given fuel component. Combustion efficiency (ç) is a term used to describe the fire condition relative to its emission source strength. Combustion efficiency is the proportion of carbonaceous emissions from combustion that are converted into CO_2. For example, perfect combustion would produce only CO_2 and water, and ç=1.00. Anything less than perfect combustion creates other products, such as CO, CH_4, and particulate matter. Ward and Hardy (1991) have synthesized various emissions data into linear functions used to predict emission factors from ç. While a function using ç to predict PM10 (particulate matter smaller then 10 micrometers in mean mass-diameter) has not been directly derived from observations, one can be estimated from known size-class distributions of particulate matter (Ward and others 1993). A linear function derived for PM10 is shown in figure 4. Rather than estimating an average ç for each fuel class, a separate ç was estimated for each of two phases of combustion (flaming and smoldering) for each fuel class, within each of the three emissions groups (table 4). A weighted-average ç was then computed for each fuel class using the proportions of consumption expected to occur in each of the combustion phases. Finally, the weighted-average ç for each of the five fuel classes was used in the linear function (figure 4) to derive specific PM10 emission factors for the wet, normal, and dry fire-weather scenarios (table 4) (figure 3, elements E2, E3, E4).

Total PM10 Emissions Per Unit Area

The total mass of PM10 produced (per unit area) from each fuel component is the product of the mass of the fuel component consumed and the weighted-average emission factor for the respective fuel component. The total mass of PM10 produced (per unit area) from all fuel within the vegetation type/structural stage combination is the sum of the PM10 emissions from the five fuel components. The example shown in table 5 lists the weighted-average emission factors for each fuel component (PM10 EF-bar) and their “grand weighted-average” (24.0 lb/ton) for the “conifer” emissions group. The grand weighted-average value is the mean of the individual PM10 emission factors for each fuel component, weighted by the total fuel consumed within each fuel component. Also given in the example shown in table 5 are the total PM10 emissions for each fuel component (Total PM10) and their sum (419.7 lb/acre).

RESULTS AND DISCUSSION

The data dictionary for The Fire-Fuels-Emissions Database is presented in table 6. The database, presented in its entirety in Appendix 1, contains the complete set of attributes relating to fire characteristics, fuel components, and PM10 emissions for each of the three weather scenarios (dry, normal, and wet). The assumption used for the CRB assessment was that the data for the dry scenario represented wildfire conditions and the data for the normal scenario were appropriate for prescribed fire conditions. The data from the wet scenario would not apply to most fire events, since the fuel moisture values are typically too wet to sustain combustion.

Spatial Analysis of Emissions Production

The total PM10 values in the Fire-Fuels-Emissions Database represent the total mass of PM10 emissions produced per unit area, expressed in units of pounds of PM10 per acre burned (lb/acre). In a spatial analysis, the area burned (in this example expressed in acres) within each respective vegetation cover type/structural stage combination is multiplied by the total PM10 values (lb/acre) to calculate total PM10 emissions from a fire within the vegetation cover type/structural stage combination. The sum of PM10 emissions produced from all the vegetation cover type/structural stage combinations burned is the total PM10 emission from the fire event(s).

Other Applications For These Procedures

The methodology as well as much of the current data prepared for the broadscale CRB assessment are transportable to many other spatial landscape assessments. Similar analysis protocols were recently used in an analysis of emissions tradeoffs between prescribed fires and wildfires (Shaaf 1996). Work currently underway for the Grand Canyon Visibility Transport Commission is utilizing many components of these data as well as the procedures used to derive them.[2] The methodology used here closely follows the procedures used in regional and national emissions inventory efforts (Ward and others 1993). Current model simulations of the effects of fire management alternatives on landscape processes and the concomitant implications for global change rely extensively on both the data and procedures presented here.[3] The Western States Air Resource Council (WESTAR) is currently developing modeling capabilities for assessing regional transport and impacts of smoke from prescribed burning. The WESTAR effort will utilize some of these database components and procedures.[4] The fuel condition classes, emission factors, and fuel consumption values are timeless and can be applied in a broad spectrum of landscape analysis activities.

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2 Personal communication with Pete Lahm, Air Resource Program Manager, U.S.D.A. Forest Service, Phoenix, AZ.

3 Keane and others [manuscript in preparation]. Simulating the effects of fire management on gasous emissions from future landscapes of Glacier National Park, Montana, U.S.A. U.S.D.A. Forest Service, Intermountain Research Station, Missoula, Montana.

4 Personal communication with WESTAR staff, Portland, OR.,

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Deeming, J.E.; Burgan, R.E.; Cohen, J.D. 1977. The national fire danger rating system--1978. Gen. Tech. Rep. INT-39. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 63 p.

Main, W.A.; Paananen, D.M.; Burgan, R.E. 1990. FIREFAMILY 1988. Gen. Tech. Rep. NC-138. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experimental Station. 35 p.

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Menakis, J.P; Long, D.; Keane, R.E.; Hann, W.J. 1996. Methods used in the development of broadscale layers and characterization files. In: Keane, R.E. and others, eds. Broadscale landscape dynamics of the Interior Columbia Basin. Gen. Tech. Rep. PNW-xxxPortland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: Chapter 5.

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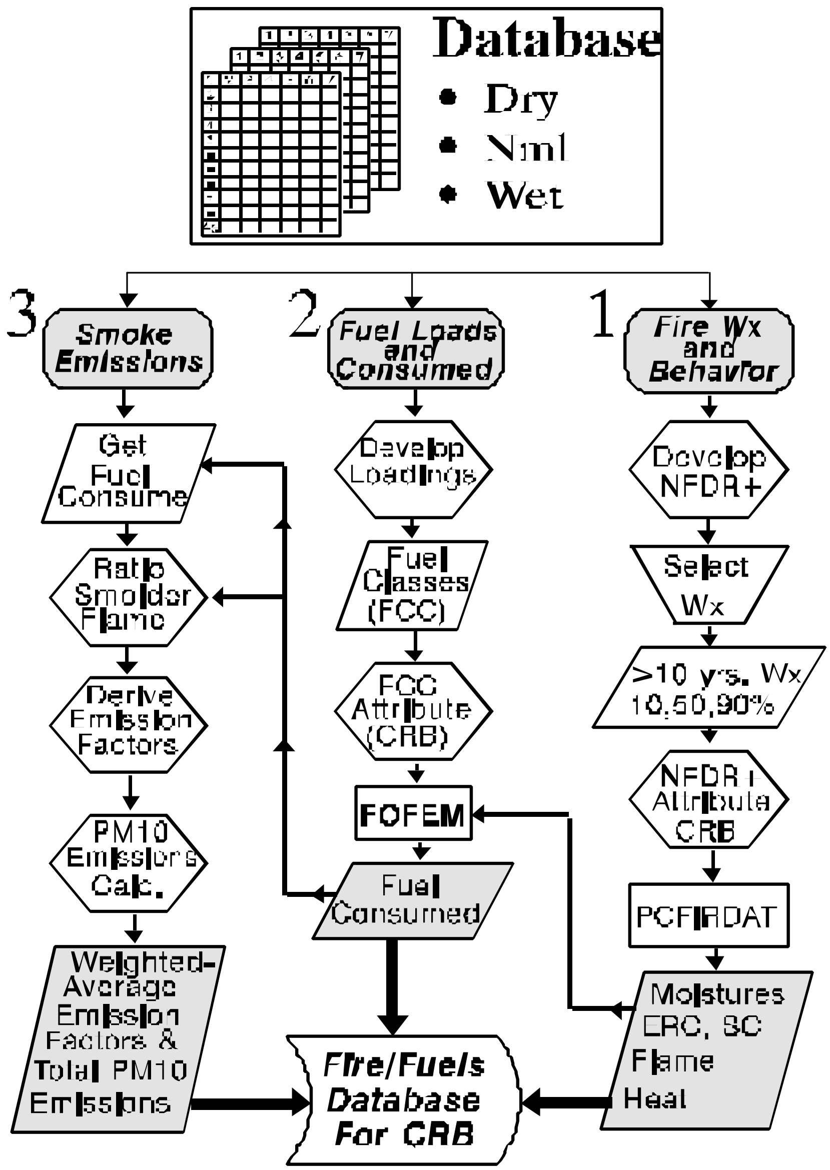
Ward, D.E.; Hardy, C.C. 1991. Smoke emissions from wildland fires. Environment International. 17:117-134.

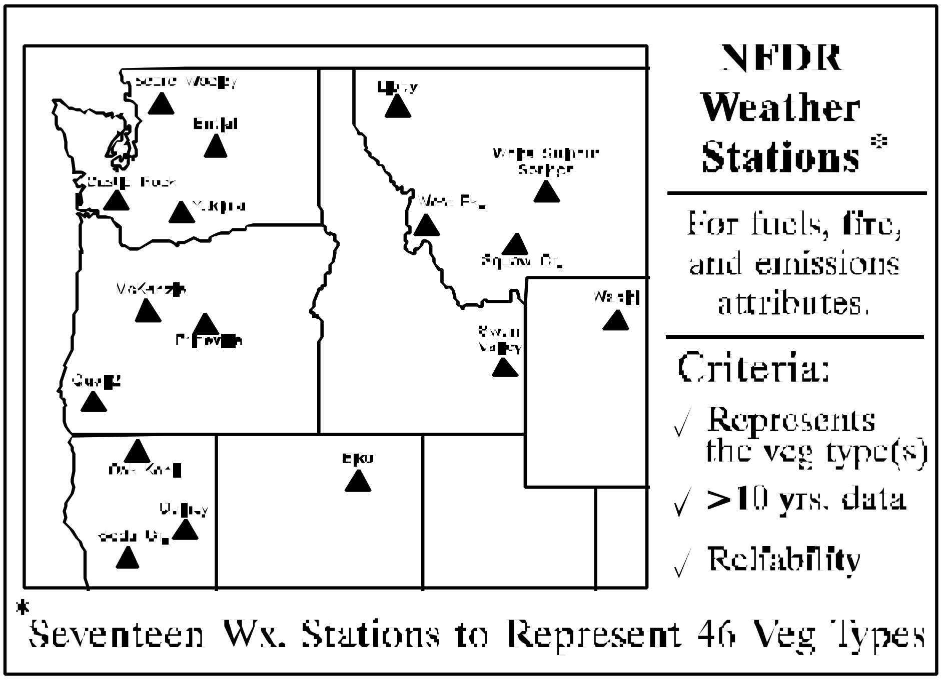
Ward, D.E.; Peterson, J.L.; Hao, W. 1993. An inventory of particulate matter and air toxic emissions from prescribed fire in the USA for 1989. In: proceedings of the 86th annual meeting and exhibition of the Air and Waste Management Association; 1993 June 13-18; Denver, CO. Pittsburgh, PA. Air and Waste Management Association; paper #93-MP-6.04. [not paged].

TABLE CAPTIONS

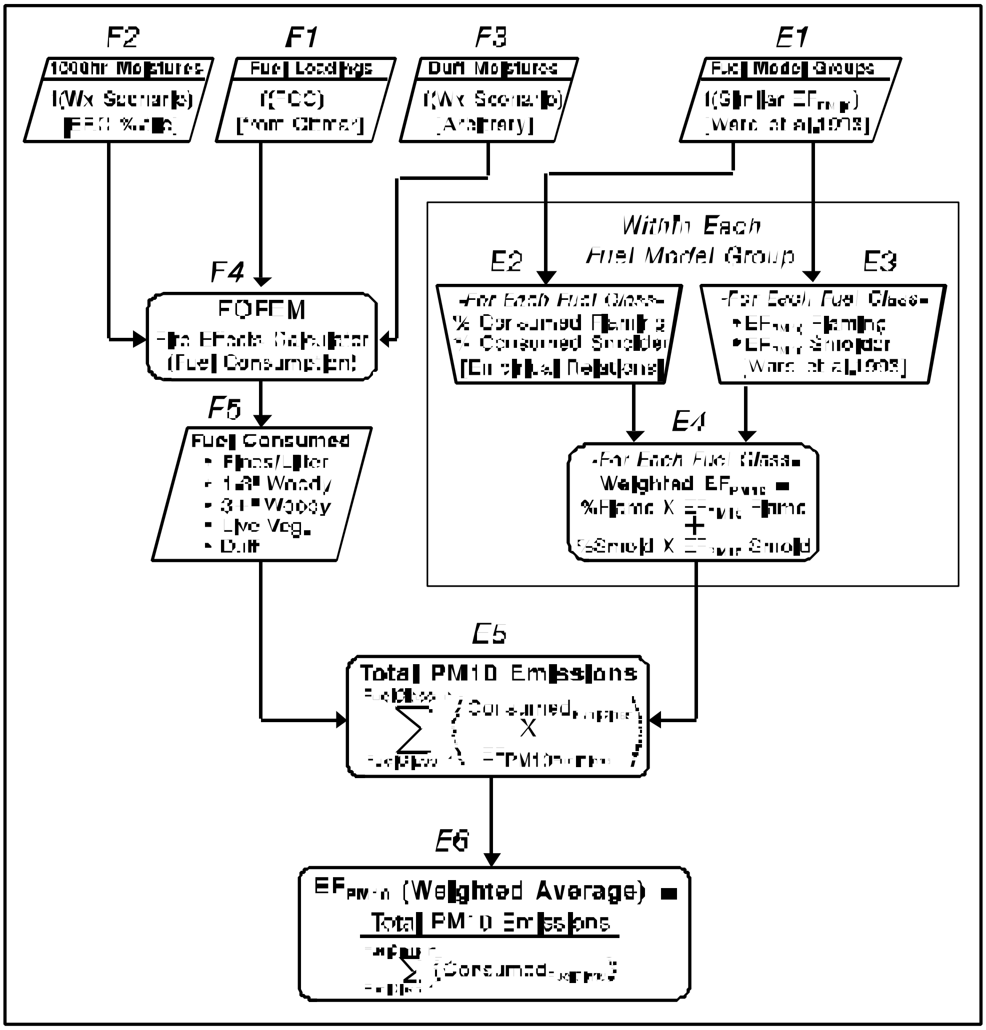
FIGURE CAPTIONS


Database
Dry
Nml
Wet
3
Smoke Emissions
2
Fuel Loads and Consumed
1
Fire Wx and Behavior
Get Fuel Consume
Develop Loadings
Develop NFDR+
Ratio Smolder Flame
Fuel Classes (FCC)
Select Wx
>10 yrs. Wx 10,50,90%
Derive Emission Factors
FCC Attribute (CRB)
NFDR+ Attribute CRB
PM10 Emissions Calc.
FOFEM
Fuel Consumed
PCFIRDAT
Weighted-Average Emission Factors & Total PM10 Emissions
Moistures ERC, SC Flame Heat
Fire/Fuels Database For CRB

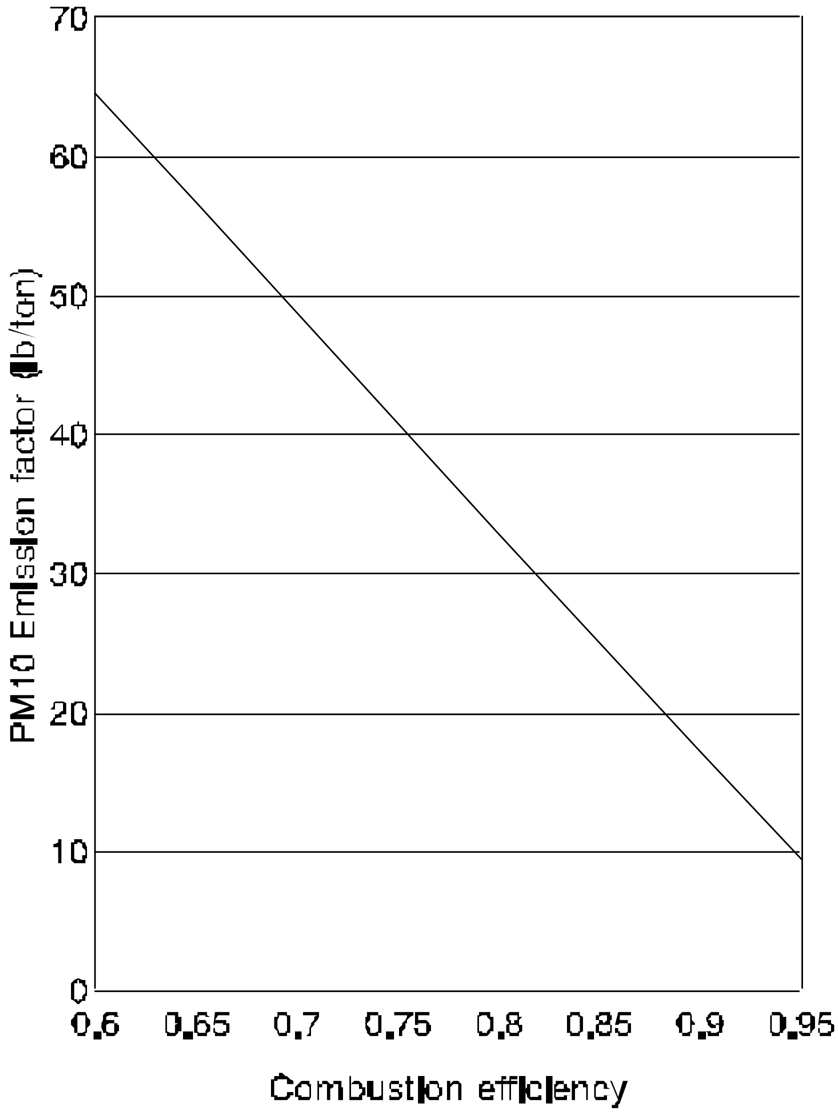
[figure 1]


NFDR
Weather
Stations *
For fuels, fire, and emissions attributes.
Criteria:
√ Represents the veg type(s)
√ >10 yrs. data
√ Reliability
Squaw Cr.
Swan Valley
Oak Knoll
Elko
*Seventeen Wx. Stations to Represent 46 Veg Types

[figure 2]



[figure 3]


70
60
50
40
30
20
10
0
PM10 Emission factor (lb/ton)
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
Combustion efficiency

[figure 4]

NFDRS fuel model	Fuel model description
A	Western annual grasses and forbs
C	Mature, dense brushfields less than six feet tall
F	Mature, closed chamise and oakbrush
G	Dense conifer stands with heavy litter and woody debris
H	Short-needled, healthy conifers
L	Perennial western grasslands
R	Hardwood areas after leafout
S	Alpine tundra; lichens and mosses
T	Sagebrush-grass types
U	Western long-needled pines; closed canopy

CRB fuel model	Fuel mass (loading) by NFDRS fuel component										Fuel depth	Packing ratio	Relative packing ratio	Surface area/ volume
	1 hr	10 hr	100 hr	1000 hr	Wood	Herbs	1 hr + herbs	Total live	Total 0-3”	Grand total				
	Tons of fuel per acre										(feet)			(ft^2/ft^3)
AL	0.13	0.00	0.00	0.00	0.00	0.20	0.33	0.20	0.13	0.33	0.53	0.0007	0.151	3000
AM	0.20	0.00	0.00	0.00	0.00	0.30	0.50	0.30	0.20	0.50	0.80	0.0007	0.151	3000
AH	0.27	0.00	0.00	0.00	0.00	0.40	0.67	0.40	0.27	0.67	1.07	0.0007	0.151	3000
CL	0.27	0.67	0.00	0.00	0.33	0.53	0.80	0.87	0.93	1.80	0.50	0.0034	0.544	2114
CM	0.40	1.00	0.00	0.00	0.50	0.80	1.20	1.30	1.40	2.70	0.75	0.0034	0.544	2114
CH	0.53	1.33	0.00	0.00	0.67	1.07	1.60	1.73	1.87	3.60	1.00	0.0034	0.544	2114
FL	1.67	1.33	1.00	0.00	6.00	0.00	1.67	6.00	4.00	10.00	3.00	0.0027	0.261	1155
FM	2.50	2.00	1.50	0.00	9.00	0.00	2.50	9.00	6.00	15.00	4.50	0.0027	0.261	1155
FH	3.33	2.67	2.00	0.00	12.00	0.00	3.33	12.00	8.00	20.00	6.00	0.0027	0.261	1155
GM	2.50	2.00	5.00	12.00	0.50	0.50	3.00	1.00	9.50	22.50	1.00	0.0172	2.434	1848
GH	3.33	2.67	6.67	16.00	0.67	0.67	4.00	1.33	12.67	30.00	1.33	0.0172	2.434	1848
HL	1.00	0.67	1.33	1.33	0.33	0.33	1.33	0.67	3.00	5.00	0.20	0.0287	4.074	1858
HM	1.50	1.00	2.00	2.00	0.50	0.50	2.00	1.00	4.50	7.50	0.30	0.0287	4.074	1858
HH	2.00	1.33	2.67	2.67	0.67	0.67	2.67	1.33	6.00	10.00	0.40	0.0287	4.074	1858
LL	0.17	0.00	0.00	0.00	0.00	0.33	0.50	0.33	0.17	0.50	0.67	0.0007	0.108	2000
LM	0.25	0.00	0.00	0.00	0.00	0.50	0.75	0.50	0.25	0.75	1.00	0.0007	0.108	2000
LH	0.33	0.00	0.00	0.00	0.00	0.67	1.00	0.67	0.33	1.00	1.33	0.0007	0.108	2000
RM	0.50	0.50	0.50	0.00	0.50	0.50	1.00	1.00	1.50	2.50	0.25	0.0115	1.484	1657
SL	0.33	0.33	0.33	0.33	0.33	0.33	0.67	0.67	1.00	2.00	0.27	0.0072	0.795	1372
SM	0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.50	3.00	0.40	0.0072	0.795	1372
TL	0.67	0.33	0.00	0.00	1.67	0.33	1.00	2.00	1.00	3.00	0.83	0.0029	0.415	1900
TM	1.00	0.50	0.00	0.00	2.50	0.50	1.50	3.00	1.50	4.50	1.25	0.0029	0.415	1900
TH	1.33	0.67	0.00	0.00	3.33	0.67	2.00	4.00	2.00	6.00	1.67	0.0029	0.415	1900
UL	1.00	1.00	0.67	0.00	0.33	0.33	1.33	0.67	2.67	3.33	0.33	0.0158	2.077	1694
UM	1.50	1.50	1.00	0.00	0.50	0.50	2.00	1.00	4.00	5.00	0.50	0.0158	2.077	1694

Fuel profile component	Model application		
	NFDRS	FOFEM	CRB
Litter		Litter	Fine
1-hr. (0-1/4")	X	Fine	Fine
10-hr. (1/4-1")	X	Fine	Fine
100-hr. (1-3")	X	Small	Small
1000-hr. (3-9")	X	Large	Large
Woody (>9")	X	Large	Large
Duff		Duff	Duff
Herbs	X	Herbs	Live
Shrubs		Shrubs	Live
Regen.		Regen.	Live

				Fire-weather scenario								
		Combustion		Wet			Normal			Dry		
Emission	CRB	efficiency		% consumed		[redacted]	% consumed		[redacted]	% consumed		[redacted]
group	fuels	Flame	Smold	Flame	Smold	[redacted]	Flame	Smold	[redacted]	Flame	Smold	[redacted]
Grasses	Fines	0.95	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Small	0.92	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Large	0.92	0.76	0.5	0.5	[redacted]	0.7	0.3	[redacted]	0.8	0.2	[redacted]
	Live	0.85	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Duff	0.90	0.76	0.5	0.5	[redacted]	0.4	0.6	[redacted]	0.4	0.6	[redacted]
Shrubs	Fines	0.95	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Small	0.92	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Large	0.92	0.76	0.5	0.5	[redacted]	0.7	0.3	[redacted]	0.8	0.2	[redacted]
	Live	0.91	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Duff	0.90	0.76	0.5	0.5	[redacted]	0.4	0.6	[redacted]	0.4	0.6	[redacted]
Conifers	Fines	0.95	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Small	0.92	0.76	0.9	0.1	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Large	0.92	0.76	0.5	0.5	[redacted]	0.7	0.3	[redacted]	0.8	0.2	[redacted]
	Live	0.85	0.76	1.0	0.0	[redacted]	1.0	0.0	[redacted]	1.0	0.0	[redacted]
	Duff	0.90	0.76	0.5	0.5	[redacted]	0.4	0.6	[redacted]	0.4	0.6	[redacted]

Fuelbed component	Total fuel consumed	Fraction consumed		Consumed		Combustion Effcy.		PM10 -bar	Total PM10
		Flame	Smold	Flame	Smold	Flame	Smold		
				- -(Tons/acre) -				(lb/ton)	(lb/acre)
Fine Woody	1.90	1.0	0.0	1.90	0.00	0.95	0.76	9.3	17.7
1-3" Woody	0.70	1.0	0.0	0.70	0.00	0.92	0.76	14.0	9.8
3"+ Woody	6.50	0.7	0.3	4.55	1.95	0.92	0.76	21.6	140.4
Live Veg	0.70	1.0	0.0	0.70	0.00	0.85	0.76	25.1	17.5
Duff/Litter	7.70	0.4	0.6	3.08	4.62	0.90	0.76	30.4	234.3
Grand-average PM10 emission factor (lb/ton) and Total PM10 produced (lb/acre) > >								24.0	419.7

Data Name	Columns	Description
Data ID#	1-5	Unique identifier.
CRB ID#	9-10	Current VegType Map Value.
Str. Stg	15	Structural Development Stage.
Wx %tile	19-21	Weather scenario (Dry, Normal, Wet).
CRB Name	24-29	SAF, SRM or CRB (custom) Classification
Weather Station	32-39	Representative fire weather station.
Fuel Row	42-44	Cross-reference to "Ottmar's FCC" Table.
Loading:		
0-1	46-49	Oven-dry mass of 0-1" biomass (tons/acre).
1-3	51-54	Oven-dry mass of 1-3" biomass (tons/acre).
3+	56-59	Oven-dry mass of biomass > than 3" diameter (tons/acre).
Live	61-64	Oven-dry mass of live vegetation (tons/acre).
Duff	66-69	Oven-dry mass of duff (tons/acre).
Total	71-74	Total oven-dry biomass (tons/acre).
Fuel Model	78-79	"Scaled" NFDR Fuel Model.
Moist 3+	84-85	Moisture content of 3+ material (percent).
PCFIRDAT:		
ERC	88-90	Energy Release Component (dimensionless).
SC	93-94	Spread Component (dimensionless).
Heat	97-99	Heat perUnit Area (BTU/foot2).
I-B	101-103	Byrom's Fireline Intensity (BTU/fireline foot/sec).
FL	107-109	Flame Length (feet).
Consumed:		
0-1	110-113	Consumption of 0-1" biomass (tons/acre).
1-3	115-118	Consumption of 1-3" biomass (tons/acre).
3+	120-123	Consumption of biomass > than 3"diameter (tons/acre).
Duff	125-128	Consumption of duff (tons/acre).
Live	130-133	Consumption of live vegetation (tons/acre).
Total	136-139	Total consumption of biomass (tons/acre).
PM10:		
Total	142-146	Total mass of PM10 emissions (pounds/acre).
EFbar	149-152	Weighted-average emission factor for PM10.