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2002 Fire Emission Inventory for the WRAP Region Phase I – Essential Documentation

WESTERN GOVERNORS ASSOCIATION / WESTERN REGIONAL AIR PARTNERSHIP

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EXECUTIVE SUMMARY

The Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP) has completed an air emission inventory for fire on wildlands in 14 of the 15 states in the WRAP Region. (Hawaii is not in the inventory.) The inventory includes emission estimates and activity data for wildfire, prescribed fire and wildland fire use (WFU) for the calendar year 2002. Actual agricultural burning emissions for 2002 were not included in this inventory. However, historical agricultural burning data used in previous WRAP air dispersion modeling analyses were distributed to states and tribes in an outreach and data quality control exercise. The FEJF collected activity data for wildfire, prescribed fire and WFU events from federal and state agencies, arrived at data quality objectives, culled data from the database that did not meet the data quality objectives, devised emission calculation routines, estimated emissions for all fire events, and published an emission inventory database and dispersion model-ready digital files.

The purpose of the wildland fire emission inventories is to further the WRAP's charge of supporting member states' and Tribes' Regional Haze State Implementation Plans and Tribal Implementation Plans. Along with emission inventories from other types of sources, the 2002 wildfire, prescribed fire and WFU emission inventories will be used by the Emissions and Air Quality Modeling Forums of the WRAP to execute, evaluate, and enhance the performance of the WRAP-wide air quality dispersion models.

Building the emission inventory involved many technical steps shaped by extensive stakeholder and expert discussion. Many of the techniques utilized for this emission inventory are based on the WRAP technical report entitled "1996 Fire Emission Inventory." Driven by the WRAP's targets for a highly resolved (temporally and spatially) dispersion model, the FEJF produced an *event-based* emission inventory, placing fire emissions at coordinate locations on specific days. Federal and state records of individual fire events were collected. Burning activity data was not collected directly from Tribal agencies. Federal land manager (especially Department of Interior – Bureau of Indian Affairs) data included in the federal databases may include burning in Indian Country. Activity records were checked for completeness for fire size, fuel loading, date, and location. Activity records deemed incomplete and therefore not useable in an emission calculation were culled from the database (and retained in a companion database). Fuel loading and emission factor tables along with diurnal consumption and plume profiles were developed from the literature, expert and professional judgment, and stakeholder input. Spreadsheet and geographic information system software was used to store the data, perform data augmentation and quality control functions, calculate emissions, and produce the strictly formatted text files of the inventories. The methods developed for this study may be refined and utilized for future air emissions analyses. Table 1 presents an abbreviated summary of the 2002 wildfire, prescribed fire and WFU inventories.

Limitations of this emission inventory include the omission of fire events (e.g., rangeland fires on private lands, actual agricultural burning activity data for 2002, and state and federal fire activity records deemed to be incomplete) and variable data quality due to the variety of data sources used. Furthermore, estimating emissions from wildland fire involves considerable scientific uncertainty. The FEJF made the decision to utilize the 2018 Agricultural Burning Base Smoke Management emission inventory (developed and delivered by the FEJF's contractor, Air Sciences Inc., under a separate contract) to serve as a placeholder for agricultural burning emissions in the WRAP's regional dispersion modeling analysis.

Table 1: Executive Summary of Fire Activity and Emissions from Wildfires, Prescribed Fires and Wildland Fire Use in 2002

	Wildfire	Prescribed Fire	Wildland Fire Use	Total
Number of Fire Events	1,785	10,000	35	11,820
Area burned (1,000 acres)	6,146 (88%)	602 (9%)	202 (3%)	6,950
Fuel consumed (1,000 tons)	195,389 (92%)	6,509 (3%)	11,388 (5%)	213,286
$PM_{2.5}$ emissions (1,000 tons)	2,354 (92%)	66 (3%)	137 (5%)	2,557

SECTION 1

INTRODUCTION

This essential documentation is a summary of the activity data, calculations, and results of the historical fire emission inventory for 2002 prepared by the Emissions Task Team (ETT) of the FEJF. The methods for this 2002 effort are intentionally the same as the WRAP 1996 fire emission inventory, where feasible, so that the 2002 inventory is comparable to its predecessor and could be executed efficiently. For detailed discussion of the topics summarized in this "essential documentation," please refer to the appropriate section in the "1996 Fire Emission Inventory" technical report. Where the technical methods used for the 2002 emission inventory differ from the methods used for the 1996 emission inventory, the methods are described in detail in this essential documentation. In particular, improvements were made by the FEJF to this 2002 process by refining the daily fire spread algorithm and updating plume profile parameters. Details of the fire activity data collection and processing are bulleted for each data set received in Appendix A.

1.1 Basic Concepts of the WRAP Fire Emission Inventories

The FEJF inventoried fire emissions for calendar year 2002 for the states in the continental WRAP region plus Alaska. The term "fire" refers inclusively to wildfire, wildland fire use (WFU, formerly prescribed natural fire), and prescribed fire. This emission inventory was based on data collected by state and federal agencies. Agricultural burning was not inventoried for 2002 and rangeland burning and burning on private lands was likely under-represented based on the FEJF's understanding of the type of fire activity data included in the activity databases utilized.

The WRAP Air Quality Modeling and Emissions Forums provided the FEJF with specific data resolution requirements for the fire emission inventories. For spatial resolution, each fire event needed a specific latitude and longitude in order to satisfy the spatial resolution goal of one minute of latitude and longitude. For temporal resolution, hourly emission estimates for each fire event were required.

Estimating emissions from fire events involves considerable scientific uncertainty. Historic data were of varying quality and for some areas unavailable. Activity records were not ground-truthed and other than quality control steps described in this report, were generally accepted "as is." Parameters such as the vegetation type of a burn, the vegetation-specific fuel loading, pollutant-specific emission factors, and combustion efficiencies, to name a few, all have uncertainties associated with them which will influence regional modeling results. The efforts of the ETT were dedicated to using professional judgment to select the best available or most representative parameters or methods to estimate emissions. However, other parameters and methods could have been chosen and would also be considered "reasonable" for estimating emissions from fire.

The specifications required by the Emissions and Air Quality Modeling Forums combined with the limitations of existing data and emission estimation methods shaped the emission inventory development. Fire, traditionally considered an "area" source, is treated as "point" sources in the WRAP's regional dispersion model. Fire emissions are placed at a latitude/longitude coordinate location for each day. From the daily and spatially resolved emission inventory, hourly consumption and plume rise are estimated.

The 2002 emission inventory was made available to the WRAP digitally as database files and text files formatted for input to the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System (PTINV, PTDAY, and PTHOUR files in IDA format).

1.2 Fire Emission Inventory Phases

The FEJF has identified a number of phases of emission inventory development to supply the WRAP with appropriate emission inventories for its regional haze dispersion modeling efforts. These phases are:

- Phase I – Modeling Evaluation Emission Inventory. Actual 2002 wildland fire and prescribed fire emission inventories and use of the 2018 Agricultural Burning Base Smoke Management Program emission inventory as a placeholder. Primary use of the Phase I inventories is to verify and enhance dispersion model performance and to test geographic source apportionment (modeling estimates of contribution at each Class I area from each upwind source jurisdiction).

- Phase II – Initial Modeling Apportionment Emission Inventory. Actual 2002 wildland fire and prescribed fire emissions (split into natural and anthropogenic events) emission inventories and actual 2002 agricultural burning emission inventory. Primary use of the Phase II inventories is to complete the WRAP's Strategic Plan 2004 geographic source apportionment for the Allocation of Haze Project.

- Phase III – Planning Baseline Period Emission Inventory. Emission inventories for wildland fire, prescribed fire, and agricultural burning that are based on 2000 through 2004 (or longer) fire activity data that is assessed to be representative of regional haze baseline period. The emission inventory format used for Phase II will be used for Phase III for consistency.

- Phase IV – Planning 2018 Projection Year Emission Inventory. Projected emission inventories for wildland fire, prescribed fire, and agricultural burning. Projections to be based on predictable variables. Projections may be in the form of emission scenarios or ranges of emissions. The emission inventory format used for the Phase III baseline planning inventory will be used for Phase IV for consistency.

The fire emission inventories delivered with and described in this essential documentation are the Phase I emission inventories for wildland fire and prescribed burning. Calculation methods and data quality standards were devised with the FEJF's stated objectives for the Phase I inventories in mind. The FEJF emission inventory reflected consistent methods and specific fire event data. Data quality standards were set for the historic activity data collected. Consistent calculation methods and calculation parameters (such as literature-based fuel loadings) were implemented. The 2002 emission inventory was constructed consistent with the 1996 historic emission inventory completed previously by Air Sciences Inc. for the FEJF.

SECTION 2

THE 2002 FIRE EMISSION INVENTORY

The ETT established a number of fire event data objectives that were used to identify and utilize fire event data suitable for the 2002 fire emissions inventory. Each individual entry in the "raw" fire activity database was analyzed to determine if all of the fire event data objectives were met in order for the record to be included in the fire emissions inventory. The data objectives were:

- A specific location for each fire event.
- A specific calendar day in 2002 for each fire event.
- A specific size for each fire event.
- Sufficient information to assign a fuel loading for each fire event.

The wildfire, prescribed burning and WFU emission inventories were developed with parallel data gathering and emission calculation techniques. The same basic inventory process was utilized with a few specific variations implemented. A summary of the technical methods follows.

The wildland fire use events were originally classified as wildfire events in the database. They were processed as wildfire events and were identified as WFU events and treated separately from wildfire only after spatial and temporal allocation; fuel loading and emission calculations; and plume characterization had been completed. Therefore, in this report, the term wildfire includes WFU data unless otherwise specified.

2.1 Activity Data

Wildfire activity data including WFU data were collected by the FEJF using a tiered process. Wildfires greater than 10 acres in size were sought but any fire record collected was used. Detailed activity data with sufficient spatial and temporal resolution were contained in the National Interagency Fire Center's (NIFC) daily National Situation Report publication and ICS-209 wildfire forms. The National Situation Report database and ICS-209 databases were merged. Procedures were implemented to avoid including duplicate records in the merged data set.

In a companion effort, 2002 records from the Department of the Interior's Wildland Fire Management Data and the Department of Agriculture's Forest Service National Interagency Fire Management Integrated Database were appended to form an independent "federal database" of fire events. Fire events in the National Situation Report/ICS-209 database were then paired with fire events in the "federal database." The National Situation Report/ICS-209 database was supplemented on a record-by-record basis with location, fire size, and fuel loading information from the "federal database" where necessary.

For the prescribed fire activity database, the FEJF set no de minimus activity level for prescribed burning. Air Sciences Inc., under the authority of the FEJF, made requests of air quality and/or department of forestry officials of each state in the WRAP region to provide wildland prescribed fire activity within their jurisdiction for 2002. Individual fire records were needed to satisfy precise temporal, spatial, and activity criteria for WRAP modeling purposes. Therefore, the FEJF requested:

1. Any information that could be used to ascertain a prescribed fire's location (i.e. legal location, latitude/longitude coordinates, and county).
2. Timing information (burn date or season) and/or fire duration.
3. Such fuels information as vegetation type, acres burned, tons burned, and burn type (piles or broadcast).

2002 prescribed fire information was received from each of the WRAP states. Generally, information received from interagency or state-facilitated smoke management programs encompassed prescribed fire data for multiple federal and state land management jurisdictions. DOI-1202 (Department of Interior), NIFPORS (National Fire Plan Operation Reporting System), and FASTRACS (Fuel Analysis, Smoke Tracking, and Report Access Computer System) data were received independently from federal agencies. State data not closely matching federal prescribed fire totals reported by NIFC were augmented with prescribed fire records from the federal databases. Fire records having sufficient spatial, temporal, and activity components were formatted into a single region-wide prescribed fire activity inventory.

See Appendix A for a more detailed description of data gathering methods, results, and assumptions for each state and agency.

2.1.1 Geo-referencing Fire Location by Township/Range/Section and County

Many of the records in the prescribed fire activity data set did not have latitude and longitude coordinates but did have location information in the form of a Township Range and Section (TRS) or county identifier.

A geographic information system (GIS) algorithm was developed to convert, or geo-reference, TRS codes to a latitude and longitude coordinate pair using the National Atlas Public Land Survey System (PLSS) map of Township and Range. Meridian was not available in the raw activity data and was assigned to each fire based on state name. The fundamental steps of the TRS geo-referencing were:

1. Convert the fire record's PLSS information to Meridian Township Range (MTR) and Section code.
2. Locate that MTR on the PLSS map.
3. Within the MTR, estimate the location of the center of the Section.
4. Identify the latitude and longitude of this point.

5. Record the estimated geographic coordinates in the activity record.

Fires were also geo-referenced by county identifier. If the county and state name matched to the National Atlas county layer, the centroid coordinates of the county shape were written to the activity record. Fire records ultimately not meeting the data quality objectives were dropped from the data set.

After geo-referencing the wildland fire data, 17 fire records, corresponding to 16 individual prescribed fire events, had locations that were outside of the WRAP region. These records were dropped from the Phase I emission inventory.

2.1.2 GIS-based NFDRS Fuel Loading Assignment

Fire events in the wildfire and prescribed burning activity databases that did not contain fuel type in the source data were assigned a fuel model using GIS techniques. The fire's location was plotted on the National Fire Danger Rating System (NFDRS) fuel model map and the corresponding fuel model code was recorded to the activity record. This procedure was applied to each record in the activity database. The specific steps are:

1. A mappable point for the fire is created from its latitude and longitude.
   (Activity records are geo-referenced based on their latitude and longitude.)
2. The fire point is converted to the different map projection of the NFDRS map.
   (Geographic coordinates are projected to Lambert Equal Area Azimuthal.)
3. The fire point is "dropped" on the NFDRS Fuel Model map.
   (The intersected grid cell is identified.)
4. The fuel model at that point, as a coded number, is identified.
   (Numeric fuel model attribute value is extracted from the grid cell.)
5. The numeric fuel model name is saved to the fire activity record.
   (Numeric fuel model code is written to a newly created field in the activity database.)
6. The numeric code is translated to the standard NFDRS Fuel Model letter code.
   (For all records, the fuel letter is looked up by fuel number and saved in a new field.)

Records receiving the "ag" designation were presumed to occur in a grassland environment and assigned the same fuel loading as NFDRS Fuel Model C, pine-grass savanna. Activity records intersecting "water" and "barren" did not receive a fuel model assignment from this process.

2.1.3 Final Activity Data Quality Control

The wildland fire activity data set was quality-controlled using geographic information science. Logical inconsistencies were identified and recorded in the activity data set. Certain flaws were considered "fatal" and resulted in the record remaining in the activity data set, but being "dropped" from the emission inventory. Only records with a valid start and end date, location (latitude and longitude coordinate), non-zero fire size in acres, and calculable fuel loading in tons were carried over to the final emission inventory. The wildfire activity data set was supplied

with 3,243 records. In total, 86 activity records (2.7 percent) totaling 18,447 acres were dropped due to insufficient or inconsistent data, and 3,157 wildfire records were carried over to the final emission inventory. This corresponds to 1820 individual fire events. The prescribed fire activity data set was supplied with 10,963 records. In total, 963 activity records (8.8 percent) totaling 51,723 acres were dropped due to insufficient or inconsistent data, and 10,000 prescribed fire events were carried over to the final emission inventory. The majority of prescribed fire records (~890) were dropped due to an invalid location input in term of TRS coordinates that could not be filled in the absence of a county code or name.

2.1.4 Wildland Fire Use

Wildland Fire Use (WFU) was included as a unique fire-type in the Phase I emission inventory. WFU events were originally categorized as wildfires and were treated as wildfires for spatial and temporal allocation as well as emission calculations. Therefore, some of the tables and charts in this report categorize data only as wildfire and prescribed fire. In these cases, WFU is combined with wildfire.

Table 2 summarizes the fire events classified as WFU. The majority of WFU fire activity in the 2002 emission inventory occurred in Alaska: 79% of the acreage, 89% of the fuel consumed and 89% of the PM2.5 emissions. Other states with reported or allocated WFU activity included California, Colorado, Idaho, Montana, New Mexico, Utah and Wyoming.

Information on WFU events was found in two data sources:

1. The DOI-1202 data contain a subset of data with a numerical code indicating WFU for the FWS, NPS, BLM, and BIA lands.

2. NIFMID data contains a subset of data that contained the WFU events for the US Forest Service in 2002.

All the WFU records from both the DOI-1202 and the NIFMID datasets were extracted and compared to the wildland fire activity data. This comparison was based on 1) Fire name, 2) Fire date, and, 3) Fire acreage. The results of this comparison indicate that the majority of the WFU activity in the DOI-1202- and the NIFMID databases were indeed included in the Phase I EI wildfire data. All WFU records were assigned a unique label to distinguish these events from wildfire events in the database.

Table 2: Summary of Wildland Fire Use Data in Phase I EI

Source Data	WFU Acres	In Phase I EI (acres)	In Phase I EI (%)
DOI 1202	168,055	167,708	99.7%
NIFMID	36,208	33,934	93.7%
Total	204,263	201,642	98.7%

Some of these discrepancies stem form the fact the Phase I EI includes fire records =10 acres only, while the other two databases include all fire sizes. Moreover, in some cases there were minor discrepancies between the acres included in the Phase I EI and the other dataset for the same fire event. For the Phase I inventory, the records in the original database were retained and the discrepancy between the DOI 1202/NIFMID records and the Phase I EI records was not resolved (approximately 2,600 acres).

2.1.5 Natural and Anthropogenic Assignments

Each wildfire, prescribed burn, and agricultural burn in the WRAP Phase I emission inventory for fire was tagged as "natural" or "anthropogenic" in origin. This was done using the following approaches, based on the WRAP Fire Emissions Joint Forum's (FEJF) *2001 WRAP Policy for Categorizing Fire Emissions* and *Guidance for Classifying Natural Versus Anthropogenic Fire Emissions*. Further approaches for categorizing natural and anthropogenic fires may be developed by the FEJF for subsequent phase II, III, and IV emission inventories.

The FEJF database for Phase I wildfire and prescribed burning was amended with a field to flag each fire event as natural or anthropogenic. Also, the Source Classification Code (SCC) assignment performed in the database was refined to assign custom SCCs which accommodate specific fire types discussed in this document. Each SCC present in the refined Phase I emission inventory identifies each event as either natural or anthropogenic. The SCC stays with the fire event in the SMOKE model-ready files delivered to the WRAP Regional Modeling Center (RMC). These SCCs are defined in Table 3.

Table 3: SCCs and their Fire Type and Natural/Anthropogenic Classification.

SCC	Fire Type	Natural or Anthropogenic
2810001000	Wildfire	Natural
2810001001	WFU	Natural
2801500000	Agricultural	Anthropogenic
2801500001	Agricultural (Native American)	Natural
2810015000	Prescribed	Anthropogenic
2810015001	Prescribed	Natural

Wildfire

All wildfire will be categorized as natural. The SCC for wildfire (2810001000) will be considered exclusively natural.

Wildland Fire Use

All Wildland Fire Use (WFU) incidents identified in the Phase I inventory will be categorized as natural. A custom SCC of 2810001001 will be used to identify WFU and be defined as natural. It is helpful to note that by definition WFU is a distinct fire source from both wildfire and prescribed burning. That is, a WFU incident cannot also be considered wildfire or prescribed burning.

Agricultural Fire

All agricultural burning in the Phase I emission inventory will be categorized as anthropogenic and given the standard SCC of 2801500000.

The *2001 WRAP Policy for Categorizing Fire Emissions* states that "vegetative burning conducted by Native Americans for traditional, religious and ceremonial purposes" is considered natural and all other vegetative burning conducted by Native Americans is classified as "prescribed", with agricultural burning fitting the definition of prescribed fire. Some agricultural fire events in the Phase I emission inventory fall within the exterior boundaries of Tribal lands, but the Phase I inventory lacks an indication of "traditional, religious, or ceremonial" purpose. Therefore agricultural events falling on tribal lands will still be categorized as anthropogenic. A custom SCC of 2801500001 will be used in the future to classify agricultural burning determined to be of a natural origin.

Prescribed Fire

Prescribed fire will be categorized as either natural or anthropogenic. The standard SCC of 2810015000 will represent anthropogenic prescribed burns and a custom SCC of 2810015001 will represent natural burns.

Categorization of prescribed fire as natural or anthropogenic will be based on the National Fire Danger Rating System (NFDRS) fuel model for each incident (Table 4). An NFDRS fuel model exists for each wildfire and prescribed burn in the Phase I emission inventory. Each incident in the Phase I emission inventory has only one NFDRS assignment based on the observed fuel model reported in the activity database (preferred) or is assigned by overlaying the fire location on the national NFDRS fuel model map using GIS (see the WRAP 1996 Fire Emission Inventory documentation). The NFDRS categorizations as natural or anthropogenic are based on examining the text descriptions of the fuel models and identifying the buildup of "above normal"

fuel loadings (for example, the short needle conifer models G and H as anthropogenic and natural, respectively).

Regardless of NFDRS fuel model, all piled prescribed burns will be categorized as anthropogenic.

Table 4: NFDRS Fuel Model Categorization as Natural or Anthropogenic

NFDRS Fuel Model	Categorization	Short Vegetation Description
A	Natural	Western Annual Grasslands
B	Anthropogenic	Tall dense older brush
C	Natural	Open pine with grass understory
D	Natural	Southeast Fuel Types
E	Natural	Hardwood after leaf fall
F	Natural	Mature closed Chamise with Oakbrush
G	Anthropogenic	Dense Conifer with heavy downed duff
H	Natural	Short Needled Conifer with thin litter
I	Anthropogenic	Clearcut Conifer Slash <6"
J	Anthropogenic	Clearcut heavily thinned Conifer Slash <6"
K	Anthropogenic	Light conifer slash partial cuts
L	Natural	Western Perennial Grasslands
N	Natural	Southeast Fuel Types
O	Natural	Southeast Fuel Types
P	Natural	Southeast Fuel Types
Q	Natural	Upland Alaska Black Spruce
R	Natural	Hardwoods after leafout
S	Natural	Apline Tundra and Grass
T	Natural	Sagebrush and Grasslands
U	Anthropogenic	Closed Western Long-Needled Pine
Piles	*Anthropogenic*	*Piled activity fuels*

2.2 Fuel Loading and Emission Factors

In the event that fire event-specific fuel loading values were not contained in the database record, fuel loading in tons per acre for the wildfire inventory were assigned using the NFDRS fuel model codes and a table of fuel loading values for NFDRS fuel model categories (Cohen and Deeming, 1985). In addition to the default NFDRS fuel loadings, additional fuel loading was added to each category to adjust for fuel present as duff and tree crowns. Similarly, for prescribed fire events for which no fuel loading value was available, the prescribed fire fuel loading values were the same as those used for the wildfire inventory. "Adjusted" NFDRS fuel loading assignments for wildfire and prescribed burning differ by the percent consumption assumed for live fuels, duff, and crown components. Table 5 presents the adjusted NFDRS fuel loading assignments for wildfire and prescribed burning.

An emission factor suite was developed to apply to wildfire and prescribed fire activity data. The emission factor suite included one lookup table for wildfire and prescribed broadcast burns and one table for prescribed pile burns. The twelve pollutants included were total suspended particulate matter (TSP), particulate matter less than 10 microns in diameter (PM_{10}), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), elemental carbon (EC), organic carbon (OC), non-methane volatile organic compounds (VOC), methane (CH_4), ammonia (NH_3), oxides of

nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and coarse particulate matter–defined as the difference between PM_{10} and $PM_{2.5}$ (PMC). The emission factor suite consists of two lookup tables. Two emission factor references were drawn upon the US Environmental Protection Agency's (U.S. EPA) AP-42 Section 13.1 and an emission inventory methods survey report (Battye, 2001) funded by the U.S. EPA Office of Air Quality Planning and Standards (OAQPS). The emission factor suite is a compilation of emission factors and emission factor relationships (multipliers) from both documents. Table 6 lists the emission factors used for the Phase I inventory.

Table 5: Summary of Fuel Loading and Consumption by NFDRS Model for Wildfires [Wildland fires?]

Dead and live fuel loadings were based on Cohen and Deeming (1985). Values in parentheses indicate total fuel loading for prescribed fire. An asterisk (*) after the NFDRS model description indicates the wildfire emissions were augmented for smoldering consumption.

NFDRS Abbr.	NFDRS Model Description	Total (Rx fire) (tons/acre)	Dead Fuels (tons/acre)				Live Fuels (tons/acre)		Additional (tons/acre)	
			1-hour	10-hour	100-hour	1,000-hour	Fine Wood	Herbaceous	Duff	Crown
A	Western grasses (annual)	0.50	0.20	0.00	0.00	0.00	0.00	0.30	0.00	0.00
B	California chaparral	19.5	3.50	4.00	0.50	0.00	11.50	0.00	0.00	0.00
C	Pine-grass savanna	4.7	0.40	1.00	0.00	0.00	0.50	0.80	4.00	0.00
D	Southern rough *	15.6 (10.6)	2.00	1.00	0.00	0.00	3.00	0.75	7.70	8.00
E	Hardwood litter (winter) *	3.8	1.50	0.50	0.25	0.00	0.50	0.50	1.10	0.00
F	Intermediate brush	15.0	2.50	2.00	1.50	0.00	9.00	0.00	0.00	0.00
G	Short needle (heavy dead) *	43.5 (25.6)	2.50	2.00	5.00	12.00	0.50	0.50	18.20	19.20
H	Short needle (normal dead) *	27.5 (15.0)	1.50	1.00	2.00	2.00	0.50	0.50	16.90	18.70
I	Heavy slash *	55.1 (49.1)	12.00	12.00	10.00	12.00	0.00	0.00	18.20	0.00
J	Intermediate slash *	34.0 (31.2)	7.00	7.00	6.00	5.50	0.00	0.00	16.90	0.00
K	Light slash *	14.4 (13.1)	2.50	2.50	2.00	2.50	0.00	0.00	9.70	0.00
L	Western grasses (perennial)	0.75	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.00
N	Saw grass *	5.0	1.50	1.50	0.00	0.00	2.00	0.00	0.00	0.00
O	High pocosin *	46.1 (45.1)	2.00	3.00	3.00	2.00	7.00	0.00	58.20	0.00
P	Southern pine plantation *	16.4 (10.2)	1.00	1.00	0.50	0.00	0.50	0.50	13.30	10.00
Q	Alaskan black spruce	57.6 (48.8)	2.00	2.50	2.00	1.00	4.00	0.50	57.90	26.80
R	Hardwood litter (summer) *	3.1	0.50	0.50	0.50	0.00	0.50	0.50	1.10	0.00
S	Tundra *	19.3 ()19.1	0.50	0.50	0.50	0.50	0.50	0.50	32.60	0.00
T	Sagebrush-grass *	4.5	1.00	0.50	0.00	0.00	2.50	0.50	0.00	0.00
U	Western pines *	19.1 (10.3)	1.50	1.50	1.00	0.00	0.50	0.50	10.60	14.20

Table 6: Summary of Emission Factors

Summary of emission factors (EF) in pounds per ton for prescribed burning. In the case of piled fuels, when two sources are mentioned, the first source refers to the emission factor and the second to the empirical relationship used to derive that emission factor.

Pollutant	Prescribed Fire - Piled Fuels EF	Source	Prescribed Fire Non-Piled EF	Source
TSP	12.0	AP42[1]	34.1	AP42[6]
PM_{10}	8.0	AP42	28.1	OAQPS
$PM_{2.5}$	8.0	AP42	24.1	OAQPS
Elemental Carbon	0.6	AP42, OAQPS $PM_{2.5}$ * 0.072	1.5	OAQPS
Organic Carbon	4.3	AP42, OAQPS $PM_{2.5}$ * 0.54	11.6	OAQPS
VOC	6.3	AP42, OAQPS CO * 0.085	13.6	OAQPS
CH_4	7.7	OAQPS 2*(42.7-43.2*CE)	13.6	OAQPS
NH_3	0.5	AP42, OAQPS CO * 0.0073	1.3	OAQPS
NO_x	6.2	OAQPS	6.2	OAQPS
CO	74.3	AP42	289.0	OAQPS
SO_2	1.7	OAQPS	1.7	OAQPS
PM coarse	0.0	$PM_{10} - PM_{2.5}$	4.0	$PM_{10} - PM_{2.5}$

2.3 Emission Calculations

For wildfire and prescribed burning, daily emissions were calculated as fuel consumed (tons of fuel) multiplied by each emission factor (pounds of pollutant per ton of fuel). Total fuel consumed was either extracted directly from the activity data (more often the case with prescribed fire) or was calculated as the size of the fire (acres burned) multiplied by the "adjusted" NFDRS fuel loading value (tons of fuel per acre burned). For wildfires and prescribed broadcast burns of "heavy" fuel model types, additional smoldering emissions were assigned to the same location on the following calendar day.

2.3.1 Daily Fire Growth Allocation

The wildfire and prescribed burn emission inventories were required to be resolved to the day, but wildfires and prescribed burns were reported both as individual fire-days and as single records spanning a number of days. Therefore, the acres burned, total fuel loading consumed, and emissions per pollutant of multi-day records were allocated to individual days to indicate their "fire growth." In the emission inventory database, new records were appended to add new daily fire events where before there was only a single multi-day record. The final date for all records was coded in "mm/dd/yy" format. The original multi-day record was overwritten with the first day's allocation.

[1] AP-42, Section 13.1, Table 13.1-3, Logging Slash Debris, No Mineral Soil, weighted average of flaming and smoldering.

Records that only indicated one day's reporting of activity (i.e., the end date was the same as the start date) were skipped over by this daily allocation step. A multi-day event was allocated to individual fire days only if its size was greater than 100 acres. Fires less than or equal to 100 acres were assigned in their entirety to the activity record's start date. The growth rate for wildfires and prescribed fires was then allocated differently:

Wildfire

Wildfires greater than 100 acres were allocated to the first two-thirds of the duration implied in the source data. The duration of fire growth in days for wildfire was calculated as:

$$\text{Wildfire Duration } (Days_n) = \text{Ceiling } [2/3 \text{ (startdate} - \text{enddate} + 1)] \qquad \textbf{Equation 1}$$

Beginning on the start date, values were allocated to the subsequent calendar days across this shortened duration. The FEPS "spreading oval" algorithm was used to emulate a geometric fire growth (FEPS version 1.0 Jan-04 Eqn. 20). The fire growth of each day as a percent of the multi-day total was calculated as:

$$\text{Percent } Day_i = (Day_i^2 / Days_n^2)) - (Day_{i-1}^2 / Days_n^2) \qquad \textbf{Equation 2}$$

Where: i = sequence number of day from the event's start date and
n is the total number of days in the shortened wildfire duration

The daily allocation percent was applied to the multi-day values to arrive at daily fire growth in acres burned, tons consumed, and tons emitted per pollutant.

Prescribed Fire

For multi-day prescribed fires greater than 100 acres, size, loading, and emissions were allocated evenly across every day from reported start date to end date, inclusive.

2.4 Plume Profile

A plume profile tailored for wildland fire was assigned to each daily fire event. Normally, plume rise is predicted using hourly pyrotechnical and meteorological information. However, given the unique physical characteristics of wildland fire events and previous experience with dispersion models that indicated poor performance with regard to dispersing smoke plumes, the FEJF utilized expert opinion to assign plume characteristics to each fire event.

2.4.1 Virtual Acres

Fires were classified into size classes based on "virtual acreage." The virtual acreage was calculated by multiplying the actual fire size by the square root of the normalized pre-burn fuel loading. This was done in order to relate fuel loading to the characteristic "stack" diameter of the plume. For wildfire the total fuel loading was normalized to 13.8 tons per acre and for prescribed

fire 5.0 tons per acre. This normalizer was the total surface loading plus crown biomass for NFDRS fuel model U (western pines) for wildfire and prescribed burns respectively.

$$\text{Acreage}_{\text{virtual}} = \text{Acreage}_{\text{actual}} \cdot \sqrt{\text{Fuel Loading} / \text{Normalizer}} \qquad \textbf{Equation 3}$$

The plume profile for days added to model smoldering for the day after an original activity day was the same as for the original fire event. In the emission inventory, the smoldering events retained the virtual acreage of the fire event they were created from and thus the plume calculations were identical.

2.4.2 Diurnal Consumption

A diurnal fuel consumption table was created to allocate daily wildland fire emissions by hour (Table 7). The table, consisting of a percent of fuel consumed for each hour of the day, summing to 100, was submitted to the Air Quality Modeling Forum (and the WRAP's Regional Modeling Center (RMC)). The diurnal fuel consumption table was implemented by the RMC within the SMOKE emissions processor to allocate daily emission estimates to hourly emissions.

Table 7: Standard Diurnal Consumption Template Used to Distribute Fire-Total Heat Production and Emissions

Hour	1	2	3	4	5	6	7	8	9	10	11	12
% Per Hour	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	2.00	4.00	7.00
Hour	13	14	15	16	17	18	19	20	21	22	23	24
% Per Hour	10.00	13.00	16.00	17.00	12.00	7.00	4.00	0.57	0.57	0.57	0.57	0.57

2.4.3 Fire Size Classes and Plume Profile Calculations

Plume values include the top and bottom of the plume (PTOP and PBOT, respectively; both expressed in meters above ground elevation) and the percent of emissions entrained within the surface layer of the atmosphere (LAY1F), defined by the ETT of the FEJF as the first 38 meters above the ground[2]. These three plume parameters are established and assigned for each of the 24 hours of each daily fire event. All of the plume values were assigned based on the limited information available for each fire event, including fire size (fire area grown per day) and either a reported fuel loading or the NFDRS fuel model.

Five plume classes were defined with increasing potential plume heights to reflect the range of "heat release" possible in wildland fires (Table 8). Plume bottom heights and percent of the

[2] For the 1996 emission inventory and 2018 emission projections, the FEJF assumed an 80 meter first layer. For this emission inventory, the original LAY1F percent allocations developed for the prior inventories were multiplied by the ratio of 38 over 80. The maximum bottom of plume value was revised to be approximately three times higher for each fire class relative to the values used in the 1996 inventory. This P_{bot} max revision was based on FEJF discussions with the USDA Pacific Wildland Fire Sciences Lab.

plume fumigated to the first layer of the atmosphere were also developed for the five plume classes. Using expert opinion and anecdotal evidence, a table of hourly buoyant efficiency values was derived (Table 9).

Table 8: Fire-Related Parameters as Function of Fire Size Classes

Class	1	2	3	4	5
Size (virtual acres)	0 – 10	>= 10 – 100	>= 100 – 1,000	>= 1,000 – 5,000	>= 5,000
BE_{size}	0.40	0.60	0.75	0.85	0.90
P_{top} max (m)	160	2,400	6,400	7,200	8,000
P_{bot} max (m)	0	900	2,400	4,800	4,800

Table 9: Buoyant Efficiency as Function of Hour of Day

Hour	1	2	3	4	5	6	7	8	9	10	11	12
BE_{hour}	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.10	0.2	0.4
Hour	13	14	15	16	17	18	19	20	21	22	23	24
BE_{hour}	0.7	0.8	0.9	0.95	0.99	0.8	0.7	0.4	0.06	0.03	0.03	0.03

Equations were used to calculate P_{top}, P_{bot} as a function of time of day and size of the fire (expressed in terms of virtual acres). Note that the calculations use an hourly value for buoyant efficiency (Table 9) and heat release value based on fire size, also referred to as normalized fire growth.

The hourly top of the plume was calculated as follows:

$$Ptop_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Ptop_{max} \quad \textbf{Equation 4}$$

where BE is the buoyant efficiency looked up from the hourly or size class tables. The hourly bottom of plume was similarly calculated as:

$$Pbot_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Pbot_{max} \quad \textbf{Equation 5}$$

Lastly, an equation was used to calculate LAY1F, the proportion of emissions fumigated into the first atmospheric layer (adjusted to be below 38 m rather than 80 m). LAY1F was calculated as the arithmetic inverse of the hour-specific buoyant efficiency multiplied by the size-specific buoyant efficiency.

$$Lay1F_{hour} = 38/80 * (1 - (BE_{hour} * BE_{size})) \quad \textbf{Equation 6}$$

Using Equations 3 through 6 the bottom and top of the atmospheric plume as well as the proportion of the plume fumigated into the first atmospheric surface layer were all scaled to fire size, fuel loading (incorporated in virtual acres calculation), and hour of the day. Figures 1 through 4 illustrate the relationships described above.

Figure 1: Buoyant Efficiency

The relationship between buoyant efficiency and time of day.

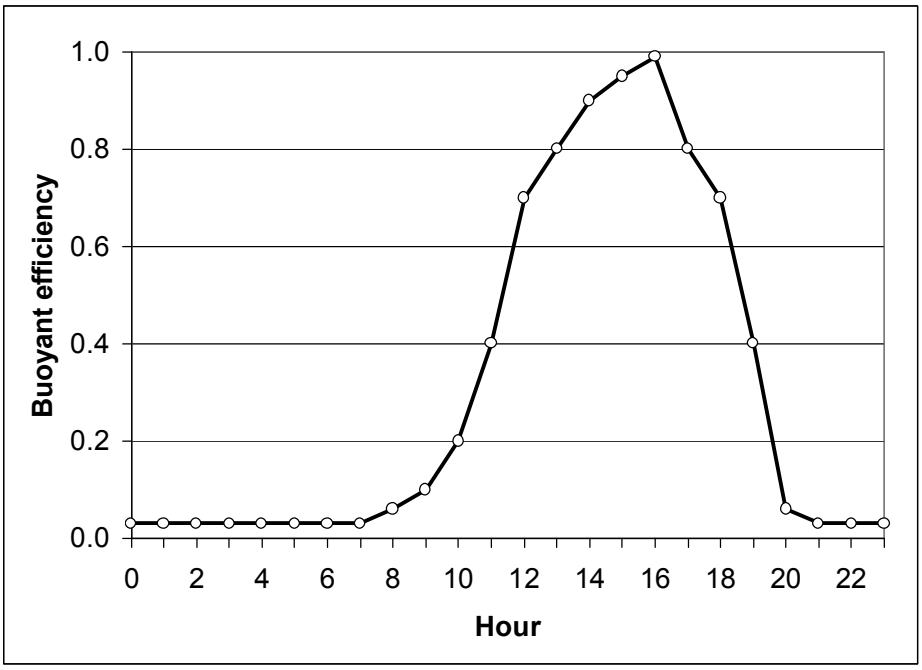


Figure 2: Projected Top of Plume

The projected top of the atmospheric plume (meters) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The lowest line represents the 10-acre cutoff. Note the logarithmic scale on the y-axis.

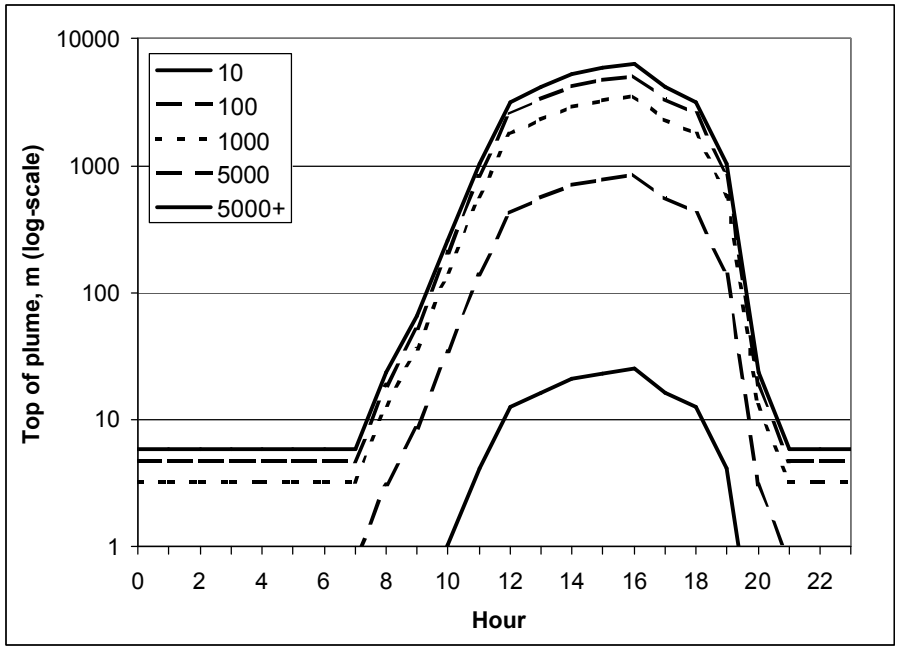


Figure 3: Projected Bottom of Plume

The projected bottom of the atmospheric plume (meters) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The line representing the 10-acre cutoff is constant at a value of zero.

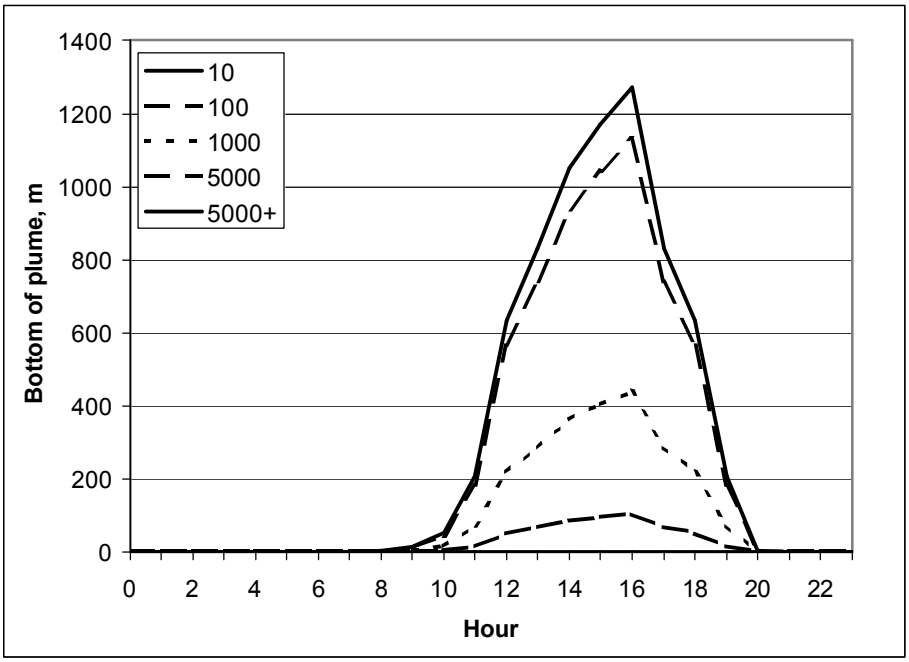
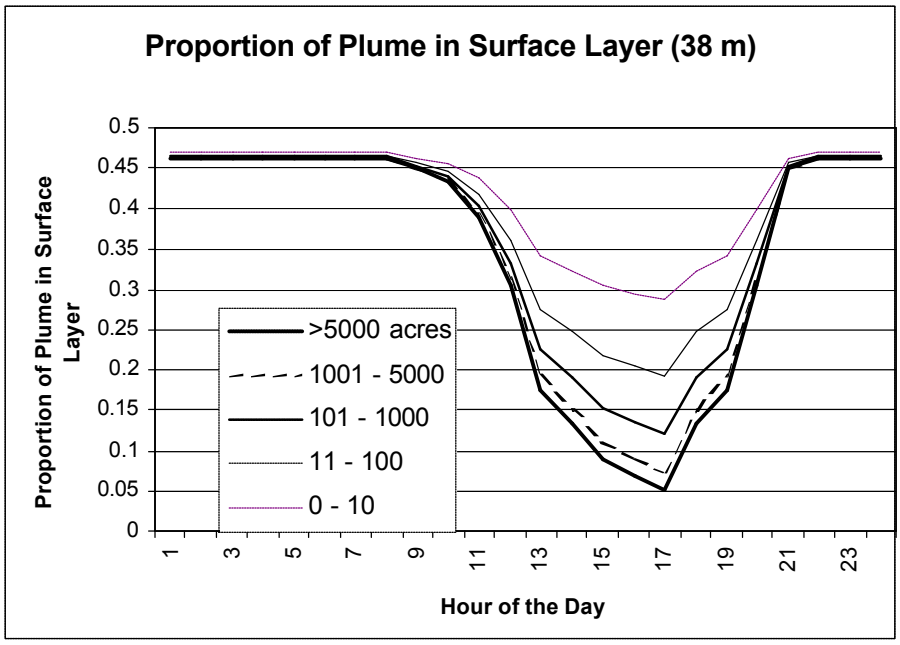


Figure 4: Proportion of Plume in Surface Layer

The proportion of the plume fumigation to the atmospheric surface layer (<38 m) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The highest line represents the 10-acre cutoff.



2.5 Summary of 2002 Fire Emission Inventory

A total of 1,820 wildfires are included in the 2002 wildfire emissions inventory with a mean duration for each fire of 3.6 days. These fires represent a total of 2,150,000 tons $PM_{2.5}$ and 2,492,000 tons $PM_{2.5}$ with smoldering factored in. An estimated total of approximately 6.3 million acres and 207 million tons of fuel were consumed by wildfire in 2002. Wildfire acres burned were highest during the summer months and peaked in the month of July. Wildfire activity differed widely by state with the highest activities in Alaska and Oregon.

The 2002 prescribed fire emission inventory is comprised of significantly more events than the wildfire inventory with 16,016 original fire days. The total acreage consumed by prescribed burns was 602,000 acres and the total fuel consumed was approximately 6.5 million tons. Over 60 percent of the prescribed burning activity records are piled fuels. Temporally, prescribed burning had two peaks: one in the spring and a higher peak in the fall.

When expressed as fire days, about 28 percent of the fire activity occurred as wildfires and 72 percent as prescribed fires. However, emission estimates for wildfire were 38 times higher than for prescribed fire due to a combination of larger (acres) events and higher fuel consumption estimates.

Figures 5 through 21 and Table 10 show the fire emissions inventory statistics by source category, state, month, season, and fire size class.

Table 10: Combined 2002 Wildfire and Prescribed Fire Activity and $PM_{2.5}$ Emissions by State (Including smoldering fuels and emissions)

	Wildfire (including WFU)					Prescribed Fire					
State	Fire Events	Fire Days	Area Burned (1,000 acres)	Fuel Burned (1,000 tons)	$PM_{2.5}$ Emissions (1,000 tons)	Fire Events	Fire Days	Area Burned (1,000 acres)	Fuel Burned (1,000 tons)	$PM_{2.5}$ Emissions (1,000 tons)	$PM_{2.5}$ Total (1,000 tons)
AK	95	1,264	2,148	123,210	1,485	4	210	0.6	14	0.2	1,485
AZ	117	383	626	4,099	49	301	572	54	1,122	14	63
CA	335	966	536	10,250	124	398	2,221	89	944	11	134
CO	115	498	495	8,630	104	171	183	17	63	0.4	104
ID	136	400	82	861	10	662	1,316	89	984	12	22
MT	114	187	115	609	7	1,795	2,756	78	651	7	14
ND	135	160	87	313	4	186	186	27	60	0.7	4.5
NM	118	269	303	4,452	54	99	533	31	194	2	56
NV	94	161	56	460	6	59	473	16	90	1	6.5
OR	184	914	1,278	42,149	508	3,498	4,075	122	1,624	12	519
SD	119	158	78	199	2	34	219	9	20	0.2	2.6
UT	104	477	271	7,633	92	50	382	15	190	2	94
WA	65	211	98	1,384	17	2,606	2,727	34	326	2	18
WY	89	314	174	2,529	30	137	163	22	225	2	33
Total	1,820	6,362	6,348	206,777	2,492	10,000	16,016	602	6,509	66	2,557

Figure 5: 2002 Wildfire and Prescribed Fire Total Mass of All Pollutants

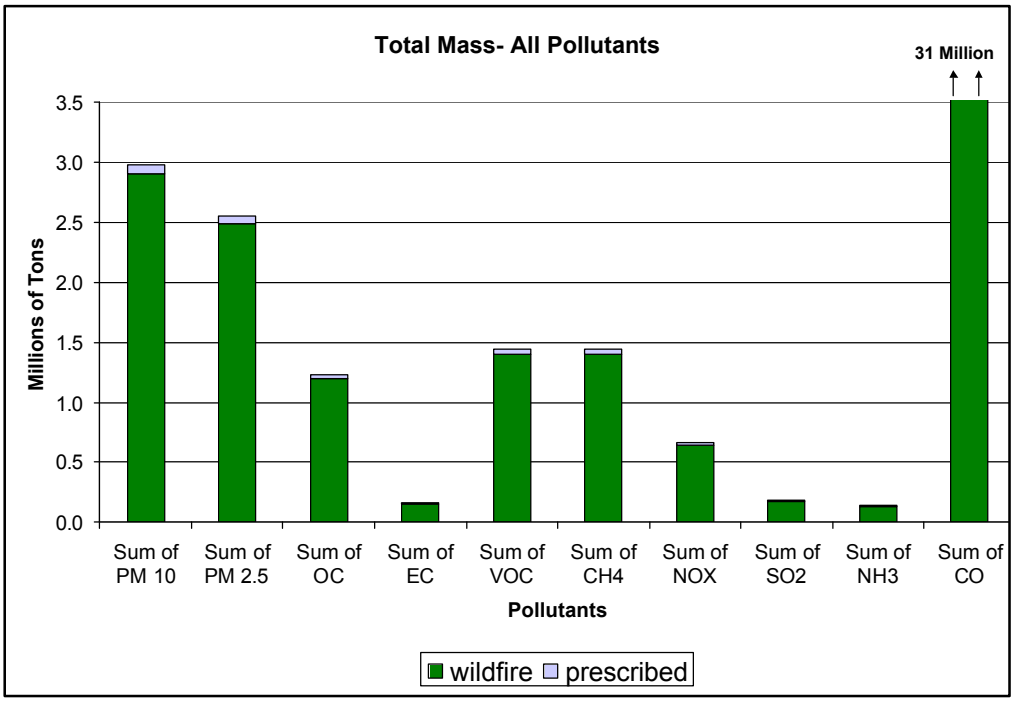


Figure 6: 2002 Prescribed Fire Total Mass of All Pollutants

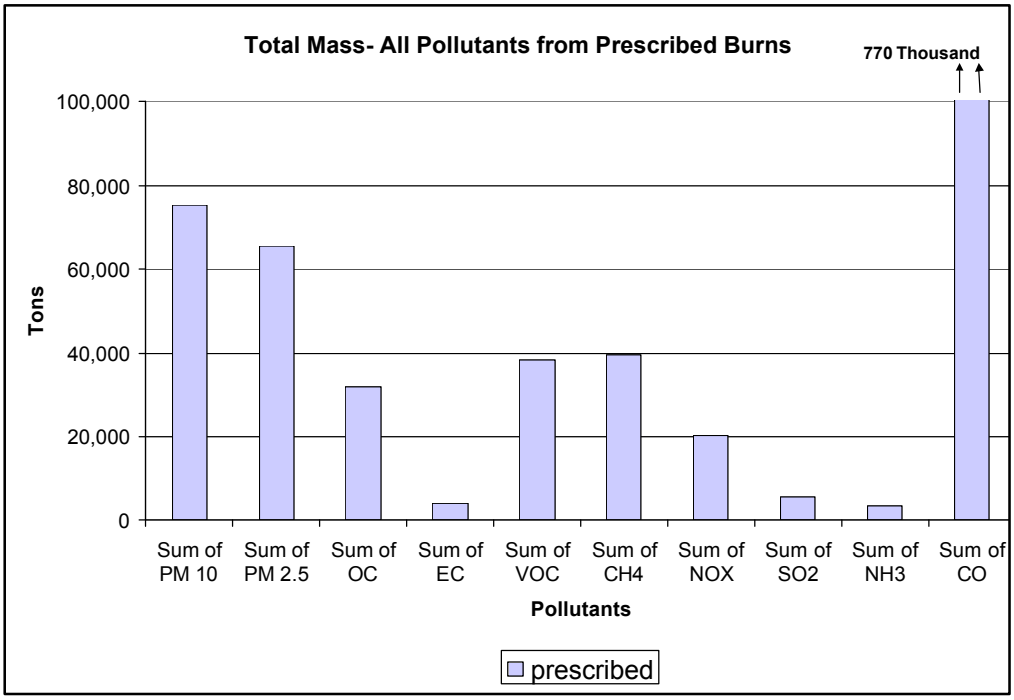


Figure 7: 2002 Wildfire and Prescribed Fire Burned Acres by State

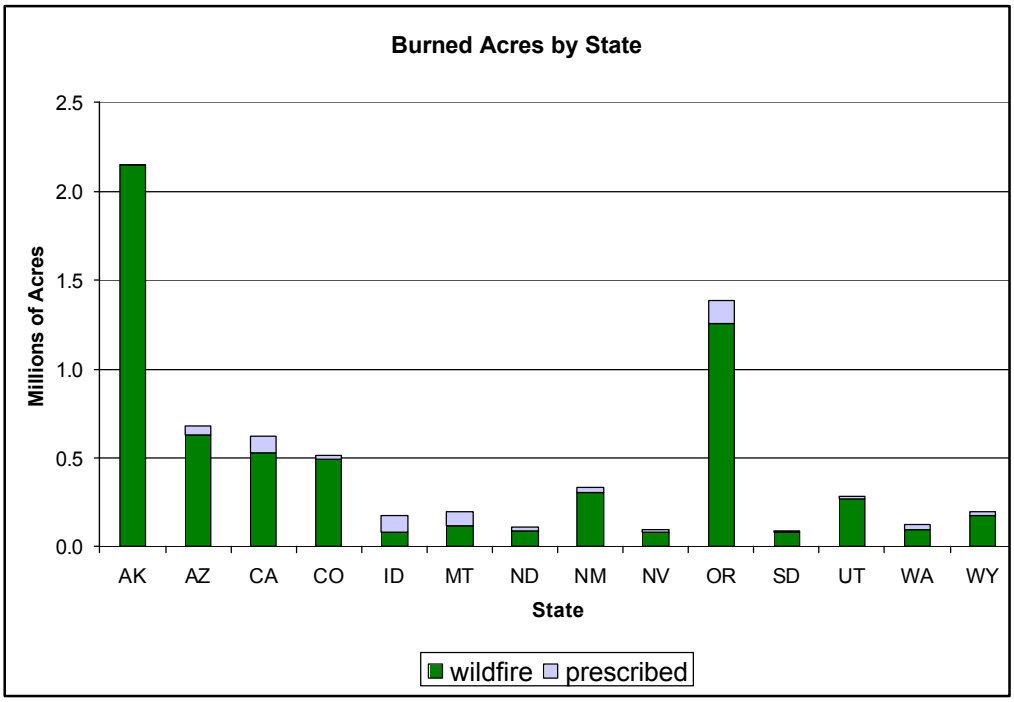


Figure 8: 2002 Prescribed Fire Burned Acres by State

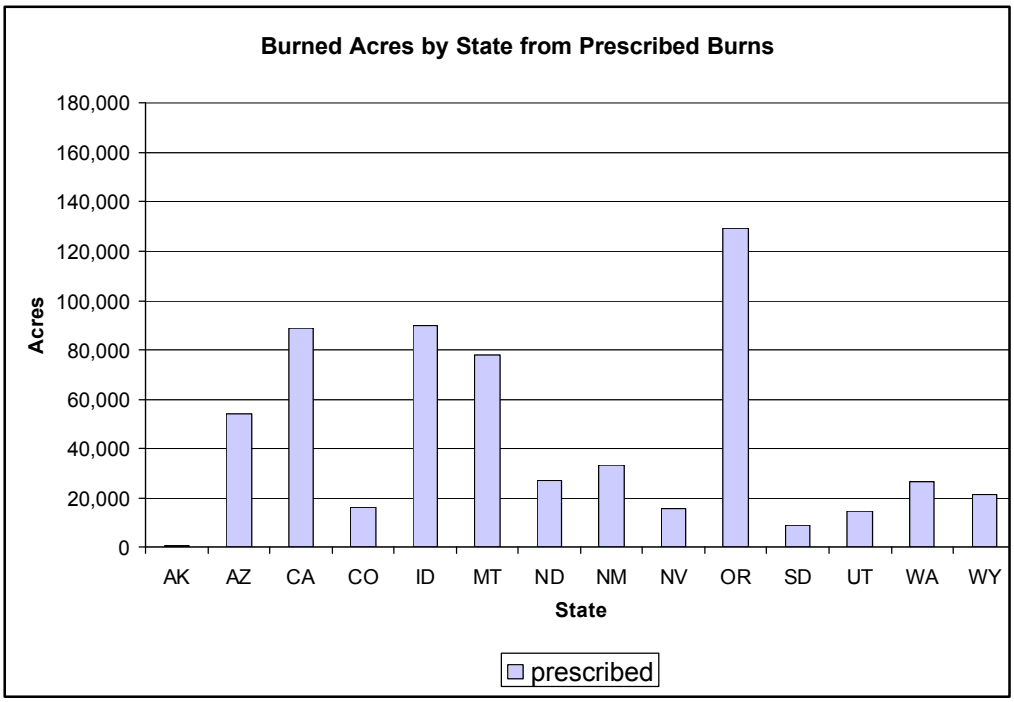


Figure 9: 2002 Wildfire and Prescribed Fire $PM_{2.5}$ by State

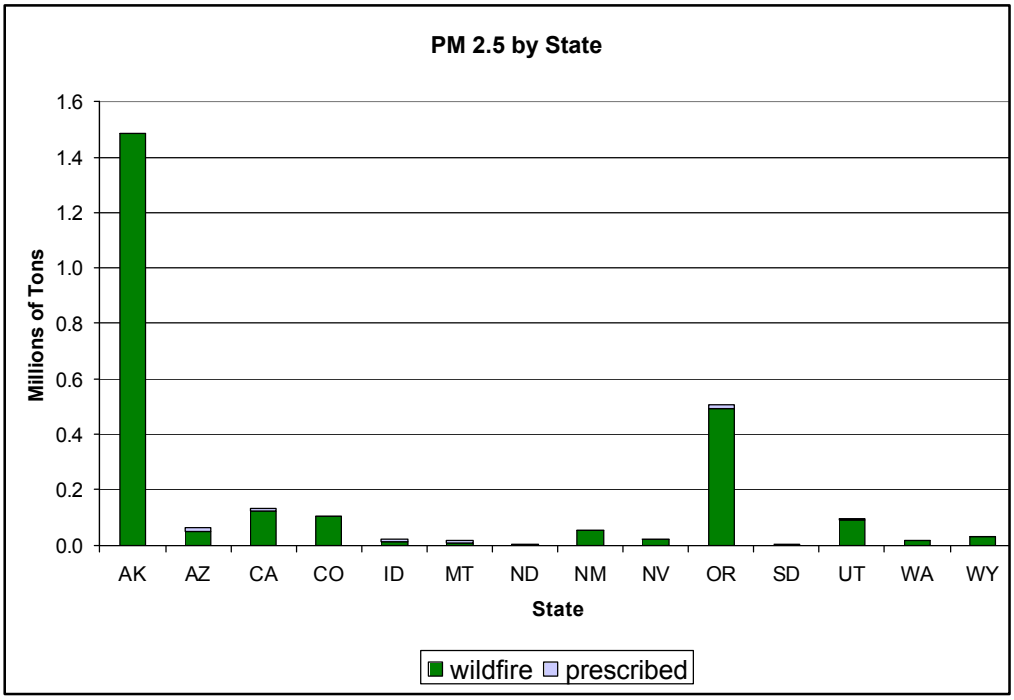


Figure 10: 2002 Prescribed Fire $PM_{2.5}$ by State

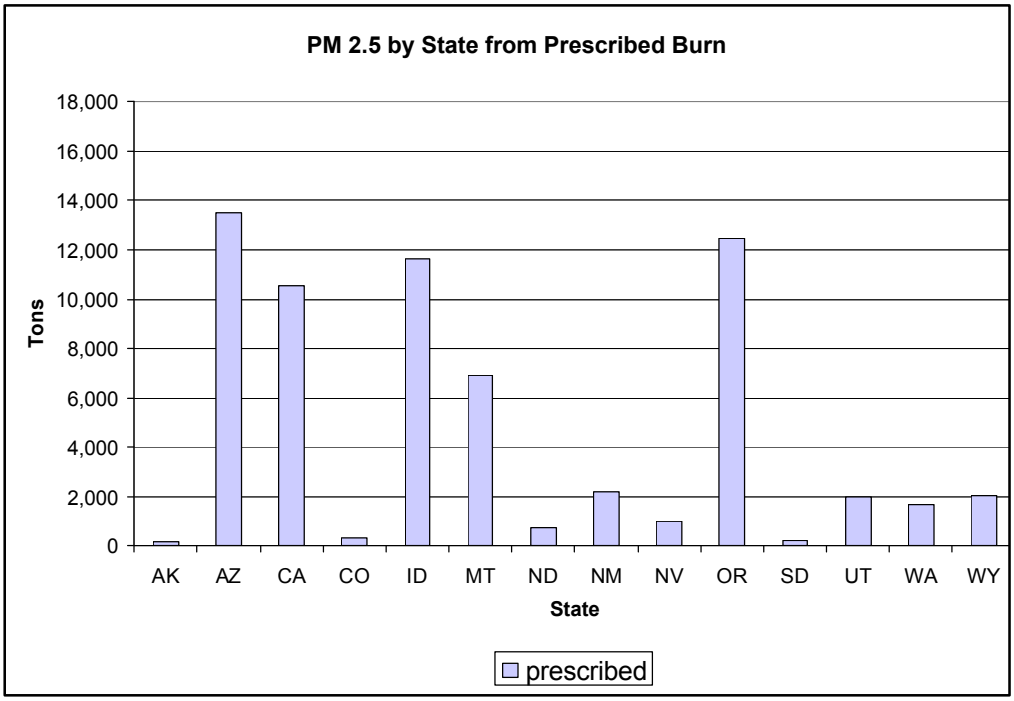


Figure 11: 2002 Wildfire and Prescribed Fire Burned Acres by Month

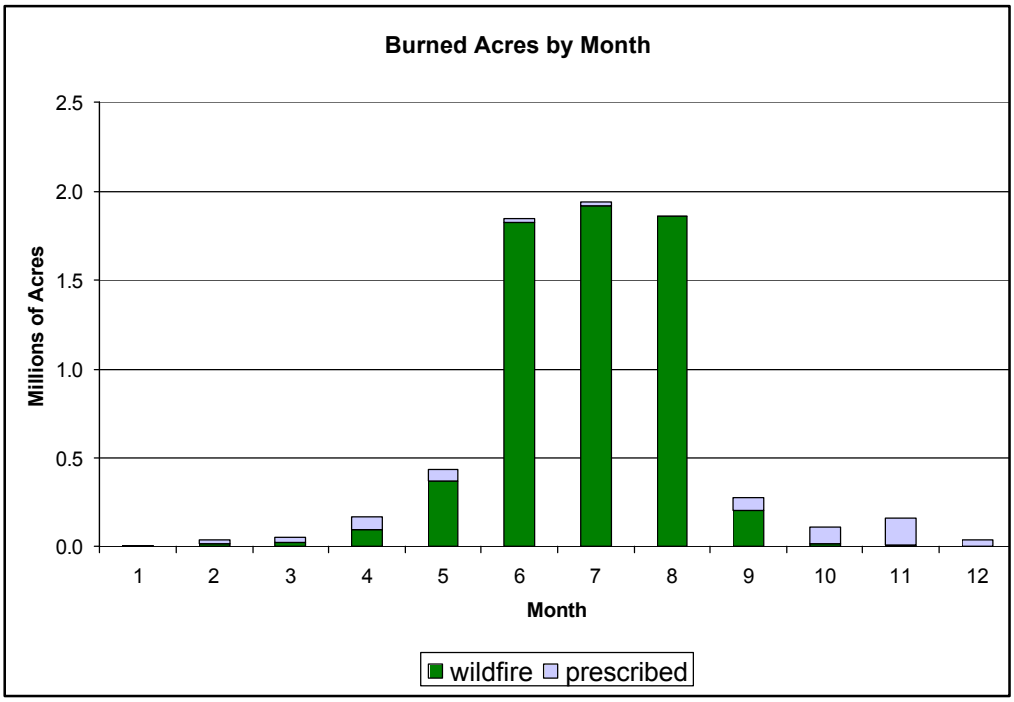


Figure 12: 2002 Prescribed Fire Burned Acres by Month

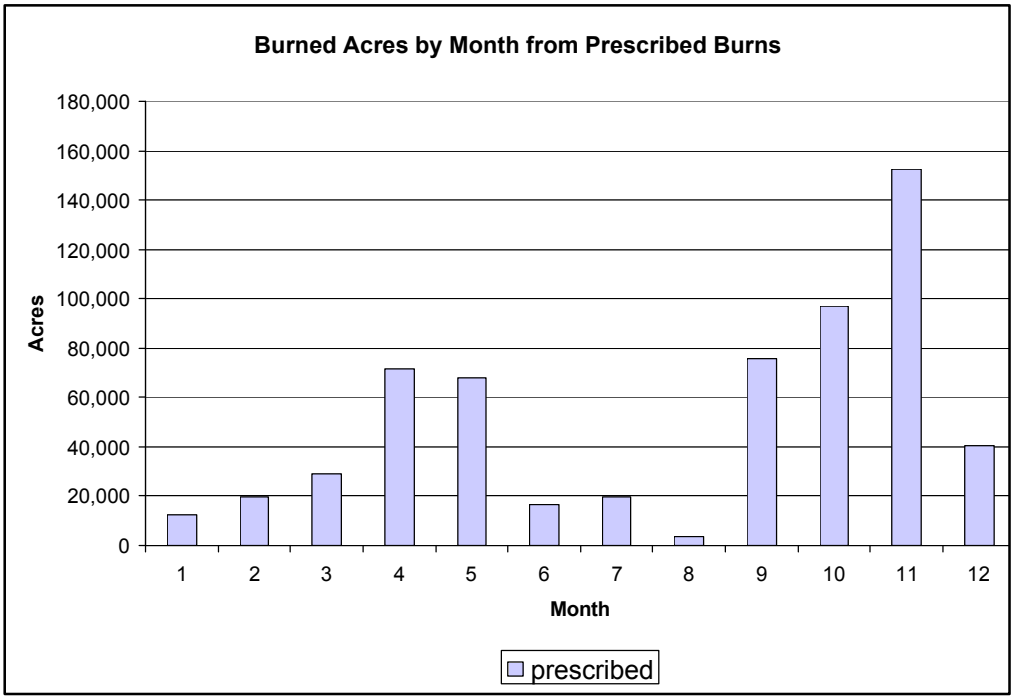


Figure 13: 2002 Wildfire and Prescribed Fire $PM_{2.5}$ by Month

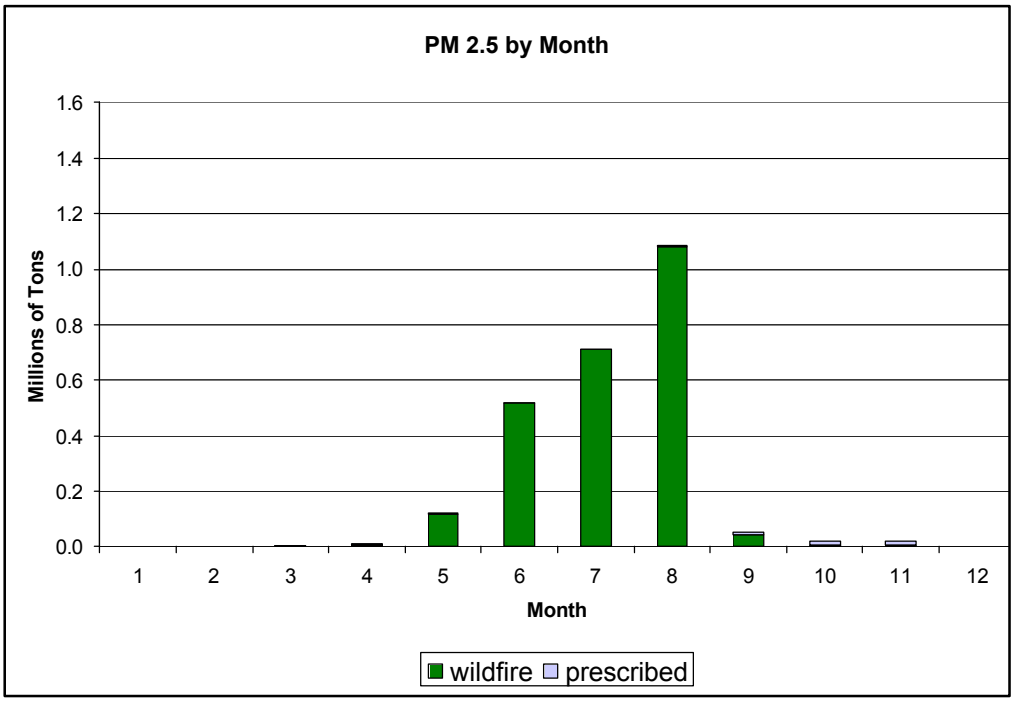


Figure 14: 2002 Prescribed Fire $PM_{2.5}$ by Month

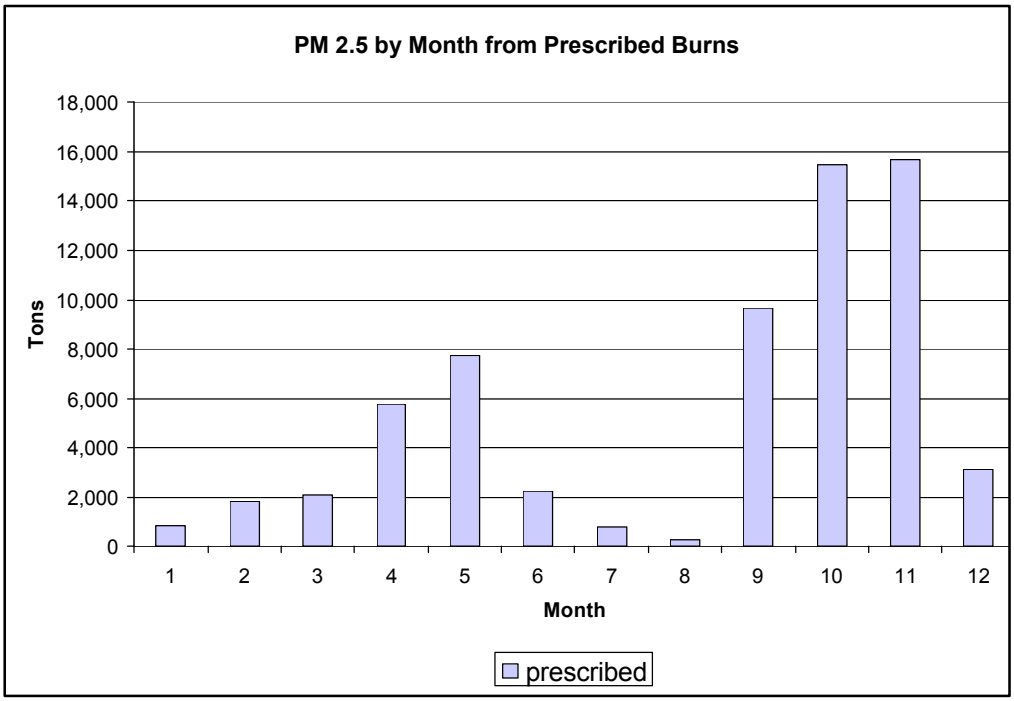


Figure 15: 2002 Wildfire and Prescribed Fire $PM_{2.5}$ by State and Season

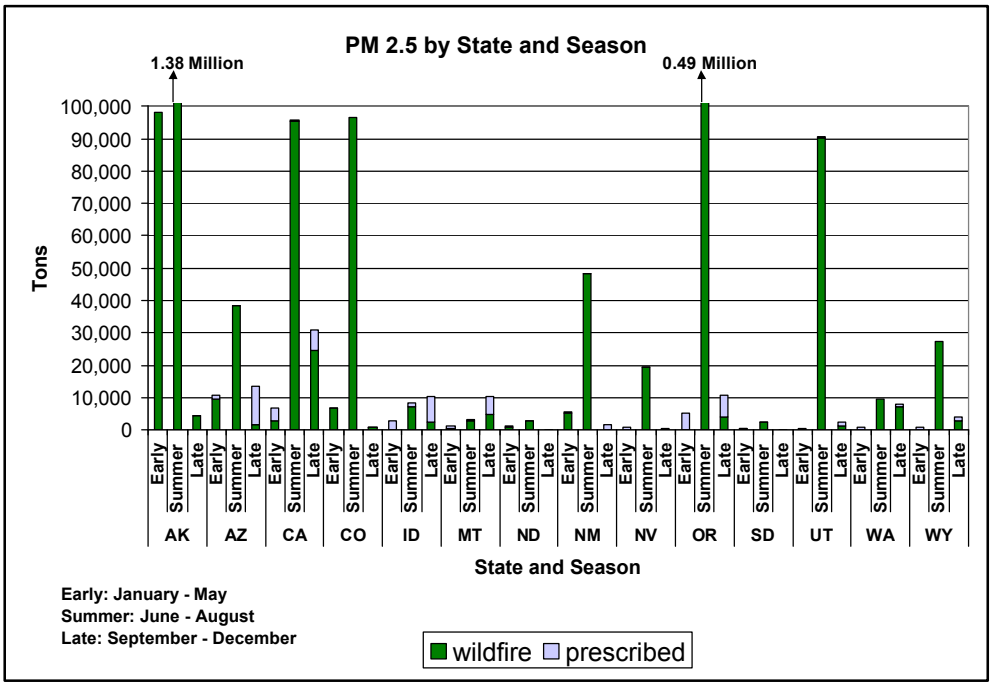


Figure 16: 2002 Prescribed Fire $PM_{2.5}$ by State and Season

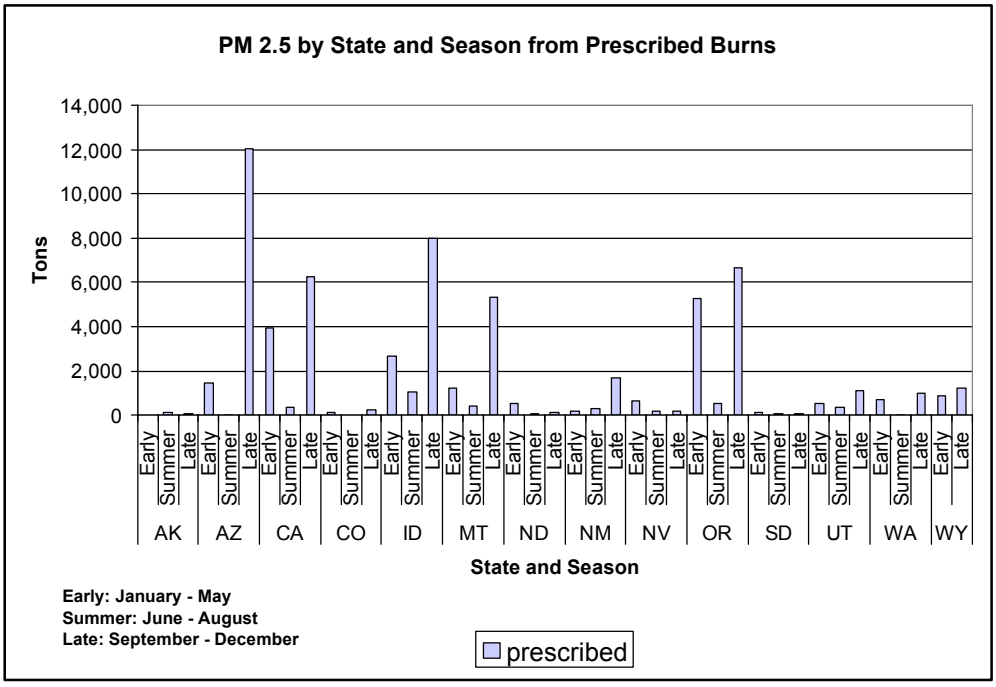


Figure 17: 2002 Percent $PM_{2.5}$ Released by Season

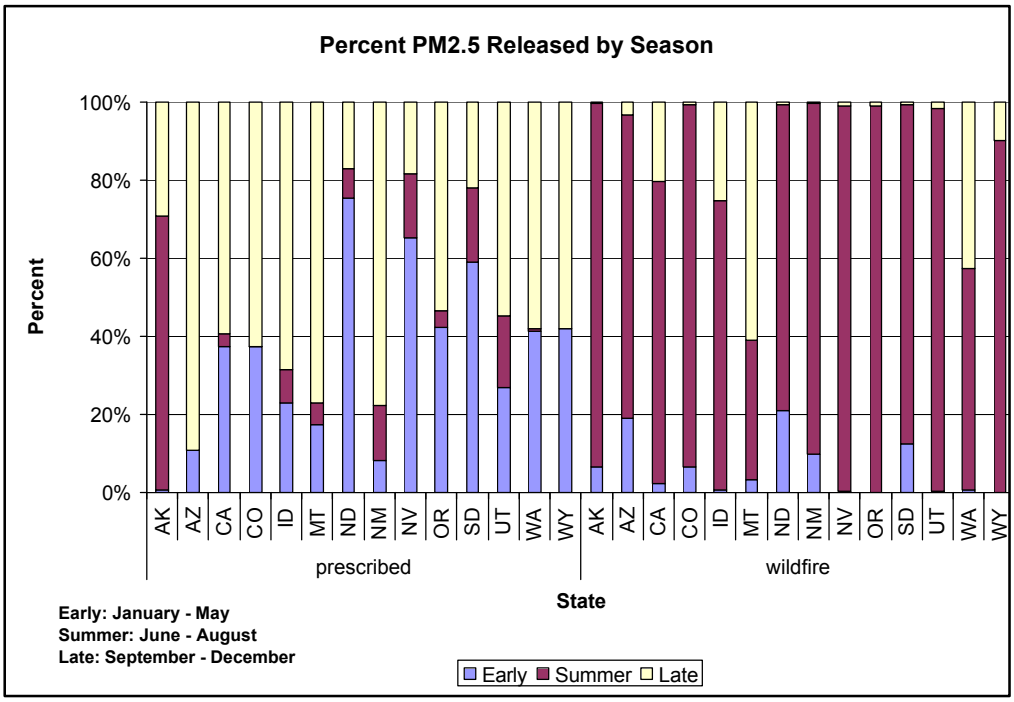


Figure 18: 2002 $PM_{2.5}$ by Fire Size Class

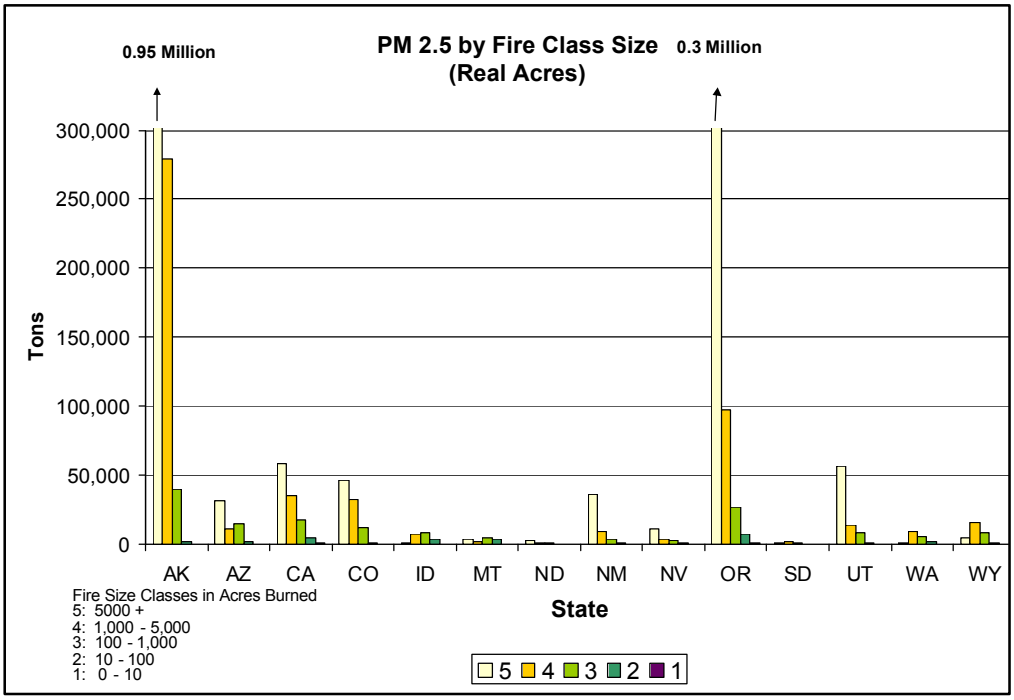


Figure 19: 2002 $PM_{2.5}$ by Month and State

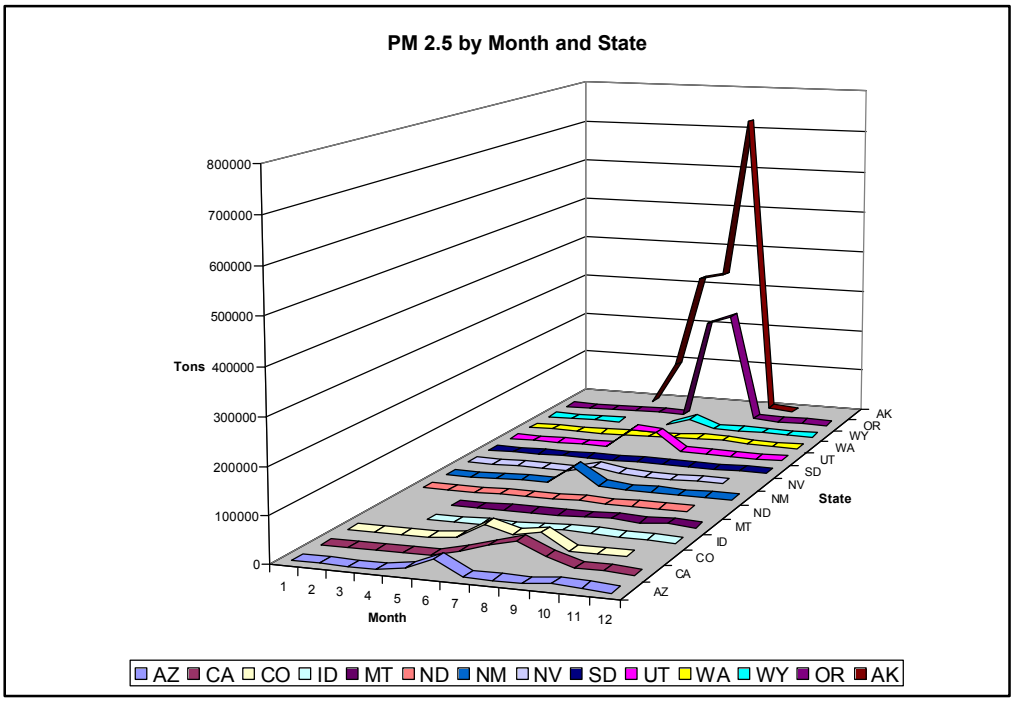


Figure 20: 2002 $PM_{2.5}$ by Month and State (w/o AK and OR)

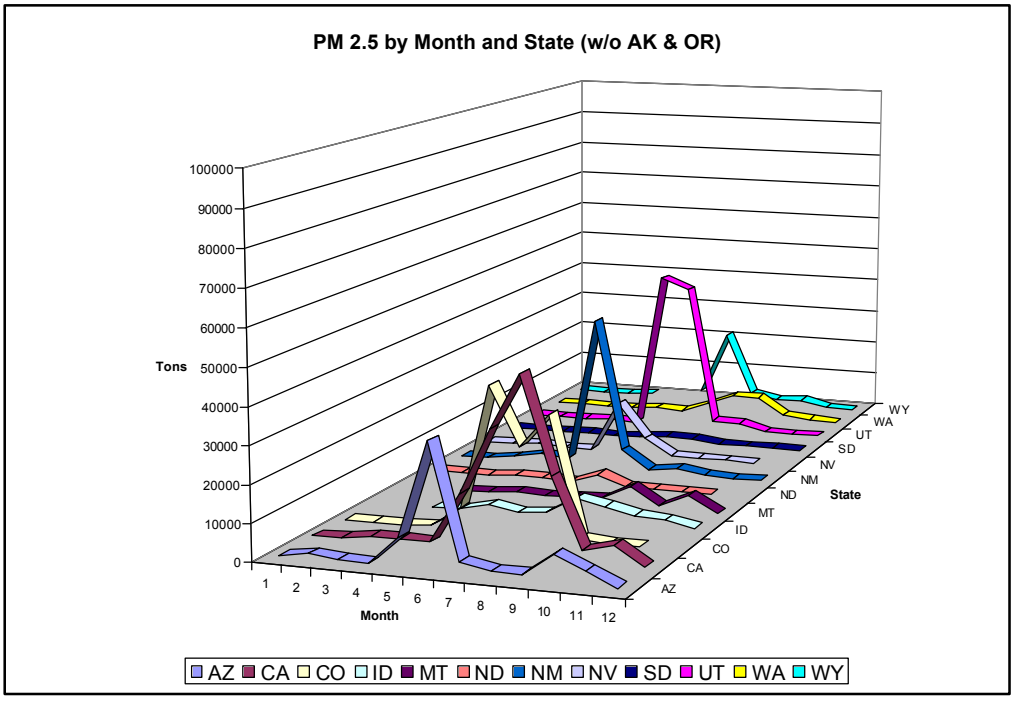
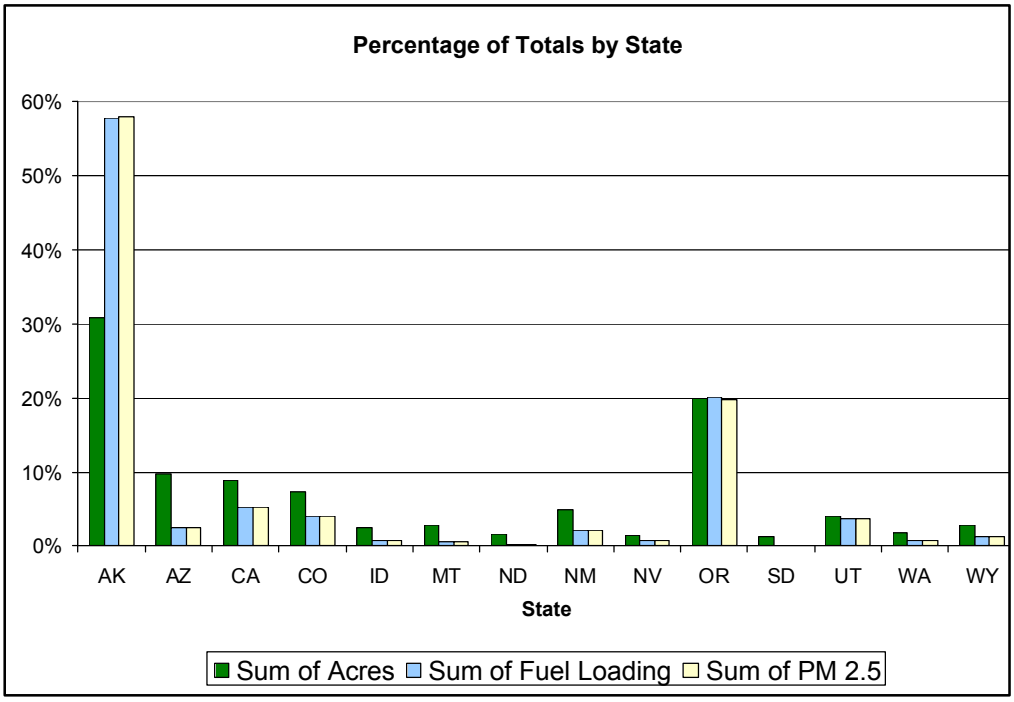


Figure 21: 2002 Percentage of Totals by State



SECTION 3

AGRICULTURAL BURNING ACTIVITY

No agricultural burning activity data was collected for 2002 for the Phase I emission inventory. As a placeholder for agricultural burning in the 2002 emission inventory, the 2018 Agricultural Burning Base Smoke Management emission inventory, which was prepared under a separate contract for the FEJF by Air Sciences Inc., was used. The report to the Western Governors Association and the WRAP/FEJF entitled "Integrated Assessment Update and 2018 Emissions Inventory for Prescribed Fire, Wildfire, and Agricultural Burning" includes detailed discussion of the 2018 agricultural burning database used in this emission inventory . Fires in this database went through a process similar to the wildfire and prescribed fire databases, including: removal of unusable records, calculation of emissions from residue loading and emission factors, and allocation of fire events to specific locations and times.

3.1 Quality Control Review Packets for States and Tribes

In an effort to improve the representativeness of the agricultural burning activity data, quality control review packets (QC packets) were sent to twelve states and three tribes in the WRAP. Each state and Tribe received a packet customized for its own region, which contained a summary of agricultural burning activity in the form of tables and graphs. It also included a WRAP-wide summary, supporting documents, forms and instructions for providing feedback on the quality of the data, and a CD with Microsoft Excel files, documentation, as well as the entire agricultural burning database.

The QC packet had two primary goals:

1. Outreach. To present what the WRAP was using in its WRAP region-wide inventory and modeling systems to represent emissions from agricultural burning and to provide states and Tribes with the emission inventory data.

2. QC Review. To obtain QC review and feedback so that the WRAP's region-wide agricultural burning emission inventory can be augmented and enhanced to be a more representative inventory for 2002.

These packets allowed WRAP states and Tribes the opportunity to give input on the agricultural burning activity data for the area under their jurisdiction. Since many of the fire records in the database lacked temporal and spatial specificity and were allocated to specific locations and times by region-wide generalizations, there was a significant opportunity for improvement by allowing the input of people with greater local knowledge of agricultural burning activity for each region.

Beta Review. Before the QC packets were sent out, a beta version was prepared and sent out for California, Wyoming and the Nez Perce Tribe. These packets were sent to get feedback on the layout and presentation of the data in the packets rather than for a QC of the actual data. Feedback from the beta packets was incorporated into the actual QC review packets that were sent to the states and tribes.

Distribution List. QC packets were sent to all of the WRAP states that had agricultural burning according the placeholder 2018 database. The following twelve WRAP states received the packets: Arizona, California, Colorado, Idaho, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming. The three tribes that received QC packets were Coeur d'Alene, Nez Perce and Spirit Lake.

3.2 Agricultural Burning on Tribal Lands

The location identifier for all fire records in the agricultural burning placeholder dataset was overlaid with National Atlas Public Land Survey System data to determine if events occurred on tribal lands within the WRAP region. A column was added to the fire activity database to list the name of the Tribe for any records falling within its boundaries. For all records that were not located within Tribal lands this column was left blank. Tribes that received a QC packet were contacted directly for spatial data of tribal lands in order to refine the assignment of agricultural burning events to the specific Tribe.

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Cohen, J.D. and J.E. Deeming. 1985. The National Fire-Danger Rating System: Basic equations. USDA, Forest Service. Report PSW-82.

U.S. Environmental Protection Agency. 1996. Supplements to the Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.1- Wildfires and prescribed burning.

APPENDIX A

Data Gathering and Compilation

Wildfire

Wildfire activity data was collected from Federal databases by WRAP staff.

- Contact name and agency: John Graves, Arizona DEQ.
- Date received: 7/24/2003
- Assumptions: Wildfire activity data reportedly included both wildfire and wildland fire use (WFU). Therefore, WFU activity in prescribed fire databases not included in the (prescribed) fire activity. This was a categorical decision based on information provided by John Graves, that was subsequently applied to all states. Decision was made since some databases for prescribed fire activity also included WFU activity, for example, the DOI database (see later in appendix).

Prescribed Fire

Alaska

- Contact name and agency: Ron Klein, Alaska DEC.
- Date received: 4/20/04
- Assumptions:
- Additional notes: Data only contained wildfire records. Based on further inquiry prescribed fire activity for AK not available. However, a NFDRS fuel loading map for AK was located in the process of additional research on AK fire data (downloadable from the state forest health web-site). This map was incorporated into the wildfire inventory in order to assign fuel loading to the AK wildfire records that did not have an NFDRS entry. The AK map was based on the Canadian equivalent of the NFDRS, the CFFDRS. A cross-referenced key to convert the CFFDRS codes to NFDRS codes was obtained from the same source as the map (http://agdc.usgs.gov/AGDCgateway.html).

Arizona

- Contact name and agency: Mark Fitch, Arizona DEQ.
- Date received: 3/8/04
- Assumptions: End date assumed to be same as start date, effectively creating all 1-day fire events. Both burn types in the database, specifically, "Activity-nonpile" and "Natural" were assumed to be prescribed burns, broadcast burns.
- Additional notes: Complete data set with approximately 73 thousand acres, distributed over 433 fire entries, and several burn agencies.

California

- Contact name and agency: Neva Sotolongo, California ARB
- Date received: 4/8/04
- Assumptions: Burn type assumed to be all broadcast burns. No identifier for piles included in data. Some records have fire end date of ZERO. End date assumed to be same as start date, effectively creating 1 day fire events.
- Additional notes: The data only includes incomplete records reported by CDF, not from other agencies. Hence, the data will underestimate actual statewide activity. Data was received in the form of a GIS layer, which was converted to latitude/longitude by Air Sciences.

Colorado

- Contact name and agency: Colleen Campbell, Colorado DPHE
- Date received: 4/9/04
- Assumptions: End date assumed to be same as start date, effectively creating 1-day fire events. Fuel loading – broadcast data was provided in terms of fuel loading and consumption (by size class). Pile loading only indicated volume of piles, percent of piles and corresponding PM emissions, not actual tonnage. Tonnage was back-calculated from PM emissions in one of two ways: (1) if pile volume and consumption available, then calculated by multiplication (Pile volume)*(percent consumption)*(loading per pile volume). The latter was back-calculated from PM emissions assuming the same emission factors for pile as for broadcast burns. (2) if only acres available for pile burn, assumed (geometric) mean of all CO pile burns (9.1 t/a). Also, the approach described under (1) resulted in two entries with very high fuel loading (up to >920 t/a); these two records were adjusted by assuming the geometric mean pile loading (~10 t/a). This adjustment decreased fuel loading and increased the acreage, thereby keeping the total fuel consumed the same as the original data.
- Additional notes: This data set had ~18K acres, distributed over 189 fire records. Data was received in two different file formats, which were combined to provide the most complete information. The daily acres file was used to derive actual acres burned under each permit. The general permit information was used as a lookup table to fill out the activity data in the daily acres file, for example, fire location.

Idaho

- Contact name and agency: David Grace, USFS.
- Date received: 3/22/04
- Assumptions: Data missing description of fire type. All fires assumed to be broadcast burns.
- Additional notes: Although data was provided by the USFS, the data was originally assembled by ID-DEQ (Email Communication, David Grace 3/22/04). After deletion of nine fire records dated in 2003, this data set was ~33K acres, distributed over 554 fire entries, and several burn agencies.

Montana

- Contact name and agency: Robert Habeck, Montana DEQ.
- Date received: 3/12/04
- Assumptions: None.
- Additional notes: Complete data set with ~219K acres, distributed over 1813 fire entries, and several burn agencies.

North Dakota

- Contact name and agency: Chuck McDonald, North Dakota Dept. of Health.
- Date received: 4/1/04
- Assumptions: If more than one section entered for location, set to first section only.
- Additional notes: Data received as hard copy and entered into spreadsheet. Corrected mix-up in units of the pre-burn fuel loading in the data-entry sheets.

New Mexico

- Contact name and agency: Lisa Bye, New Mexico DEQ.
- Date received: 3/16/04
- Assumptions: End date assumed to be same as start date, effectively creating 1-day fire events. If more than one section entered for location, set to first section only, but this was not a major issue, since latitude and longitude were provided for each entry as well.

- Additional notes: Complete data set with ~9K acres, distributed over 44 fire entries, and several burn agencies. Also, two entries in the data set (~3,500 acre total) had 2003 data instead of 2002. Assumed to be 2002.

Nevada

- Contact name and agency: Samuel Jackson, Nevada DEP.
- Date received: 4/13/04
- Assumptions: Fuel loading provided for 3 records only; loading for remaining records based on NFDRS. NFDRS assigned by the fuel type description provided in the raw data. Location - some fire locations were reported as a lat/long combination; most reported as TRS. If more than one section entered for location, set to first section only.
- Additional notes: Data received in form of excel file with 21 fire records, totaling ~8K acres.

Oregon

- Contact name and agency: Mike Ziolko, Oregon DF.
- Date received: 4/19/04
- Assumptions: The piled burns were inconsistent in quality. Some records had very high acreages associated, up to 9,600 acres, others had very high fuel loading, up to 2,500 tons/acre. In order to resolve these unrealistically high values, the mean loading for piled burns in the OR data (excluding the outliers, specifically, acreage>1,500 acres or loading >150 t/a) was calculated. Next all OR pile burns were normalized based on the (geometric) mean loading, specifically, 12.5 t/a. Since this procedure concurrently adjusted fuel loading and acreage, the total fuel consumption for each fire record stayed the same. Location – format of state TRS notation was converted to GIS format. Specifically, T or R entries, which were in the hundreds, had the last zero removed (for example, township 360 N changed to 36N).
- Additional notes: This data set was clean and complete except for inconsistent reporting of piled fire acreage, with ~166K acres total, distributed over 3603 fire records.

South Dakota

- Contact name and agency: Steven Hasenohrl, South Dakota DA.
- Date received: 3/26/04

- Assumptions: No fire type provided, so assumed to be broadcast burn.
- Additional notes: Only one state record for 2002 (150 acres).

Utah

- Contact name and agency: Greg Zschaechner, Utah DEQ. (Via Pete Lahm)
- Date received: 2/20/04
- Assumptions:
- Additional notes: Only 11 records totaling ~1.5K acres satisfied data quality objectives and were carried over to EI. UTM coordinates (provided) were converted to latitude and longitude using a GIS overlay map.

Washington

- Contact name and agency: Mark Gray, Washington DNR.
- Date received: 4/6/04
- Assumptions: Agency information based on key from Mark Gray. Burn type indicated as piled or broadcast. Calculated default fuel loadings were 14.2 and 8.5 t/a for broadcast- and piled burns, respectively. Broadcast fuel loading - if data available loading in t/a calculated from provided data, if not, set to default. Piled fuel loading set to default loading, calculated as the mean loading for broadcast burns, multiplied with fuel collection efficiency of 60 percent (*0.6). Blackened acres for broadcast burns were available from the data. Acres for piled burns (not provided) were calculated based on total loading (provided) and default tonnage per acre. Location – format of state TRS notation was converted to GIS format. Specifically, T or R entries, which were in the hundreds, had the last zero removed (for example, township 360 N changed to 36N).
- Additional notes: Large data set containing 3261 records totaling ~41K acres.

Wyoming

- Contact name and agency: Darla Potter, Wyoming DEQ.
- Date received: 8/3/04
- Assumptions: Start date - assumed to be same as date in comment field. If comment data absent, set to planned date; if planned date absent, than assumed to be on submitted date. End date - assumed to be same as start date, effectively creating 1-day fire events. Fuel type - raw data gives fuel type. This description was specific enough

to assign an NFDRS fuel model (letter code). Fire location - if more than one section reported for location, set to first section only. Fire type - several fire entries without acres, but with number of piles. In absence of loading data, the median pile size was calculated from all complete WY acres by number of pile combinations. This resulted in 1 acre per pile (n=24). For all pile burns without acreage then, acreage was set to 1 acre per pile. Fuel loading – no data, but will be calculated based on assigned NFDRS model.

- Additional notes: The pre-processing described above resulted in ~40K acres, distributed over 100 fire entries, and several burn agencies. One 11,000 fire was deleted from database upon recommendation as it never was burned (Personal communication, Gavin Lowell, 6/3/04).

DOI-1202

- Contact name and agency: [Confirm with source]
- Date received: [Confirm with source]
- Assumptions: All fires assumed to be broadcast burns. Location based on provided latitude and longitude or, alternatively, TRS coordinates. Fuel loading based on NFDRS fuels map, which was either provided in the data or derived from a GIS overlay with the NFDRS fuels map.
- Additional notes: This data set covered four agencies: BIA, BLM, FWS and NPS. It was clean and had ~180K acres, distributed over 707 fire records, all for Rx on USFS lands.

NIFPORS

- Contact name and agency: Susan Lee, USFS
- Date received: 4/20/04
- Assumptions: Fuel loading was not provided and was calculated based on NFDRS fuel loading map. Two large fires set to zero due to extreme outliers: UT Dixie National Forest D3 Adams Head (~25K acres) and D3 Sandford Creek (~10K acres). Both were broadcast burns. If kept in database, these fires would have been assigned to one-day event only.
- Additional notes: This data set was clean and had ~290K acres, distributed over 1,145 fire records, all for Rx on USFS lands.

FASTRAC (WA and OR)

- Contact name and agency: Jim Russell, USFS.
- Date received: 4/22/04

- Assumptions: None
- Additional notes: This data set was similar to data provided earlier by the state agencies in WA and OR. Hence, to avoid duplicate fire entries this data was not incorporated in the emission inventory. However, it was used in the quality assurance effort of the WA and OR state data.