AIR SCIENCES INC.

DENVER ▲ PORTLAND

FINAL

2005 Alaska Wildland Fire Emissions Inventory and Wildland Fire Emissions Inventory Template

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT NO. 217-2
JUNE 2007

CONTENTS

Page

Tables

CONTENTS - continued

Page

Figures

ACRONYMS

ADEC	Alaska Department of Environmental Conservation
AFS	Alaska Fire Service
AWFCG	Alaska Wildland Fire Coordinating Group
BLM	Alaska Bureau of Land Management
CFFDRS	Canadian Forest Fire Danger Rating System
CH_4	Methane
CO	Carbon Monoxide
EC	Elemental Carbon
EFIG	Emission Factor And Inventory Group
EPA	Environmental Protection Agency
ERF	Emission Reduction Factors
ERT	Emission Reduction Techniques
ESMP	Alaska's Enhanced Smoke Management Plan
FEJF	Fire Emissions Joint Forum
FEPS	Fire Emissions Production Simulator
FIPS	Federal Information Processing Standard code
FMOs	Fire Management Officers
FMZ	Fire Management Zone
FWS	Fish and Wildlife Service
GIS	Geographical Information Sciences
NFDRS	National Fire Danger Rating System
NH_3	Ammonia
NIFC	National Interagency Fire Center
NO_x	Oxides of Nitrogen
NPS	Alaska National Park Service
NWFCG	National Wildland Fire Coordinating Group
OAQPS	Office of Air Quality Planning and Standards
OC	Organic Carbon
PM_{10}	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
Prescribed Fire	Rx
SO_x	Oxides of Sulfur
VOC	Volatile Organic Compounds
WFU	Wildland Fire Use
WRAP	Western Regional Air Partnership

EXECUTIVE SUMMARY

The Alaska Department of Environmental Conservation (ADEC) in coordination with the Alaska Wildland Fire Coordinating Group (AWFCG) has developed Alaska's Enhanced Smoke Management Plan (ESMP). The ESMP and accompanying volume of appendices have been implemented by ADEC and participating wildland owners and managers. According to the ESMP, ADEC is responsible for collecting, reviewing, tracking, and summarizing statewide pre- and post-burn data for annual ESMP emissions inventory reports to be distributed to AWFCG, the U.S. Environmental Protection Agency (EPA), and the Western Regional Air Partnership (WRAP).

This report summarizes the development of emission estimates for fire for calendar year 2005 and summarizes the results for wildfire, wildland fire use (WFU), prescribed fire (Rx), and agricultural burning within the state of Alaska. In addition, a draft fire emissions inventory software tool (or "template"), intended to be used to calculate and report annual emissions in future years as required by the ESMP, is presented. ADEC has contracted Air Sciences Inc. to develop the 2005 emissions inventory for all types of fire in Alaska. The emissions inventory summary for 2005 is intended to suffice for the annual ESMP emissions inventory summary report.

Fire activity data were collected from federal databases as well as state sources for 2005. The federal fire activity data consisted of a national fire activity summary report prepared by the National Interagency Fire Center (NIFC). This information served as a reference data set in the quality assurance process. At the state level, data was provided by the Alaska Bureau of Land Management (BLM). This database consisted of a complete 2005 fire activity database, including wildfire, wildland fire use, and prescribed burning. Activity data on agricultural burning information was not collected by the BLM, as this type of burning is considered marginal in the state of Alaska (Personal communication, ADEC). Additional state-based resources included wildland fire use reports from the Alaska National Park Service (NPS) and Fish and Wildlife Service (FWS), and two post-prescribed burn reports provided by ADEC. These additional sources were used for the quality assurance process.

This final draft includes modifications based on specific feedback received regarding the draft report on the 2005 inventory during the comment period and in meetings with the AWFCG Air Quality Committee in January and March of 2007. The methodology for fuel consumption derivation has been modified significantly, affecting emissions results compared to the draft inventory. The final methodology for the Alaska 2005 fire emissions inventory is presented in the body of this report. The key differences between the methods used in the draft 2005 fire emissions inventory and the final 2005 fire emissions inventory are discussed in Appendix B.

The effects of the changes to the technical methods have been quantified and are also presented in Appendix B.

The fire activity data and emission estimates are summarized by fire type, spatial and temporal distribution, total acreage burned, and calculated emission estimates. The emission estimates are largely based on methodology developed as part of earlier WRAP-wide fire activity and emissions inventories. After all quality assurance procedures, 574 fire events remained in the inventory, totaling 4,664,428 acres of burned acres and 2,019,000 tons $PM_{2.5}$ emitted. The results indicate that in 2005 the fire activity in the state of Alaska was dominated by wildfire, compromising 97 percent of fire events, 96 percent of burned acres, and 97 percent of fire emissions. Wildland fire use accounted for 2 percent of fire events, 4 percent of burned acres, and 3 percent of fire emissions. Prescribed fire activity included four events of the emissions inventory totaling only 626 acres.

The deliverables for this project include:

- Report: "2005 Alaska Wildland Fire Emissions Inventory and Wildland Fire Emissions Inventory Template," Air Sciences Inc., June 2006 (delivered as PDF and Microsoft Word files): PDF – AK 2005 Fire EI_20060630.pdf; Microsoft Word – AK 2005 Fire EI_20060630.doc.

- 2005 fire emissions inventory files (delivered as .dbf files):
  - Event Emissions Inventory: ADEC2005_events_20060629.dbf
  - Daily Emissions Inventory: ADEC2005_daily_20060629.dbf

- Emissions Inventory Template (Microsoft Excel): event_template_20060629.xls

Electronic files of all deliverables can be downloaded from the web site www.airsci.com/adec/2005ei/ (all lower case).

SECTION 1

ALASKA 2005 FIRE EMISSIONS INVENTORY METHODS

1.1 Background

The purpose of this inventory is to provide a database of fire activity and emissions within the political boundaries of the state of Alaska for the calendar year 2005. Wildfire, wildland fire use, and prescribed burning on wildlands are included in this inventory. This report is intended to serve as the annual emissions inventory report for 2005 to be distributed to the AWFCG, EPA, and WRAP per the State of Alaska's Enhanced Smoke Management Plan (ESMP).

In two specific ways, the 2005 emissions inventory may underestimate total burning activity in AK. Reported agricultural burning activity (land clearing/agricultural burning) in the state in 2005 was minimal (<200 acres; Personal Communication, ADEC [Joan Hardesty], 6/23/2006) and is not included in the 2005 emissions inventory project. The 2005 fire emission inventory also does not include small fires. The reporting and permitting threshold for burns in AK is 40 acres (i.e., fires less than 40 acres do not require permits) and the state of AK has no means to track these fire events. The effect on the entire annual fire emission inventory from omitting agricultural burning and small fires is expected to be small.

Emissions calculation methodologies and emission factors were adapted from ongoing work commissioned by the Fire Emissions Joint Forum (FEJF) of the WRAP (Air Sciences Inc., 2004, 2005). Fire activity data for the inventory were gathered from public sources, including the National Interagency Fire Center (NIFC), and the Alaska Bureau of Land Management (BLM), National Park Service (NPS), and Fish and Wildlife Service (FWS). The raw data from the various sources were merged into a consistent and functional fire activity inventory for Alaska. For the purposes of this effort, a complete fire activity database was received from the BLM, thereby excluding the need for any gap-filling procedures. Additional available data resources were used for the quality assurance and control procedures.

Two emissions inventory files have been prepared as final deliverables for this project.

- 2005 ***Event*** Fire Emissions Inventory. The Event emissions inventory is comprised of the fire activity data as reported by the raw input database. Multi-day fire events are represented as a single event in the Event emissions inventory. Total emissions (the sum of flaming and smoldering emissions) are calculated for each event. This emissions inventory file is most suitable for preparing annual fire activity and emissions summaries. The Template (Section 3) is designed to produce an Event emissions inventory for subsequent years.

- 2005 ***Daily*** Fire Emissions Inventory. The Daily emissions inventory is comprised of individual fire and smoldering days. In the Daily emissions inventory, multi-day fire events have been disaggregated into daily events (acres) per day (see Section 1.6). This emissions inventory file is most suitable when spatially and temporally resolved fire data are necessary, such as input files for dispersion models or for analyses to link daily emissions to monitored ambient air concentrations of pollutants.

1.2 Emissions Calculation Equation

The Alaska fire emissions inventory process adopts techniques developed by the WRAP (Air Sciences Inc., 2004, 2005). The general fire emissions calculation follows Equation 1:

$$\underset{\text{(ton pollutant)}}{\textit{Emission Mass}} = \underset{\text{(acre)}}{\textit{Fire Size}} * \underset{\text{(ton/acre)}}{\textit{Fuel Consumption}} * \underset{\text{(lb/ton)}}{\textit{Emission Factor}} * \underset{\text{(ton/lb)}}{0.0005} \tag{1}$$

Emission mass (tons of each pollutant estimated) are calculated for each event (in the Event emissions inventory) and for each fire and smoldering day (in the Daily emissions inventory). Fire size is a site-specific input provided in the raw input data. Fuel consumption values are selected from spatial data layers (e.g., fuel model map) and reference (Microsoft Excel lookup) tables based on input data and fire location (see Section 1.4). Emission factors are selected from reference (Microsoft Excel lookup) tables based on EPA- and WRAP-accepted emission factors from the literature (see Section 1.5). The pollutants to be inventoried are 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), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), carbon monoxide (CO), volatile organic compounds (VOC), methane (CH_4), and ammonia (NH_3).

1.3 Fire Activity Data Compilation

1.3.1 Data Sources

Fire activity data were collected from several sources (Table 1.1). The data set provided by NIFC contained substantially fewer fire acres than reported in the national summary report (NIFC, 2005), which reported approximately 4.6 million fire acres in Alaska for 2005. A complete database with fire activity, including wildfire, WFU, and prescribed fire was obtained from the BLM. This data set included all required data fields to build the emissions inventory. Moreover, this data set also contained a unique identifier linking the fire activity database to the Geographical Information Science (GIS) shape files containing fire perimeters. The fire perimeters were downloaded from the Alaska Geospatial Clearinghouse web site. Information on specific WFU events was obtained from the NPS and FWS and used to verify fire type designations in the larger fire activity database. Finally, ADEC provided post-burn prescribed fire reports, which were also used to verify fire type designations in the larger fire activity database.

Table 1.1: Wildfire, Prescribed Fire, and Agricultural Burning Activity Data Sources

Data Source Code	Source Type	Data Source	Description
NIFC	Wildfire	National Interagency Fire Center, Boise ID	2005 National wildfire activity database for large fire incidents.
NIFC	Wildfire	National Interagency Fire Center, Boise ID	National fire activity summary report "2005 Statistics and Summary."
AK BLM/AFS	Wildfire, WFU, Prescribed	Bureau of Land Management, Alaska Fire Service	Database with wildfire, WFU, and prescribed fire activity.
AKFIREHIST	Wildfire, WFU	Alaska Geospatial Clearinghouse (online)	Spatial GIS layers describing Alaska fuel models and wildfire and WFU fire perimeters in 2005 for event greater that 100 acres.
AK NPS	WFU	National Park Service	WFU fire names, locations, dates, and acreages on NPS managed lands.
AK FWS	WFU	Fish and Wildlife Service	WFU fire names, locations, dates, and acreages on FWS managed lands.
AK DEC	Prescribed	Alaska Department of Environmental Conservation	Post-burn prescribed fire reports.

1.3.2 Data Compilation

Based on the fire activity database, adjusted with the input from the additional data sources, data were then collapsed into a smaller fire activity database that only contains the data fields essential to the emissions inventory. The data fields are summarized in Table 1.2.

Table 1.2: Site-Specific Activity Parameters Collected

Parameter	Data Type	Format
Fire identifier	Text	Fire event name or summary description
Source type	List	Wildfire, prescribed, or WFU
Burn type	List	Broadcast or pile burn[1]
Lat/Lon location	Value	Latitude and longitude coordinates
Start date	Number	YYYYMMDD
End date	Number	YYYYMMDD
Area burned	Value	Acres
Fuel class	List	NFDRS[2] letter code or vegetation designation
Fuel consumed	Value	Tons (if supplied)

[1] A burn type of "broadcast" or "pile" burn should be determined for each fire event. Prescribed burns can be executed either as broadcast burns (fuels scattered over the area to be burned) or as piled burns (fuels from an area collected in localized piles before ignition). Each type of fire has a unique pollutant emission factor (Battye/Battye, 2002). Due to the lack of information in the Alaska data on the type of prescribed burn, all prescribed fires were considered broadcast burns. All wildfire and WFU events were considered broadcast burns.

[2] National Fire Danger Rating System

The fire event information was extracted directly from the raw data where available. In some cases a translation of the data into essential units or formats was necessary, including:

- Coordinate location to be standardized to decimal degrees of latitude and longitude.
- Date notations to be standardized from MM/DD/YY to YYYYMMDD format.
- Source type to be recorded based on the origin of the raw data file.
- Burn type to be assumed to be "broadcast" unless "pile" burn is indicated.
- Using the coordinates in the activity database, a geographic information system was used to obtain county name, state Federal Information Processing Standard code (FIPS), and county FIPS from the county layer of the National Atlas of the United States. Coordinate locations were overlaid on the county map with the relevant attribute data and then written to the activity database. (For the purpose of describing data fields and statistics used in this inventory, the term "county" refers to boroughs and census areas that subdivide the state of Alaska.)

1.4 Fuel Consumption Assignment

In order to calculate emissions, the activity data must include either total mass of fuel consumed or a fuel class. The fuel class selection process made use of the National Fire Danger Rating System (NFDRS) and the Canadian Forest Fire Danger Rating System (CFFDRS). The CFFDRS system served as the primary source of fuels information as it is used by the BLM and Alaska Fire Service (AFS) (who manage the majority of all fire activity in Alaska). The information for the fuel loading and associated fuel consumption was selected using the following modified hierarchy:

1. Fire Manager-assigned fuel description cross-walked to CFFDRS fuel model.

   The raw database did not provide quantitative fuel loading or total fuel consumption. However, there were 80 records with a primary vegetation type (fuel model) assigned by the Fire Manager. These primary fuel categories were specific enough to cross-reference these with the CFFDRS fuels models and to assign a fuel model to each of the fires. For the remaining majority of the records, a GIS technique was utilized to derive fuel consumption rates for each event.

2. Fuel consumption refinement technique utilizing fire perimeters, GIS spatial layer of CFFDRS fuel models, and calculated weighted fuel consumption rate (see Section 1.4.1).

3. Single CFFDRS fuel model applied to the entire event derived by fire location and GIS drop onto spatial layer of CFFDRS fuel models.

   For any event greater than 100 acres for which a fire perimeter was available, the refined fuel consumption method described in Section 1.4.1 was used. For all remaining fires, a CFFDRS model was assigned with a GIS-based overlay of the fire location, provided in the data as a *latitude-longitude pair, with the CFFDRS GIS map, (Figure 1.1) provided by the AFS (BLM and Alaska Fire Service, 2007). The assigned fuel model and associated fuel consumption rate was used to represent the entire fire event.*

4. Single NFDRS fuel model applied to the entire event derived by fire location and GIS drop onto spatial layer of NFDRS fuel models. This was done for events that returned a "null" or "undefined" value when using the CFFDRS spatial fuel layer.

   For several events, the CFDRS overlay resulted in an "undetermined" value, in many cases corresponding to areas with rock or glaciers, but in others it was unclear. In addition, the 30-meter resolution of the map allowed for inclusion of rivers in the data set, resulting in some fires showing up on the edge of a river boundary and given a "water" value. In these cases, the NFDRS classification derived from a lower-resolution map (Figure 1.2) was used as a basis for a crosswalk. This affected a small fraction of the total acreage, and therefore it was not expected to alter the results significantly.

   Since default fuel consumption values for CFFDRS classes have not been published, the fuel consumption was based on the WRAP-modified NFDRS classes in Table 1.3 (Air Sciences Inc., 2004). The modified classes were broken out by fire type, specifically by wildfire and prescribed burning. These fuel consumption rates include the default NFDRS loadings for dead and live fuel, with additional duff and crown biomass, and assumptions about the percent of each consumed (for further discussion, see Appendix A). Based on the fuel class descriptions, the NFDRS classes were cross-walked to corresponding CFFDRS classes based on those present in Figure 1.1. For CFFDRS classes O1a/O1b and M1/M2, the average of the two corresponding NFDRS classes was used. Total fuel consumption (tons fuel consumed per event or per fire day) is then calculated by looking up nominal per-acre fuel model-specific fuel consumption rates (stored in reference tables) from each fuel model, and multiplying by the acres in the fire event.

5. All records with fire perimeter information are adjusted for seasonality based on month and CFFDRS fuel class (see Section 1.4.2).

Table 1.3: WRAP-Modified Fuel Consumption for NFDRS Fuel Model, Cross-Walked to CFFDRS

Fuel Model	Description	Wildfire/WFU Fuel Consumption (ton/acre)	Prescribed Fire (ton/acre)	CFFDRS Crosswalk
A	Western grasses (annual)	0.5	0.5	O1a/O1b
F	Intermediate brush	15	15	M1/M2
G	Short needle (heavy dead)	43.5	25.6	M1/M2
L	Western grasses (perennial)	0.75	0.75	O1a/O1b
Q	Alaskan black spruce	57.57	48.76	C2
R	Hardwood litter (summer)	3.05	3.05	M1/M2
S	Tundra	19.3	19.05	O1

Figure 1.1: 30-Meter CFFDRS Fuel Classification Layer (BLM and Alaska Fire Service, 2006)

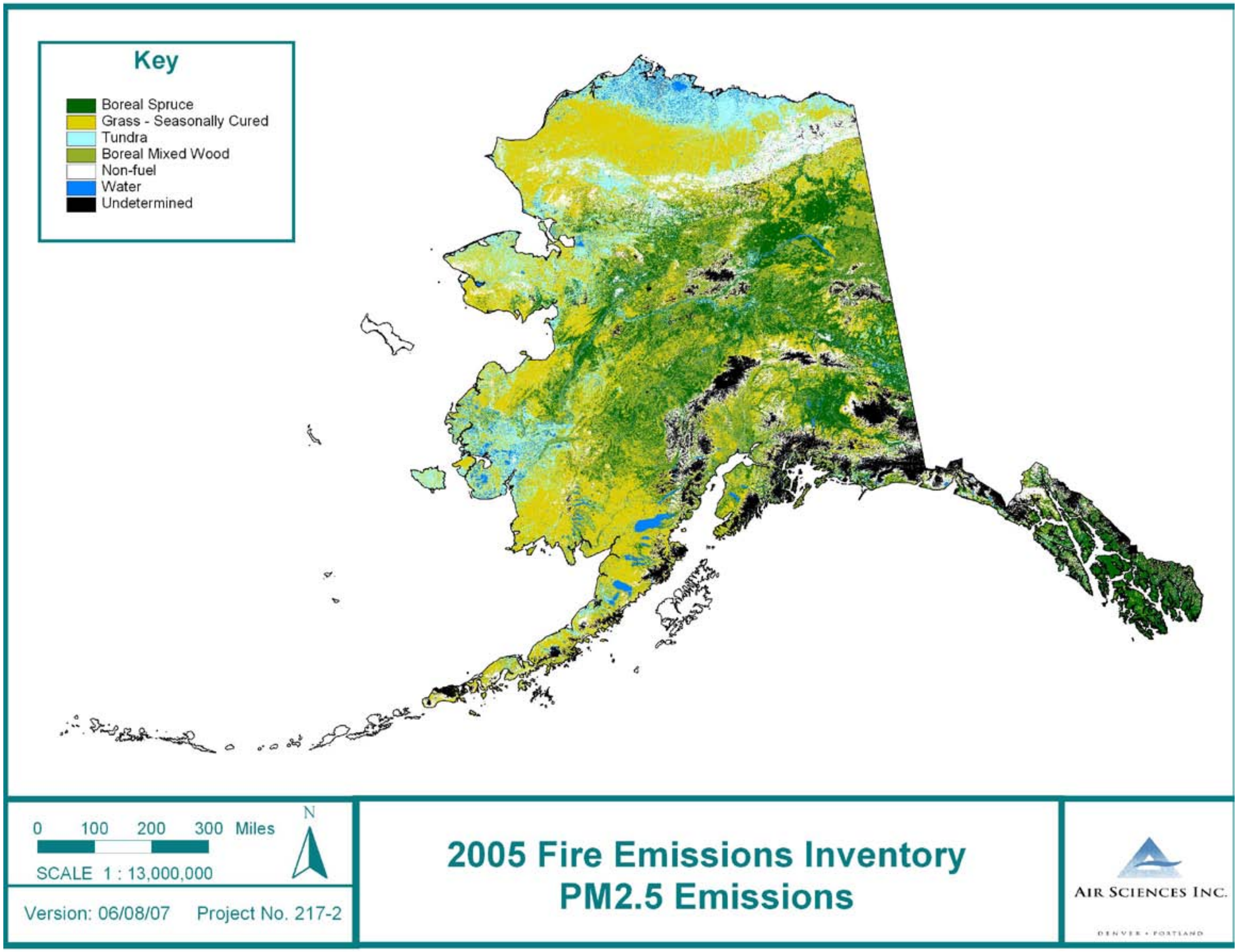
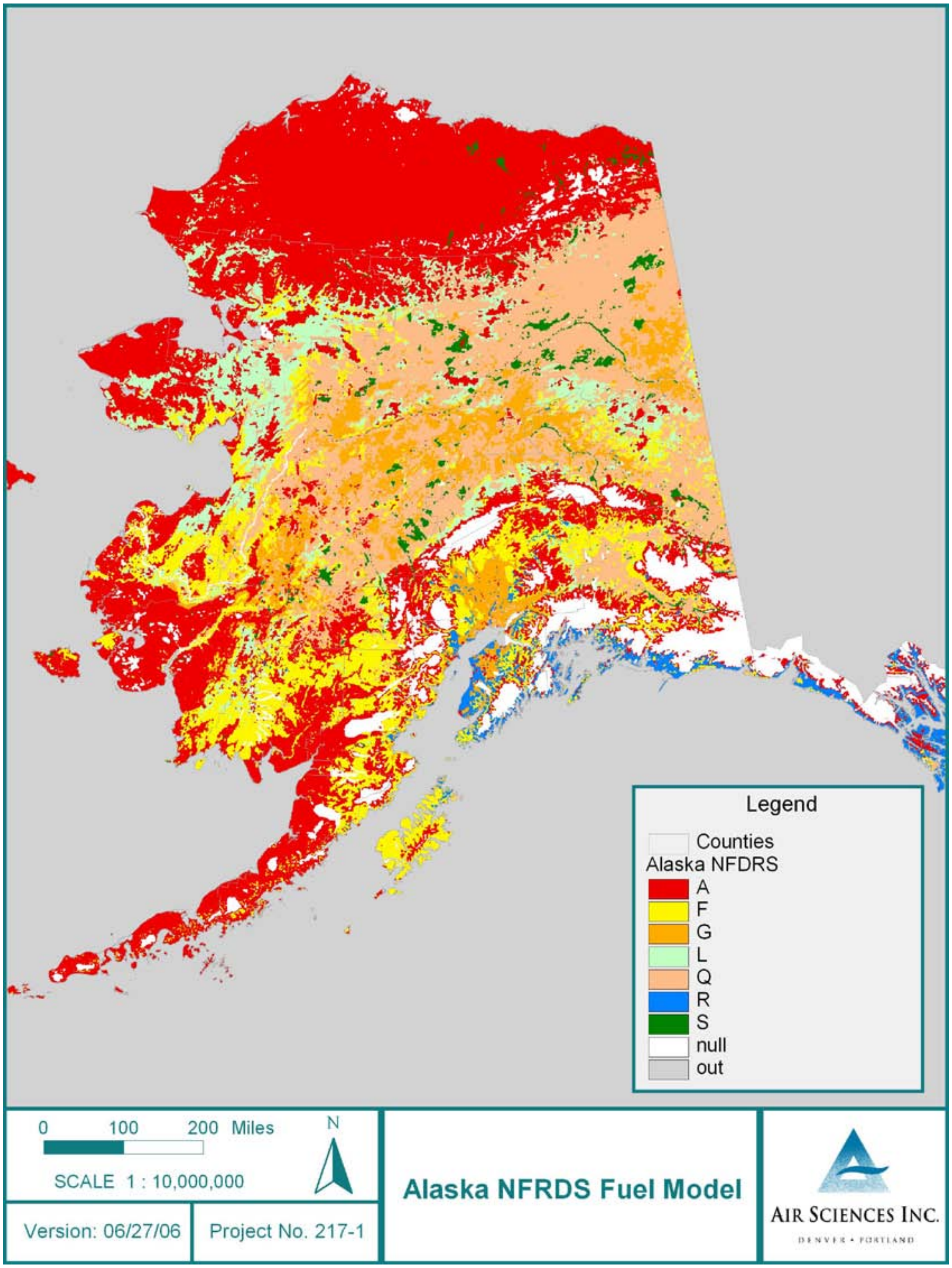


Figure 1.2: NFDRS Fuels Models Map for Alaska (Alaska Geospatial Clearinghouse, 2006) "Null" (white) indicates non-burnable areas such as rock, glaciers, and water. "Out" (grey) indicates areas outside of the Alaska landmass. Fires that fell in either of these classes were removed from the inventory.



Fire locations were plotted on the CFFDRS fuel model coverage map, and the corresponding fuel model code was recorded to the activity record. The fire locations extracted from the raw database are shown in Figure 1.3 (blue circles). The following steps were involved in the spatial overlay of the fire locations with the CFFDRS fuel model map:

1. A data point for each fire is created from its latitude and longitude recorded in the fire activity.
2. The fire point is converted to the projection coordinates of the CFFDRS map. (Conversion from latitude/longitude to Lambert Equal Area Azimuthal)
3. The fire point is intersected with the NFDRS Fuel Model map.
4. The fuel model of the grid cell at that point is identified and saved to a new column in the fire activity record.
5. The numeric code from the GIS overlay is translated to the standard CFFDRS Fuel Model letter code using a reference table.

1.4.1 Fuel Consumption Refinement

For fires greater than 100 acres, GIS-based fire perimeters were available from an Alaska fire history spatial layer (Alaska Geospatial Clearinghouse web site). The shape file with individual fire perimeters (Figure 1.3, red polygons) was used to refine the fuel loading assignment by calculating an area-weighted fuel loading based on the distribution of the CFFDRS fuel models within a fire perimeter. The area-weighted fuel loading was determined by using GIS to overlay the fire perimeters on the CFFDRS fuel model map and calculating the area of a fire in each fuel type. For some events, the CFFDRS fuel model map, which has a resolution of 30 meters, shows a portion of the event on areas with zero fuel loading (e.g., rock, water, or snow). The percent area of each fuel type within each fire perimeter was calculated for the entire area of the fire, including these areas of zero fuel loading. This calculation technique of the weighted fuel loading method eliminates a potential source of over-estimation fuel loading for large fires. The fuel consumption refinement method is illustrated in Figure 1.4.

The refined 2005 fire emission inventory calculations are based on the more refined weighted fuel consumption for all fires greater than 100 acres and on the point-base fuel consumption (either from the description from raw data or in CFFDRS) for the smaller fires. This method improves the accuracy of the estimated fuel consumption of individual fires and therefore improves the accuracy of the distribution of emission estimates. This is particularly relevant should the 2005 emissions inventory be used as input for atmospheric smoke dispersion modeling, a process sensitive to the temporal and spatial accuracy of the input information. Figure 1.5 illustrates a significant reduction in fuel consumption from using the refinement technique.

Figure 1.3: Fire Locations and Perimeters Extracted From the Raw Data

Individual fire locations that fell within the Alaska landmass (blue circles) and the fire perimeters for fires greater than 100 acres (red polygons).

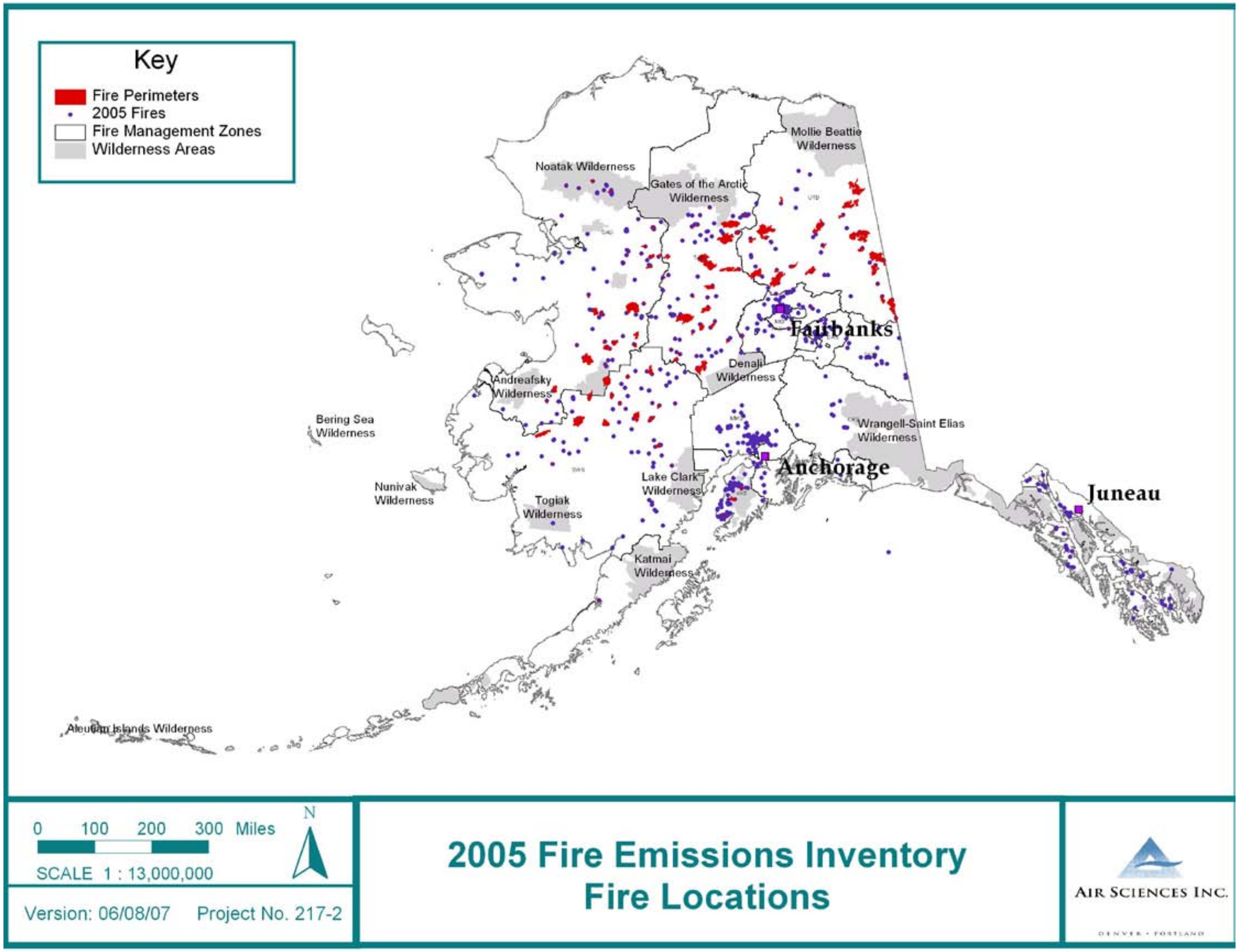
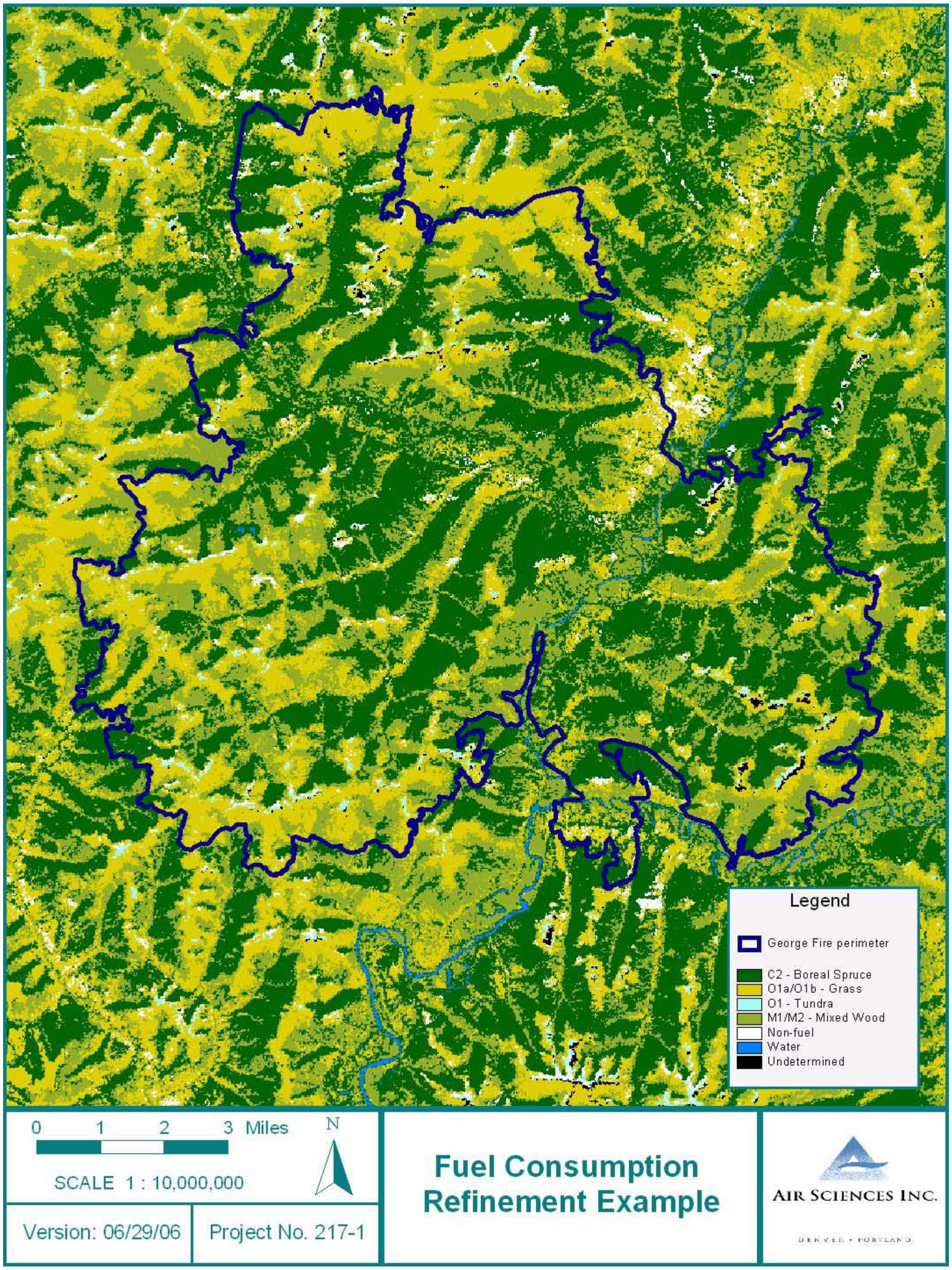


Figure 1.4: Fuel Consumption Refinement Example

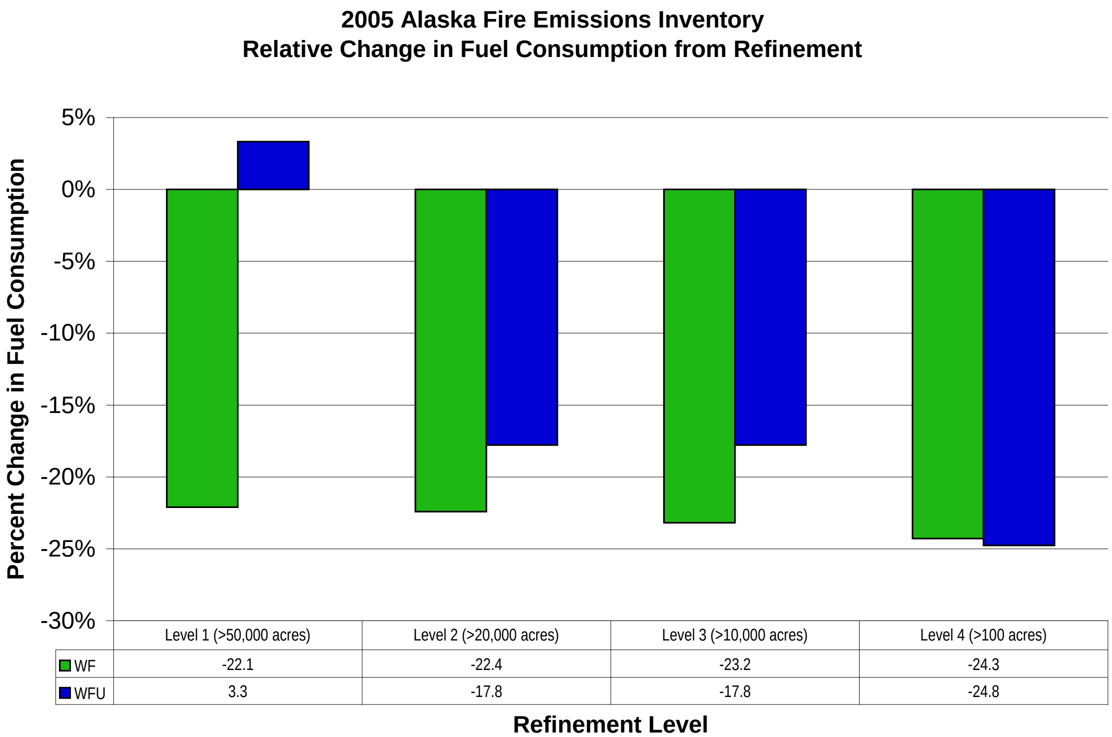
A fire perimeter overlain on the CFFDRS fuel map. The table below shows the areas associated with each fuel model within the perimeter, used to calculate the weighted fuel consumption.



	Percent Area in Fuel Model						
Fire Key	**C2**	**O1a/O1b**	**O1**	**M1/M2**	**Non-fuel**	**Water**	**Undetermined**
551	43%	23%	1.0%	31%	1.7%	0.15%	0.38%

Figure 1.5: Comparison of Estimated Fuel Consumption Data

The bars indicate the relative change in estimated fuel consumption for wildland fire (green bars) and WFU (blue bars). The refinement levels represent the application of area weighted fuel consumption estimates at four levels of fire size: Fires greater than or equal to 50,000 acres (Level 1), fires greater than or equal to 20,000 acres (Level 2), fires greater than or equal to >=10,000 acres (Level 3), and fires greater than or equal to >=100 acres (Level 4).



1.4.2 Fuel Consumption Seasonality

Deriving fuel consumption using cross-walked CFFDRS fuel loadings in Table 1.3 assumes 100 percent consumption over the entire year, which does not account for seasonal differences such as fuel moisture, soil moisture, or frozen soil. Air Sciences and the AWFCG Air Quality Committee explored several ways to account for seasonal differences in fuel consumption. The method that was agreed upon and implemented for this project relied upon some relatively resolved fuel consumption estimates prepared for a separate project performed by Air Sciences (Inter-RPO 2002 National Wildfire Emission Inventory [Air Sciences and ECR, 2007]).

In the Inter-RPO project, the Fire Emissions Production Simulator (FEPS) was used to develop seasonal fuel consumption estimates for each NFDRS class under multiple moisture regimes (from very wet to very dry). For this project, these fuel consumption estimates were cross-walked to CFFDRS in the same manner as presented in Table 1.3. Further details of the process implemented for the 2005 Alaska Fire EI are provided in Appendix B.

With the help of several Alaska FMOs (Fire Management Officers that work for AK DNR – Division of Forestry), a seasonality matrix was created for Alaska based on six fuel moisture regimes: Very Dry, Dry, Moderate, Moist, Wet, and Very Wet[1]. For each month of the year, a moisture regime was assigned for the Interior and all other regions, shown in Table 1.4. In addition, Fire Management Zones were classified as Interior or Other, shown in Table 1.5.

Table 1.4: Monthly Moisture Regimes for the Alaskan Interior and All Other Regions

Month	Interior	Coastal
January	Very Wet	Very Wet
February	Very Wet	Very Wet
March	Moist	Very Wet
April	Moderate	Moist
May	Dry	Moderate
June	Very Dry	Dry
July	Very Dry	Very Dry
August	Very Dry	Very Dry
September	Dry	Dry
October	Moderate	Moist
November	Very Wet	Wet
December	Very Wet	Very Wet

Table 1.5: Location Classification of Fire Management Zones in Alaska

Fire Management Zone	FMZ Abbr.	Location Class
Galena (AFS)	gad	Interior
Tanana (AFS)	tad	Interior
Upper Yukon (AFS)	uyd	Interior
Military (AFS)	mil	Interior
Fairbanks (DOF)	fas	Interior
Delta (DOF)	das	Interior
Tok (DOF)	tas	Interior
Copper River (DOF)	crs	Interior
Matanuska-Susitna (DOF)	mss	Coastal
Kenai-Kodiak (DOF)	kks	Coastal
Southwest (DOF)	sws	Interior
Haines (DOF)	hns	Coastal
Chugach National Forest (USFS)	cgf	Coastal
Tongass National Forest (USFS)	tnf	Coastal

[1] See Appendix B, Table B.1, for a list of fuel consumption values associated with each moisture regime.

The following steps assigned a seasonal fuel loading to each fire event:

1. Each fire event in the inventory is assigned a month based on the reported start date.
2. A GIS overlay is done to assign each fire to the proper fire management zone (FMZ).
3. Each fire is assigned a moisture regime based on month and FMZ.
4. A lookup routine assigns a seasonal fuel loading to each fire based on CFFDRS class (previously assigned) and moisture regime.

This procedure was executed for all fires event in 2005. Appendix B explores the effect of introducing seasonal fuel consumption on the emissions results.

1.5 Emission Factors

Emission factors for wildfire and prescribed fire were assigned based on the WRAP Phase II 2002 fire emissions inventory (Air Sciences Inc., 2005). The WRAP emission factor suite includes separate emission factors for wildfire, WFU, and prescribed broadcast burns and for prescribed pile burns (Table 1.4). The WRAP suite was based on two emission factor reference sets: The U.S. Environmental Protection Agency's AP-42 Section 13.1 and a report titled "Development of Emission Inventory Methods for Wildland Fires" (Battye/Battye, 2002) 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 1.6: WRAP-Modified Emission Factors

Pollutant	Broadcast Burns (lbs/ton)	Piled Burns (lbs/ton)
$PM_{2.5}$	24.1	8.0
PM_{10}	28.1	8.0
SO_2	1.7	1.7
NO_X	6.2	6.2
VOC	13.6	6.3
CO	289	74.3
PM	34.1	12
EC	1.5	0.6
OC	11.6	4.3
CH_4	13.6	7.7
NH_3	1.3	0.5
PM-Coarse	4.0	0

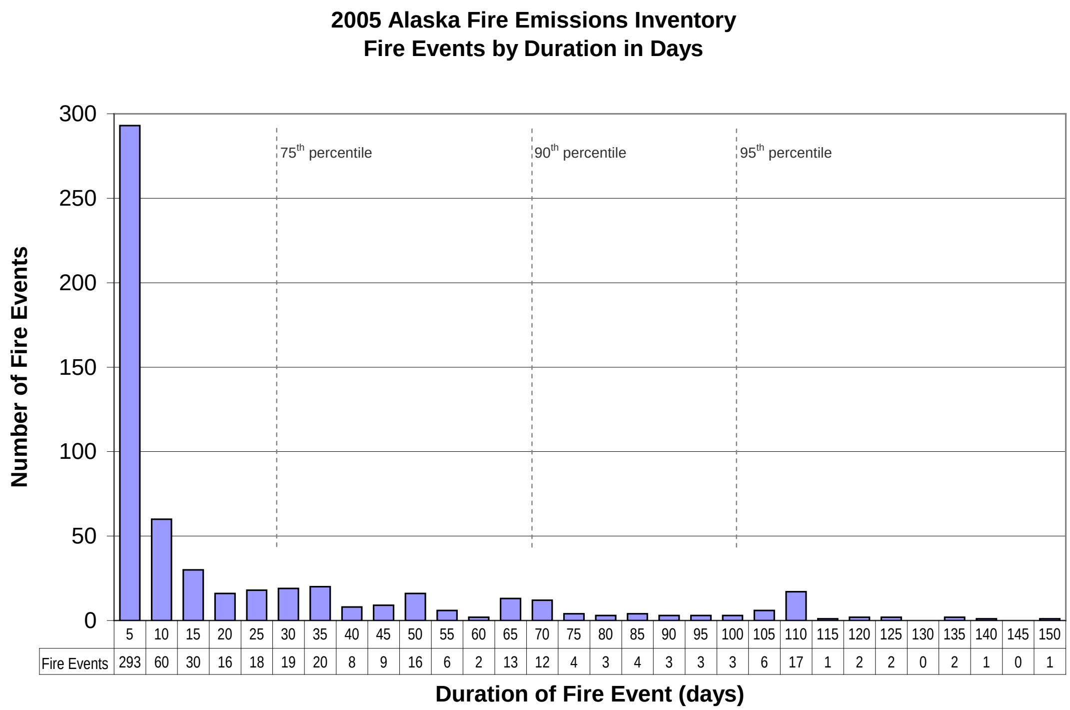
1.6 Conversion from Fire Events to Daily Fire Records

The raw input data reports fire events in terms of its start (typically date of discovery) and end (typically date controlled) date. These multi-day fires are referred to as "events" and are represented as a single record in the Events emissions inventory. For the Daily emissions inventory, it is necessary to disaggregate events into fire days (e.g., the acres burned per day over the duration of the event). Based on the start and end dates, the duration of the fire events can be calculated (Figure 1.6). The frequency distribution of the duration (Figure 1.6) indicates that while the majority of fires are relatively short (50 percent of fire events last four days or less), there is a significant portion of 2005 fire events that are of long duration (some last up to five months [147 days maximum]). The percentile cutoffs (Figure 1.6) show that 25 percent of fires lasted more than 26 days (75^{th} percentile), 10 percent of fires lasted more than 66 days (90^{th} percentile), and 5 percent of fires lasted more than 103 days (95^{th} percentile).

For the Daily emissions inventory, fire acreage and emissions for the multi-day fires events in the refined 2005 emissions inventory were evenly distributed between the start and end date of the fire. Using this approach, the activity data reflects an estimate of the activity (acres, fuel consumption, and emissions) burned per location per day. In this manner, each row in the daily activity data file represents a "fire day," rather than an entire fire event. Only multi-day fire events greater than 100 acres in fire event size were distributed to the daily temporal scale. Fires less than or equal to 100 acres were assigned in their entirety to the activity record's start date. The conversion from the fire events database to the daily fire activity database was performed in ArcView using a processing script that automatically identifies all the fire events to be re-distributed, calculates the new daily acres, and states the "new" fire records to a new database. This process was applied to 156 fire events, totaling 4,660,881 acres (99.9 percent of the total fire acres).

Figure 1.6: Distribution of Fire Events by Duration in Days

The bars indicate the proportion of fire events by duration bin (days). Vertical lines indicate the 75th, 90th, and 95th percentiles, respectively, 26, 66, and 103 days. For example, 25 percent of the fire events are longer than 26 days in duration.



	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
Fire Events	293	60	30	16	18	19	20	8	9	16	6	2	13	12	4	3	4	3	3	3	6	17	1	2	2	0	2	1	0	1

1.7 Additional Smoldering Emissions for Wildland Fire

Emissions due to smoldering were added to the emissions inventory in two ways. The primary technique was used for all fires with a seasonal fuel loading derived by one of the methods outlined in Section 1.4.2. For all fire manager-assigned fuel loadings, smoldering was estimated consistent with the WRAP methods (Air Sciences Inc., 2005, Phase II report). For all fire, fuel density was calculated as the daily fuel consumed divided by daily fire acres. If the fuel density was greater than 5 tons per acre, smoke emissions from smoldering consumption were calculated.

Seasonal smoldering fuel loadings were derived in the Inter-RPO 2002 National Wildfire Emission Inventory as unique values for each NFDRS class and moisture regime (see Section 1.4.2). Inter-RPO seasonal smoldering fuel loadings were cross-walked to CFFDRS. The total fuel loading for each fire in the Event emissions inventory was then augmented to include both the flaming and smoldering fuel loadings.

In the Daily emissions inventory, to account for smoldering, for every wildfire and prescribed burn activity record tied to a specific date, a new activity record was inserted into the database on the subsequent day. On this inserted day, the smoldering day, smoldering emissions were calculated if the fuel density was greater than the threshold (5 tons per acre). If the fuel density was below the threshold, smoldering emissions were set to zero. In the resulting database, an additional data field ("Smolrec") was created to indicate whether the emissions in that row are regular flaming phase emissions (value=0) or following day smoldering phase emissions (value=1). This allows the user of the database to distinguish between emissions from each fire phase.

1.8 Quality Assurance and Quality Control

A critical task in the development of the 2005 fire emissions inventory was to implement quality assurance and control measures to (1) check the quality of raw input data and (2) to review the processes used to develop the fire activity database and emissions inventory for potential errors.

First the raw database, the source database, was checked against the detailed reports received from other agencies. The source database consisted of a complete fire activity data set provided by the BLM and AFS (define). Additional information on specific WFU events was obtained from the NPS and FWS and used to verify fire type designations in the source database. Based on this crosswalk, two additional WFU events on FWS land were identified in the source database. ADEC provided post-burn prescribed fire reports, which were used to verify fire type designations in the source database. There were no discrepancies between these reports and the assigned fire designation in the source database.

Second, there were 57 wildfire events in the source database that had zero acres associated with them. These events were all labeled as false alarms and removed from further analyses.

Third, the visual locations of the fire locations were checked using GIS analysis, by overlays with the NFDRS fuel-loading map. These overlay procedures resulted in identifying several fire events without fuel loadings because their coordinate location fell on ocean, other water, snow or glaciers, or within Canada. With the exception of one fire, all of these events were less than 60 acres and the majority less than 1 acre. This resulted in 53 events, totaling 77 acres, without fuel loading that were dropped from the inventory. One fire event without fuel loading was 17,000 acres, and its coordinate fell into Canada. For this large fire, the coordinate was changed to be in Alaska by using the center of the fire perimeter, and a new NFDRS Fuel Model was determined by repeating the procedure.

Fourth, using GIS scripts, all fire locations were overlaid with the county layer from the National Atlas to garner an independently "GIS-obtained" state and county FIPS codes. The GIS-obtained state FIPS were then verified to match the county name, if indicated, in the source data. Fires that fell outside the state, or where the source county name did not match the GIS-obtained county name, were investigated.

Fifth, the accuracy of the data processing was checked by tracking the subtotal and total fire events, fire acres, and emissions from the source data through to the final 2005 emissions inventory to insure that fire records were carried over consistently from one data processing step to the next.

Finally, a comparison was made of the total fire acres by fire type in the activity database and total acres as published in reference fire activity summaries. The reference sets consisted of the national 2005 fire summary (NIFC, 2005) and the statewide fire summary for Alaska (BLM and Alaska Fire Service, 2005). This comparison indicated that the 2005 fire activity database described in this report is within 0.3 percent of the acreage reported by the AFS and a deviation of about 1 percent from the national fire summary report by NIFC. Based on these small relative differences in estimated fire acres, the source data appears to represent the total fire activity in the state very well. No further steps were taken to research the differences in total fire acres.

Table 1.7: Comparison of 2005 Fire Acres With Published Summary Reports

Data Source	Wildfire	WFU	Wildfire + WFU	Prescribed Fire
2005 Emission Inventory	4,493,846	169,956	4,663,802	626
BLM AFS Summary	---	---	4,649,597	---
NIFC National Summary	4,440,149	168,595	4,608,744	626
Deviation from BLM AFS Acres (Percent)	---	---	14,205 (+0.3%)	---
Deviation from NIFC Acres (Percent)	53,697 (+1.2%)	1,361 (+0.8%)	55,058 (+1.2%)	0 (0)

SECTION 2

ALASKA 2005 FIRE EMISSIONS INVENTORY RESULTS

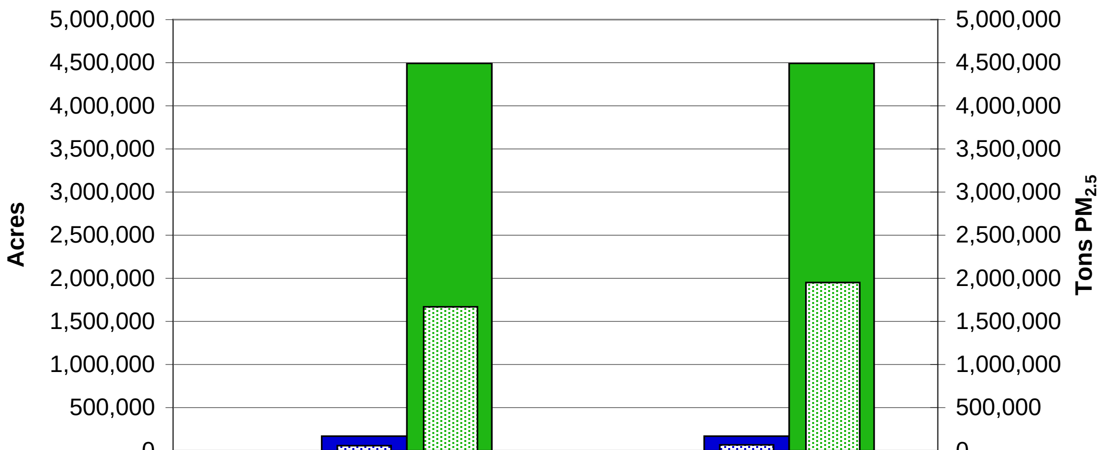
Several charts (with associated data tables), maps, and tables are presented in this section to display the results of the 2005 Fire Emissions Inventory for Alaska. Quantitative results (e.g., tons of $PM_{2.5}$ due to wildfire events in 2005) are presented as displays of the spatial and temporal distribution of fire events in 2005. Spatial data are displayed by county and by Fire Management Zone (FMZ). FMZ boundaries are established by the state of Alaska and are included for the benefit of Alaska Fire Managers. Similarly, in addition to federal fire size classes the National Wildland Fire Coordinating Group (NWFCG) fire size classifications are used to present data. The NWFCG classification scheme helps to resolve the distribution of smaller fires.

Table 2.1: Data Results Summary

Parameter	Wildfire	WFU	Prescribed Fire	Total
Number of Fire Events	558	12	4	574
Fire Acres	4,493,846	169,956	626	4,664,428
Emissions (Tons)				
$PM_{2.5}$	1,951,420	67,344	210	2,018,974
PM_{10}	2,275,307	78,521	245	2,354,074
Elemental Carbon (EC)	121,458	4,192	13	125,662
Organic Carbon (OC)	939,273	32,415	101	971,788
SO_2	137,652	4,750	15	142,417
NO_x	502,025	17,325	54	519,404
VOC	1,101,216	38,003	119	1,139,338
CO	23,400,846	807,569	2,522	24,210,937
CH_4	1,101,216	38,003	119	1,139,338
NH_3	105,263	3,633	11	108,907

Figure 2.1: Summary of Fire Acres and $PM_{2.5}$ Emissions by Fire Type

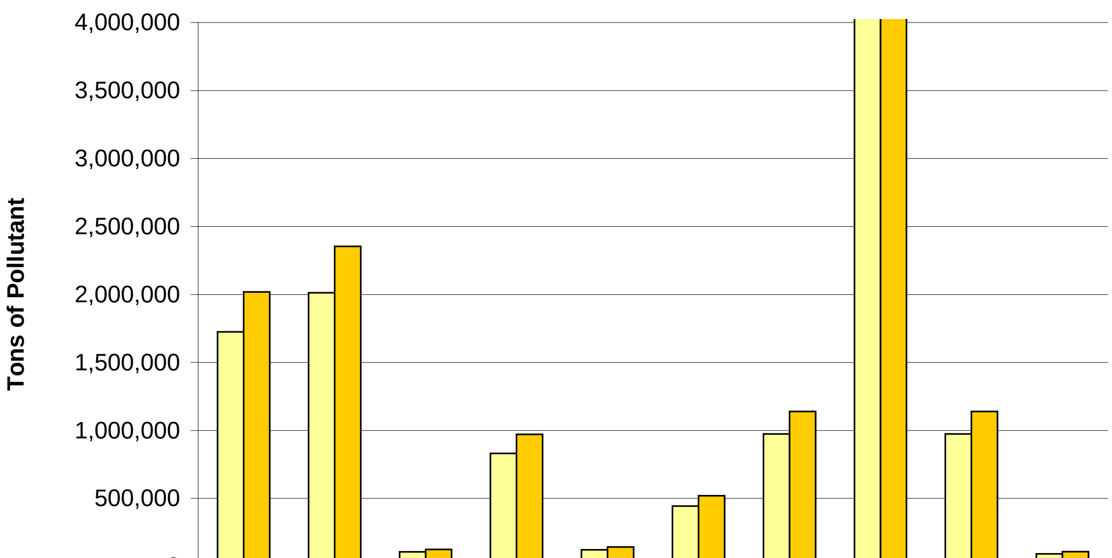
2005 Alaska Fire Emissions Inventory
Flaming Versus Flaming Plus Smoldering Acres and Tons $PM_{2.5}$



	Flaming	Flaming + Smoldering
Prescribed acres	626	626
WFU acres	169,956	169,956
Wildfire acres	4,493,846	4,493,846
Prescribed PM2.5	189	210
WFU PM2.5	57,562	67,344
Wildfire PM2.5	1,667,910	1,951,420

Figure 2.2: Summary of Total Emissions by Pollutant

2005 Alaska Fire Emissions Inventory
Flaming Versus Flaming Plus Smoldering by Pollutant



	PM2.5	PM10	EC	OC	SO2	NOX	VOC	CO	CH4	NH3
Flaming	1,725,682	2,012,102	107,408	830,619	121,729	443,951	973,829	20,693,862	973,829	93,087
Flaming + Smoldering	2,018,997	2,354,100	125,664	971,799	142,419	519,410	1,139,351	24,211,208	1,139,351	108,909

Table 2.2: Acres Burned (and Number of Fire Days) by County and Month for All Fire Types

Acres Burned in and Number of Wild, Prescribed and
WFU Fires by Fire Type and County

Acres Burned
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

Acres (Number of Events)

		Month									
Fire Type	County	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Acres Burned (Number of Events)
Wildfire	Yukon-Koyukuk	0 (0)	0 (0)	9,053 (4)	390,975 (76)	900,052(122)	1,642,497(188)	1,123,775(112)	0 (2)	0 (0)	4,066,352(284)
	Southeast Fairbanks	0 (0)	202 (4)	753 (13)	18,201 (9)	49,004 (19)	71,424 (8)	59,930 (10)	0 (0)	0 (0)	199,515 (48)
	Bethel	0 (0)	0 (0)	0 (2)	3,673 (7)	16,092 (4)	136,143 (23)	13,340 (0)	0 (0)	0 (0)	169,247 (29)
	Northwest Arctic	0 (0)	0 (0)	15 (0)	4,697 (7)	8,895 (23)	6,561 (8)	1,688 (6)	0 (0)	0 (0)	21,857 (25)
	Kenai Peninsula	0 (0)	218 (7)	3,111 (4)	2,519 (6)	2,413 (3)	2,397 (1)	2,319 (3)	2,397 (1)	232 (0)	15,605 (17)
	Denali	0 (0)	0 (0)	0 (0)	1,017 (4)	1,780 (4)	3,904 (3)	4,403 (2)	529 (1)	0 (0)	11,632 (9)
	Lake and Peninsula	0 (0)	0 (0)	1,316 (1)	3,635 (1)	9 (1)	0 (0)	0 (0)	0 (0)	0 (0)	4,960 (2)
	Fairbanks North Star	0 (0)	4 (3)	457 (22)	1,449 (9)	801 (7)	439 (2)	420 (1)	126 (1)	0 (0)	3,695 (31)
	Haines	0 (0)	0 (0)	0 (0)	0 (0)	86 (1)	41 (0)	68 (1)	70 (5)	66 (1)	330 (6)
	Skagway-Hoonah-Angoon	0 (0)	8 (0)	242 (5)	55 (9)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	306 (11)
	Valdez-Cordova	0 (0)	38 (1)	31 (2)	53 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	122 (3)
	Nome	0 (0)	0 (0)	0 (0)	0 (0)	67 (0)	50 (0)	0 (0)	0 (0)	0 (0)	117 (0)
	Dillingham	0 (0)	0 (0)	0 (0)	0 (0)	57 (0)	0 (0)	0 (0)	0 (0)	0 (0)	57 (0)
	Matanuska-Susitna	0 (0)	2 (10)	23 (13)	3 (5)	6 (2)	3 (1)	0 (0)	0 (0)	0 (0)	37 (25)
	Wade Hampton	0 (0)	0 (0)	2 (1)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (1)
	Prince of Wales-OuterKetchikan	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)
	Sitka	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Wrangell-Petersburg	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Juneau	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Anchorage	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Ketchikan Gateway	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildfire Total		0 (0)	473 (25)	15,003 (67)	426,279(134)	979,267(187)	1,863,458(234)	1,205,943(135)	3,122 (10)	297 (1)	4,493,842(491)
Prescribed	Anchorage	0 (0)	0 (0)	400 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	400 (0)
	Fairbanks North Star	0 (0)	0 (0)	120 (10)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	200 (11)
	Yukon-Koyukuk	0 (0)	0 (0)	26 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	26 (0)
Prescribed Total		0 (0)	0 (0)	546 (10)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	626 (11)
WFU	Denali	0 (0)	0 (0)	0 (0)	20,105 (7)	34,132 (3)	32,548 (1)	31,498 (1)	0 (0)	0 (0)	118,284 (6)
	Kenai Peninsula	0 (0)	0 (0)	0 (0)	0 (0)	4,923 (3)	7,221 (16)	6,988 (1)	7,221 (25)	862 (4)	27,215 (42)
	Northwest Arctic	0 (0)	0 (0)	0 (0)	7,751 (0)	11,627 (18)	0 (0)	0 (0)	0 (0)	0 (0)	19,378 (15)
	Southeast Fairbanks	0 (0)	0 (0)	0 (0)	861 (1)	1,482 (4)	1,482 (5)	1,243 (3)	0 (0)	0 (0)	5,069 (9)
WFU Total		0 (0)	0 (0)	0 (0)	28,717 (8)	52,165 (28)	41,251 (22)	39,729 (5)	7,221 (25)	862 (4)	169,946 (72)
Grand Total		0 (0)	473 (25)	15,549 (77)	455,076(145)	1,031,431(215)	1,904,709(256)	1,245,673(140)	10,342 (35)	1,160 (5)	4,664,415(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Counties and months with no fire events do not appear in table.

Table 2.3: $PM_{2.5}$ Emissions (and Number of Fire Days) by County and Month for All Fire Types

PM2.5 Emissions from and Number of Wild, Prescribed and WFU Fires by Fire Type and County

PM2.5 Emissions (tons)
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

PM2.5 Emissions in Tons (Number of Events)

		Month									
Fire Type	County	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Tons PM2.5 (Number of Events)
Wildfire	Yukon-Koyukuk	0 (0)	0 (0)	3,399 (4)	177,705 (76)	413,354(122)	667,439(188)	485,093(112)	926 (2)	0 (0)	1,747,916(284)
	Southeast Fairbanks	0 (0)	49 (4)	344 (13)	10,193 (9)	29,713 (19)	42,845 (8)	36,132 (10)	0 (0)	0 (0)	119,278 (48)
	Bethel	0 (0)	0 (0)	0 (2)	1,683 (7)	8,108 (4)	46,879 (23)	5,357 (0)	0 (0)	0 (0)	62,027 (29)
	Northwest Arctic	0 (0)	0 (0)	2 (0)	1,728 (7)	3,516 (23)	2,831 (8)	556 (6)	0 (0)	0 (0)	8,633 (25)
	Denali	0 (0)	0 (0)	0 (0)	639 (4)	1,270 (4)	2,762 (3)	3,075 (2)	350 (1)	0 (0)	8,096 (9)
	Kenai Peninsula	0 (0)	16 (7)	260 (4)	307 (6)	723 (3)	722 (1)	698 (3)	722 (1)	73 (0)	3,521 (17)
	Fairbanks North Star	0 (0)	0 (3)	135 (22)	812 (9)	373 (7)	123 (2)	116 (1)	35 (1)	0 (0)	1,594 (31)
	Haines	0 (0)	0 (0)	0 (0)	0 (0)	16 (1)	25 (0)	42 (1)	44 (5)	41 (1)	168 (6)
	Skagway-Hoonah-Angoon	0 (0)	1 (0)	65 (5)	40 (9)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	106 (11)
	Valdez-Cordova	0 (0)	3 (1)	1 (2)	43 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	47 (3)
	Lake and Peninsula	0 (0)	0 (0)	9 (1)	28 (1)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	38 (2)
	Nome	0 (0)	0 (0)	0 (0)	0 (0)	12 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12 (0)
	Matanuska-Susitna	0 (0)	0 (10)	2 (13)	0 (5)	2 (2)	1 (1)	0 (0)	0 (0)	0 (0)	6 (25)
	Wade Hampton	0 (0)	0 (0)	0 (1)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
	Prince of Wales-OuterKetchikan	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Dillingham	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Sitka	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Juneau	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Anchorage	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Wrangell-Petersburg	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Ketchikan Gateway	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildfire Total		0 (0)	69 (25)	4,218 (67)	193,178(134)	457,089(187)	763,628(234)	531,070(135)	2,077 (10)	114 (1)	1,951,443(491)
Prescribed	Fairbanks North Star	0 (0)	0 (0)	86 (10)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	152 (11)
	Anchorage	0 (0)	0 (0)	44 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	44 (0)
	Yukon-Koyukuk	0 (0)	0 (0)	19 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	19 (0)
Prescribed Total		0 (0)	0 (0)	149 (10)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	215 (11)
WFU	Denali	0 (0)	0 (0)	0 (0)	8,750 (7)	14,882 (3)	14,172 (1)	13,715 (1)	66 (0)	0 (0)	51,585 (6)
	Kenai Peninsula	0 (0)	0 (0)	0 (0)	0 (0)	2,191 (3)	3,244 (16)	3,140 (1)	3,244 (25)	372 (4)	12,191 (42)
	Northwest Arctic	0 (0)	0 (0)	0 (0)	825 (0)	1,259 (18)	0 (0)	0 (0)	0 (0)	0 (0)	2,084 (15)
	Southeast Fairbanks	0 (0)	0 (0)	0 (0)	249 (1)	432 (4)	432 (5)	365 (3)	0 (0)	0 (0)	1,479 (9)
WFU Total		0 (0)	0 (0)	0 (0)	9,824 (8)	18,765 (28)	17,849 (22)	17,219 (5)	3,311 (25)	372 (4)	67,340 (72)
Grand Total		0 (0)	69 (25)	4,367 (77)	203,067(145)	475,853(215)	781,477(256)	548,289(140)	5,388 (35)	486 (5)	2,018,997(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Counties and months with no fire events do not appear in table.

Table 2.4: Acres Burned (and Number of Fire Days) by Fire Management Zone and Month for All Fire Types

Acres Burned in and Number of Wild, Prescribed and WFU Fires by Fire Type and Fire Management Zone

Acres Burned
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

Acres (Number of Events)

		Month									
Fire Type	region	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Acres Burned (Number of Events)
Wildfire	Upper Yukon (AFS)	0 (0)	0 (0)	3,380 (4)	184,859 (16)	364,559 (26)	551,605 (33)	467,505 (23)	2,431 (4)	297 (1)	1,574,636 (43)
	Tanana (AFS)	0 (0)	187 (0)	3,200 (2)	164,692 (23)	271,501 (40)	340,698 (48)	214,422 (32)	0 (0)	0 (0)	994,701 (67)
	Galena (AFS)	0 (0)	0 (0)	0 (0)	28,849 (12)	128,762 (48)	408,928 (50)	323,601 (36)	655 (2)	0 (0)	890,795 (75)
	Southwest (DOF)	0 (0)	0 (0)	4,727 (1)	13,853 (7)	89,073 (21)	496,385 (45)	170,991 (19)	0 (0)	0 (0)	775,029 (58)
	Fairbanks (DOF)	0 (0)	1 (3)	73 (13)	9,784 (17)	70,575 (20)	9,877 (16)	5,205 (5)	0 (0)	0 (0)	95,515 (61)
	Kenai-Kodiak (DOF)	0 (0)	240 (8)	219 (9)	1,187 (6)	41,117 (13)	40,998 (19)	6,765 (4)	2 (1)	0 (0)	90,529 (41)
	Matanuska-Susitna (DOF)	0 (0)	2 (10)	726 (12)	1,114 (23)	8,879 (11)	2,140 (8)	10,348 (8)	5 (2)	0 (0)	23,213 (71)
	Military (AFS)	0 (0)	0 (0)	2,184 (2)	8,777 (7)	0 (0)	3,828 (3)	2,500 (3)	0 (0)	0 (0)	17,290 (13)
	Tok (DOF)	0 (0)	3 (2)	16 (3)	11,190 (5)	2,450 (3)	204 (2)	2,437 (3)	0 (0)	0 (0)	16,300 (15)
	Haines (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8,229 (4)	2,169 (2)	29 (1)	0 (0)	10,428 (4)
	Copper River (DOF)	0 (0)	38 (1)	15 (3)	1,752 (2)	1,681 (1)	12 (1)	0 (0)	0 (0)	0 (0)	3,497 (8)
	Delta (DOF)	0 (0)	3 (1)	221 (13)	167 (7)	669 (4)	553 (5)	0 (0)	0 (0)	0 (0)	1,613 (25)
	Tongass National Forest (USFS)	0 (0)	0 (0)	242 (5)	55 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	297 (10)
Wildfire Total		0 (0)	473 (25)	15,003 (67)	426,279(134)	979,267(187)	1,863,458(234)	1,205,943(135)	3,122 (10)	297 (1)	4,493,842(491)
Prescribed	Tongass National Forest (USFS)	0 (0)	0 (0)	332 (2)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	412 (4)
	Tanana (AFS)	0 (0)	0 (0)	124 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	124 (0)
	Chugach National Forest (USFS)	0 (0)	0 (0)	60 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	60 (6)
	Military (AFS)	0 (0)	0 (0)	20 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	20 (0)
	Fairbanks (DOF)	0 (0)	0 (0)	10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (1)
Prescribed Total		0 (0)	0 (0)	546 (10)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	626 (11)
WFU	Galena (AFS)	0 (0)	0 (0)	0 (0)	18,059 (3)	34,500 (10)	32,548 (1)	31,546 (2)	0 (0)	0 (0)	116,653 (12)
	Tanana (AFS)	0 (0)	0 (0)	0 (0)	4,773 (2)	6,107 (10)	4,526 (3)	8,183 (3)	6,868 (4)	636 (3)	31,094 (11)
	Upper Yukon (AFS)	0 (0)	0 (0)	0 (0)	3,993 (0)	10,410 (1)	227 (0)	0 (0)	0 (0)	0 (0)	14,630 (0)
	Matanuska-Susitna (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	443 (3)	1,813 (8)	0 (0)	38 (6)	227 (1)	2,521 (18)
	Southwest (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	452 (1)	956 (4)	0 (0)	258 (6)	0 (0)	1,666 (10)
	Delta (DOF)	0 (0)	0 (0)	0 (0)	1,266 (3)	0 (0)	227 (1)	0 (0)	6 (1)	0 (0)	1,499 (5)
	Tok (DOF)	0 (0)	0 (0)	0 (0)	578 (0)	0 (0)	227 (1)	0 (0)	0 (0)	0 (0)	804 (1)
	Copper River (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	453 (2)	0 (0)	0 (0)	0 (0)	453 (2)
	Fairbanks (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	247 (2)	48 (1)	0 (0)	6 (1)	0 (0)	301 (4)
	Kenai-Kodiak (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	6 (1)	227 (1)	0 (0)	44 (7)	0 (0)	277 (9)
	Military (AFS)	0 (0)	0 (0)	0 (0)	48 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	48 (0)
WFU Total		0 (0)	0 (0)	0 (0)	28,717 (8)	52,165 (28)	41,251 (22)	39,729 (5)	7,221 (25)	862 (4)	169,946 (72)
Grand Total		0 (0)	473 (25)	15,549 (77)	455,076(145)	1,031,431(215)	1,904,709(256)	1,245,673(140)	10,342 (35)	1,160 (5)	4,664,415(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Regions and months with no fire events do not appear in table.

Table 2.5: $PM_{2.5}$ Emissions (and Number of Fire Days) by Fire Management Zone and Month for All Fire Types

PM2.5 Emissions from and Number of Wild, Prescribed and WFU Fires by Fire Type and Fire Management Zone

PM2.5 Emissions (tons)
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

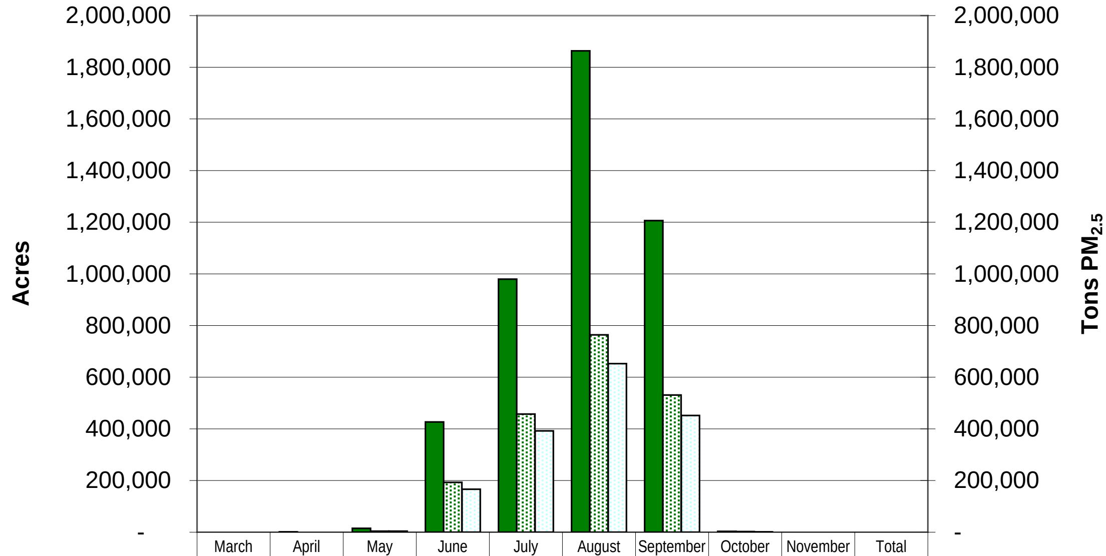
PM2.5 Emissions in Tons (Number of Events)

		Month									
Fire Type	region	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Tons PM2.5 (Number of Events)
Wildfire	Upper Yukon (AFS)	0 (0)	0 (0)	823 (4)	80,601 (16)	167,771 (26)	239,516 (33)	212,948 (23)	933 (4)	114 (1)	702,707 (43)
	Galena (AFS)	0 (0)	0 (0)	0 (0)	12,335 (12)	61,275 (48)	192,395 (50)	162,428 (36)	756 (2)	0 (0)	429,189 (75)
	Tanana (AFS)	0 (0)	25 (0)	315 (2)	79,120 (23)	109,250 (40)	134,282 (48)	85,662 (32)	258 (0)	0 (0)	408,913 (67)
	Southwest (DOF)	0 (0)	0 (0)	1,949 (1)	5,873 (7)	43,673 (21)	163,389 (45)	56,687 (19)	40 (0)	0 (0)	271,611 (58)
	Fairbanks (DOF)	0 (0)	0 (3)	15 (13)	4,155 (17)	45,968 (20)	3,768 (16)	1,532 (5)	4 (0)	0 (0)	55,442 (61)
	Kenai-Kodiak (DOF)	0 (0)	39 (8)	82 (9)	327 (6)	22,326 (13)	23,252 (19)	3,785 (4)	23 (1)	0 (0)	49,834 (41)
	Matanuska-Susitna (DOF)	0 (0)	0 (10)	303 (12)	547 (23)	4,225 (11)	651 (8)	5,542 (8)	43 (2)	0 (0)	11,310 (71)
	Military (AFS)	0 (0)	0 (0)	618 (2)	4,709 (7)	0 (0)	1,935 (3)	1,029 (3)	0 (0)	0 (0)	8,290 (13)
	Tok (DOF)	0 (0)	0 (2)	5 (3)	4,636 (5)	1,768 (3)	82 (2)	789 (3)	0 (0)	0 (0)	7,281 (15)
	Haines (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4,124 (4)	666 (2)	22 (1)	0 (0)	4,812 (4)
	Copper River (DOF)	0 (0)	3 (1)	5 (3)	764 (2)	693 (1)	4 (1)	0 (0)	0 (0)	0 (0)	1,468 (8)
	Delta (DOF)	0 (0)	1 (1)	39 (13)	72 (7)	140 (4)	230 (5)	0 (0)	0 (0)	0 (0)	481 (25)
	Tongass National Forest (USFS)	0 (0)	0 (0)	65 (5)	40 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	105 (10)
Wildfire Total		0 (0)	69 (25)	4,218 (67)	193,178(134)	457,089(187)	763,628(234)	531,070(135)	2,077 (10)	114 (1)	1,951,443(491)
Prescribed	Tongass National Forest (USFS)	0 (0)	0 (0)	48 (2)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	114 (4)
	Chugach National Forest (USFS)	0 (0)	0 (0)	43 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	43 (6)
	Tanana (AFS)	0 (0)	0 (0)	36 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	36 (0)
	Military (AFS)	0 (0)	0 (0)	14 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	14 (0)
	Fairbanks (DOF)	0 (0)	0 (0)	7 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (1)
Prescribed Total		0 (0)	0 (0)	149 (10)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	215 (11)
WFU	Galena (AFS)	0 (0)	0 (0)	0 (0)	7,822 (3)	14,451 (10)	14,172 (1)	13,729 (2)	66 (0)	0 (0)	50,241 (12)
	Tanana (AFS)	0 (0)	0 (0)	0 (0)	1,021 (2)	1,512 (10)	1,929 (3)	3,489 (3)	3,124 (4)	254 (3)	11,327 (11)
	Upper Yukon (AFS)	0 (0)	0 (0)	0 (0)	316 (0)	2,564 (1)	118 (0)	0 (0)	0 (0)	0 (0)	2,998 (0)
	Matanuska-Susitna (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	64 (3)	824 (8)	0 (0)	10 (6)	103 (1)	1,001 (18)
	Delta (DOF)	0 (0)	0 (0)	0 (0)	588 (3)	0 (0)	103 (1)	0 (0)	2 (1)	0 (0)	692 (5)
	Southwest (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	136 (1)	279 (4)	0 (0)	96 (6)	15 (0)	526 (10)
	Copper River (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	206 (2)	0 (0)	0 (0)	0 (0)	206 (2)
	Tok (DOF)	0 (0)	0 (0)	0 (0)	64 (0)	0 (0)	103 (1)	0 (0)	0 (0)	0 (0)	167 (1)
	Kenai-Kodiak (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	103 (1)	0 (0)	12 (7)	0 (0)	116 (9)
	Fairbanks (DOF)	0 (0)	0 (0)	0 (0)	0 (0)	35 (2)	12 (1)	2 (0)	2 (1)	0 (0)	51 (4)
	Military (AFS)	0 (0)	0 (0)	0 (0)	14 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	14 (0)
WFU Total		0 (0)	0 (0)	0 (0)	9,824 (8)	18,765 (28)	17,849 (22)	17,219 (5)	3,311 (25)	372 (4)	67,340 (72)
Grand Total		0 (0)	69 (25)	4,367 (77)	203,067(145)	475,853(215)	781,477(256)	548,289(140)	5,388 (35)	486 (5)	2,018,997(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Regions and months with no fire events do not appear in table.

Figure 2.3: Fire Acres and $PM_{2.5}$ Emissions by Month - Wildfire

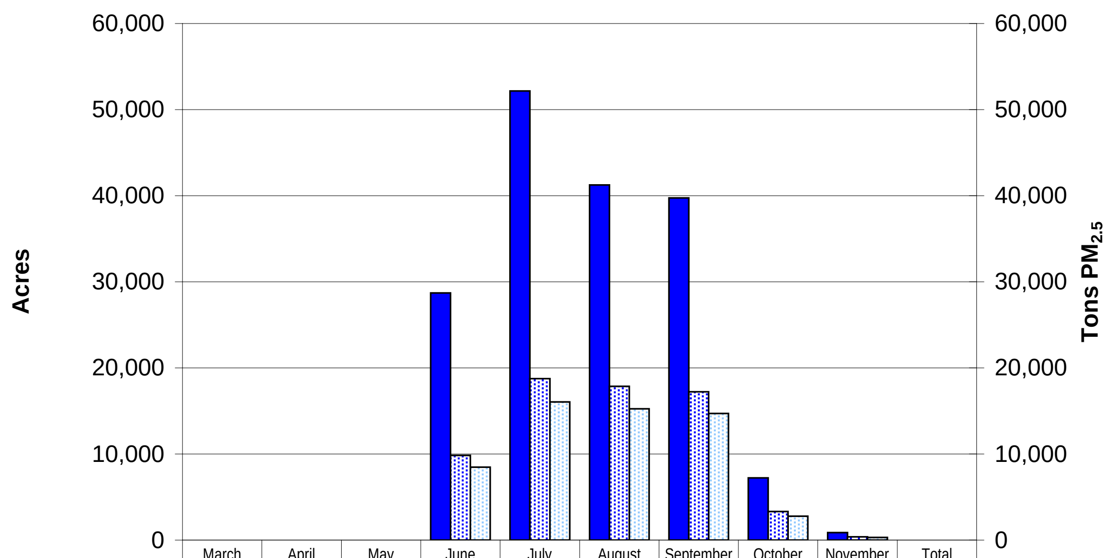
2005 Alaska Fire Emissions Inventory
Wildfire Flaming Versus Flaming Plus Smoldering



	March	April	May	June	July	August	September	October	November	Total
Wildfire Acres	0	473	15,003	426,279	979,267	1,863,458	1,205,943	3,122	297	4,493,842
Wildfire PM2.5 (F)	0	64	3,719	166,446	392,057	652,927	451,653	970	95	1,667,931
Wildfire PM2.5 (F+S)	0	69	4,218	193,178	457,089	763,628	531,070	2,077	114	1,951,443

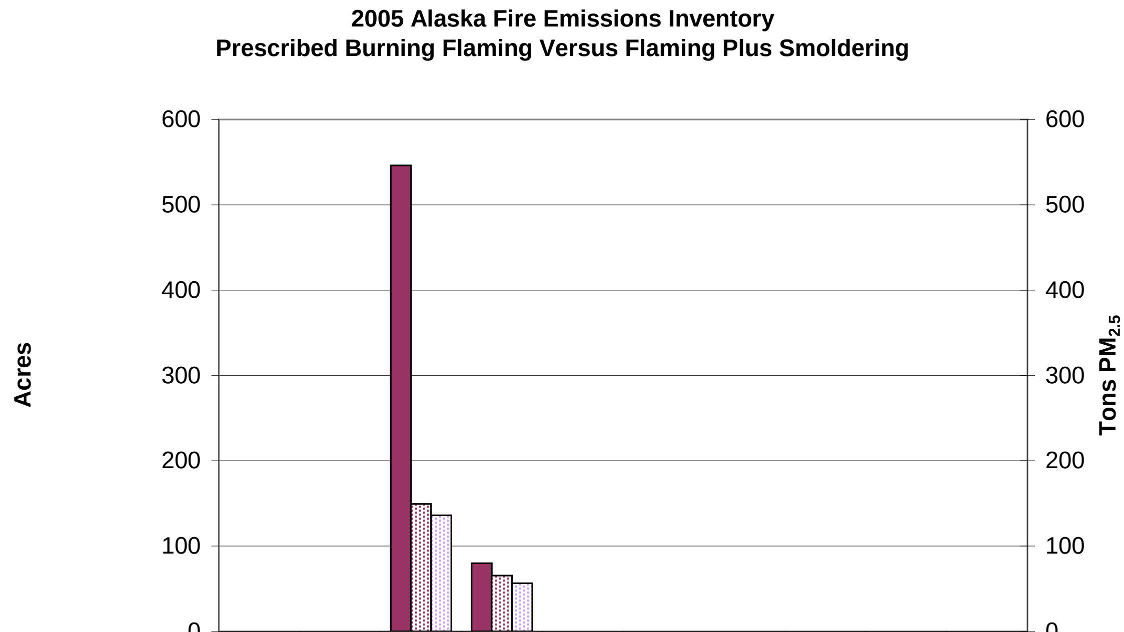
Figure 2.4: Fire Acres and $PM_{2.5}$ Emissions by Month - Wildland Fire Use

2005 Alaska Fire Emissions Inventory
WFU Flaming Versus Flaming Plus Smoldering



	March	April	May	June	July	August	September	October	November	Total
WFU Acres	0	0	0	28,717	52,165	41,251	39,729	7,221	862	169,946
WFU PM2.5 (F)	0	0	0	8,471	16,038	15,256	14,716	2,773	305	57,558
WFU PM2.5 (F+S)	0	0	0	9,824	18,765	17,849	17,219	3,311	372	67,340

Figure 2.5: Fire Acres and $PM_{2.5}$ Emissions by Month - Prescribed Fire



	March	April	May	June	July	August	September	October	November	Total
Prescribed Acres	0	0	546	80	0	0	0	0	0	626
Prescribed PM2.5 (F)	0	0	136	56	0	0	0	0	0	193
Prescribed PM2.5 (F+S)	0	0	149	65	0	0	0	0	0	215

Figure 2.6: Summary of Fire Acres

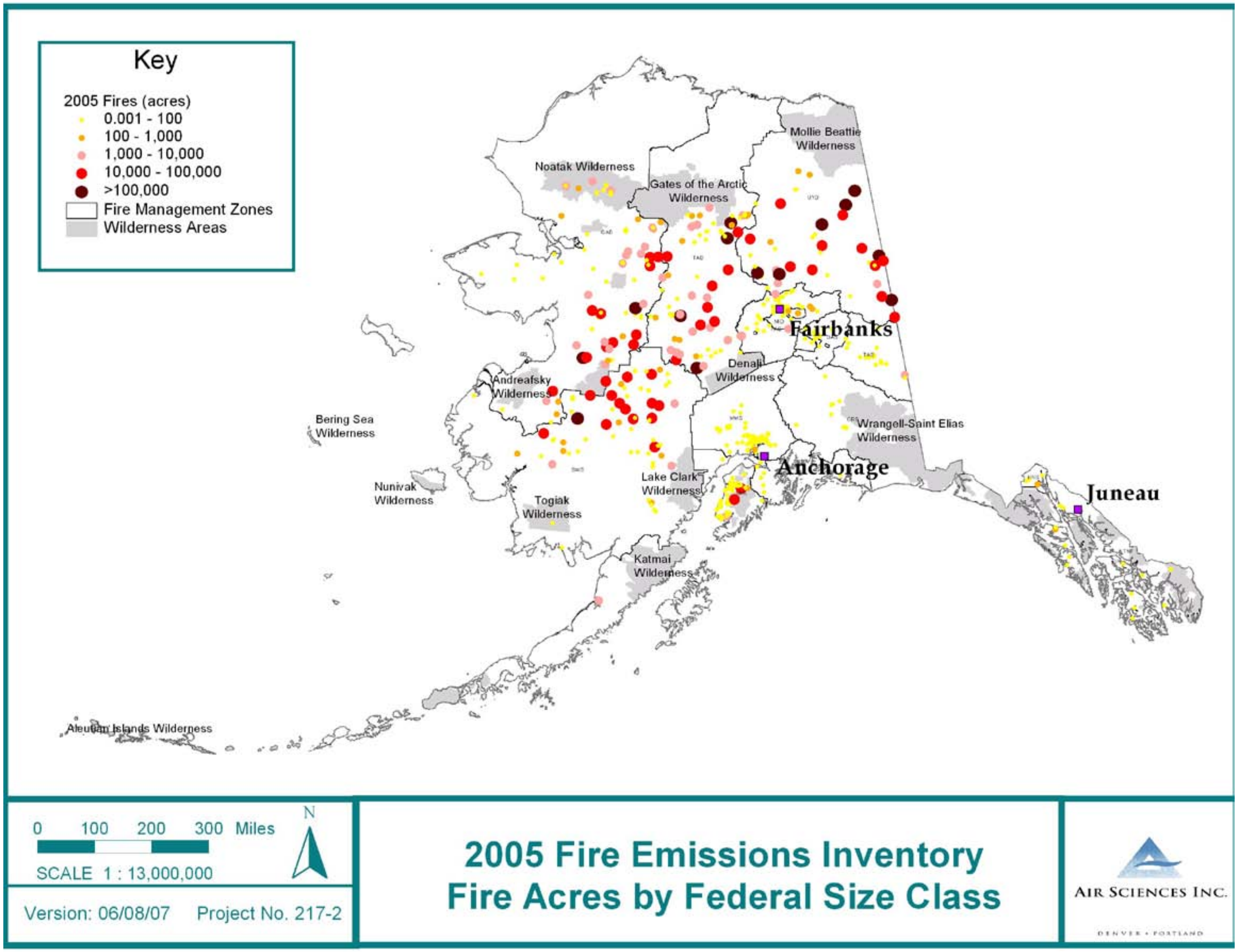


Figure 2.7: Summary of $PM_{2.5}$ Emissions Location (FMZ)

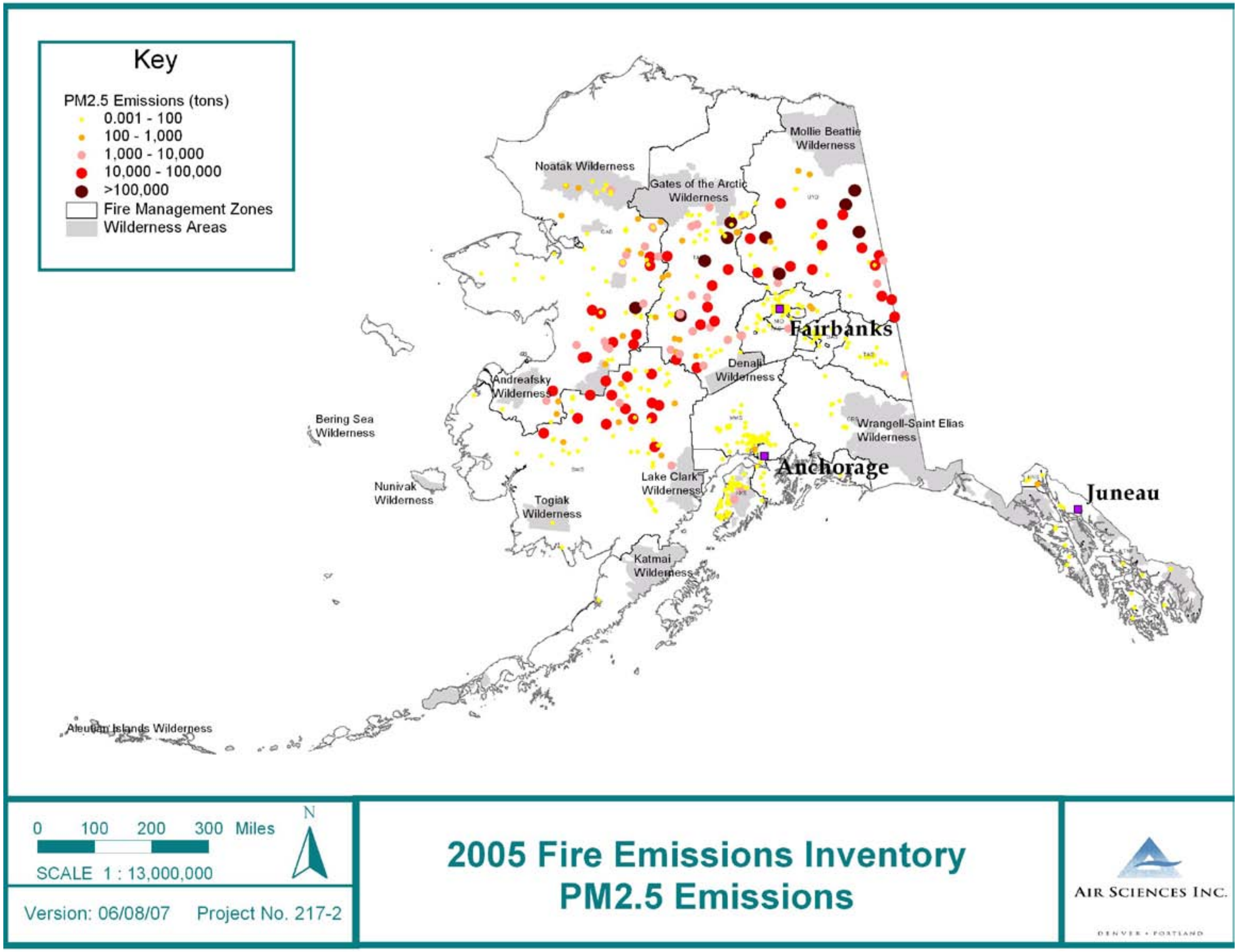
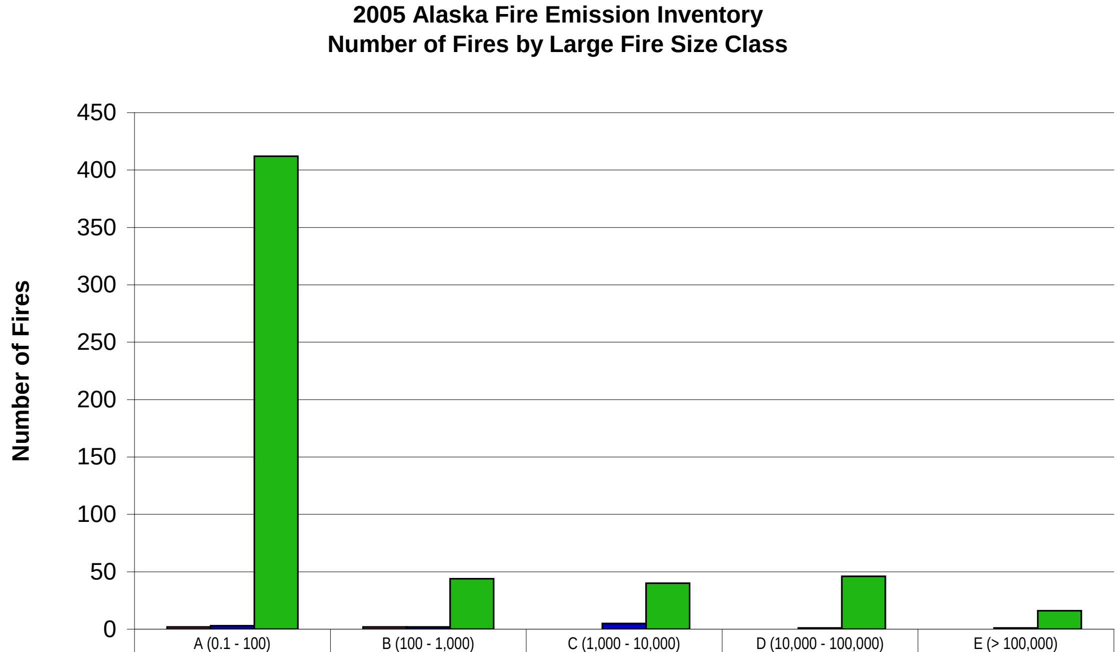
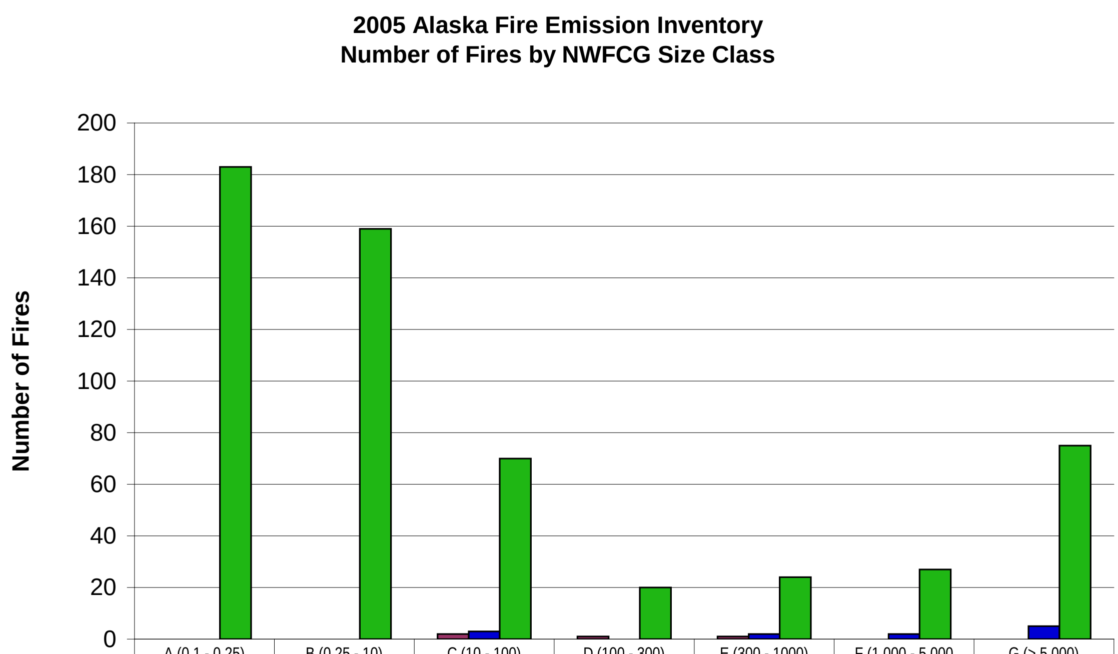


Figure 2.8: Number of Fire Events by Fire Type and Size Class Highlighting Large Fires



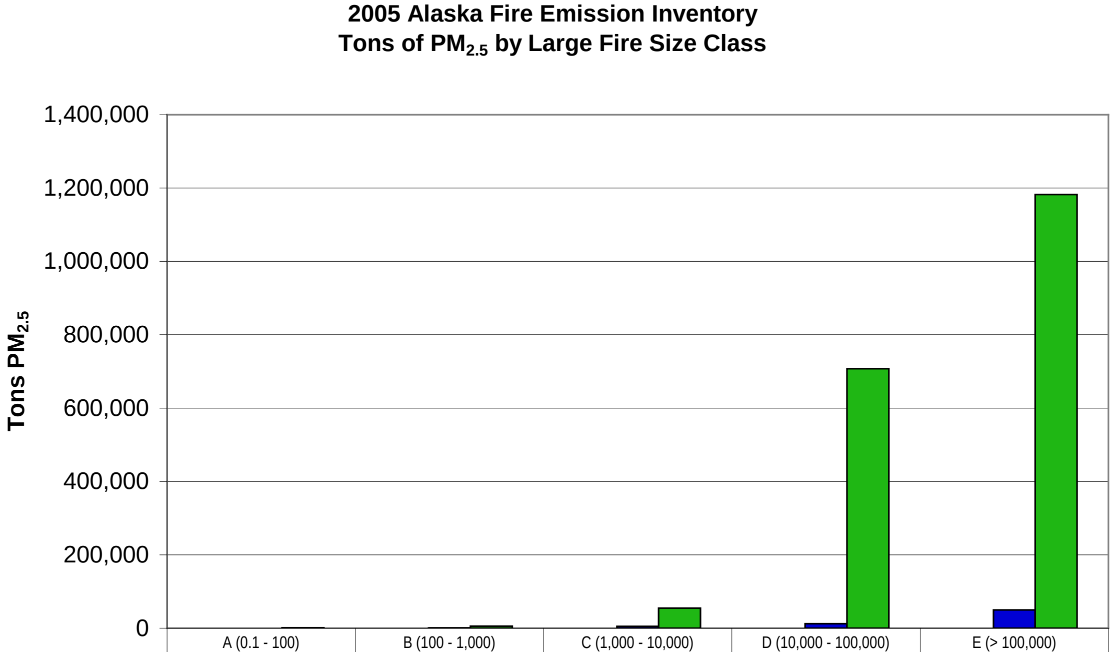
	A (0.1 - 100)	B (100 - 1,000)	C (1,000 - 10,000)	D (10,000 - 100,000)	E (> 100,000)
Prescribed	2	2	0	0	0
WFU	3	2	5	1	1
Wildfire	412	44	40	46	16

Figure 2.9: Number of Fire Events by NWFCG Fire Size Class and Fire Type



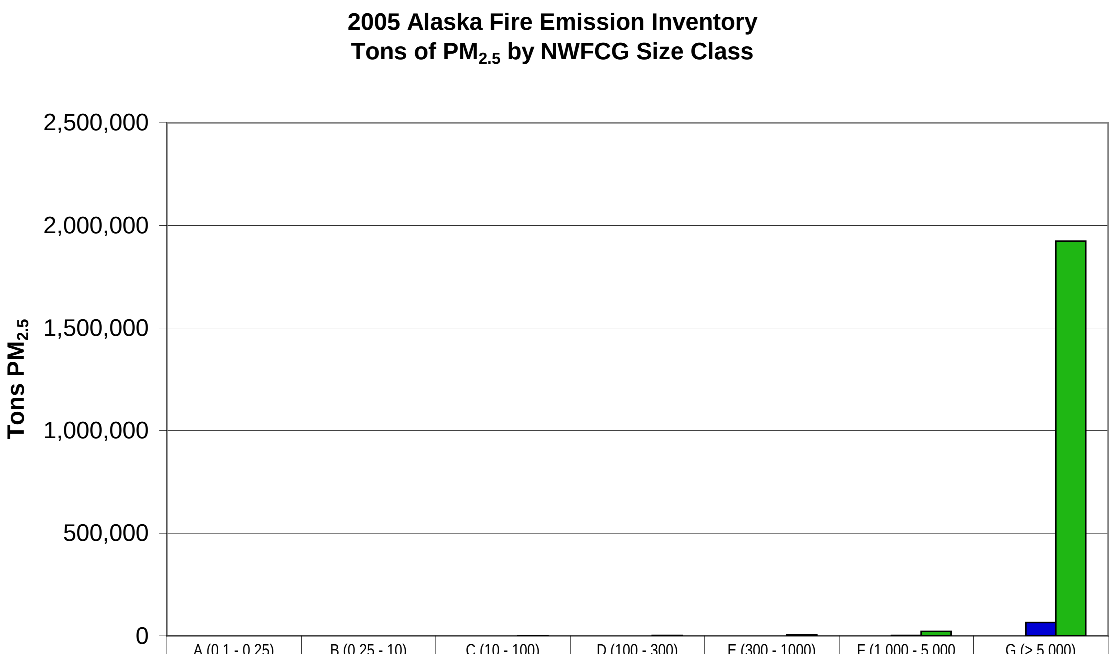
	A (0.1 - 0.25)	B (0.25 - 10)	C (10 - 100)	D (100 - 300)	E (300 - 1000)	F (1,000 - 5,000	G (> 5,000)
Prescribed	0	0	2	1	1	0	0
WFU	0	0	3	0	2	2	5
Wildfire	183	159	70	20	24	27	75

Figure 2.10: Fire Acres and $PM_{2.5}$ Emissions by Size Class Highlighting Large Fires



	A (0.1 - 100)	B (100 - 1,000)	C (1,000 - 10,000)	D (10,000 - 100,000)	E (> 100,000)
Prescribed	22	188	0	0	0
WFU	91	367	5,100	11,954	49,831
Wildfire	895	5,511	54,792	707,692	1,182,531

Figure 2.11: Fire Acres and $PM_{2.5}$ Emissions by NWFCG Fire Size Class



	A (0.1 - 0.25)	B (0.25 - 10)	C (10 - 100)	D (100 - 300)	E (300 - 1000)	F (1,000 - 5,000	G (> 5,000)
Prescribed	0	0	22	145	43	0	0
WFU	0	0	91	0	367	1,664	65,222
Wildfire	7	122	766	1,525	3,986	21,511	1,923,503

Table 2.6: Acres Burned (and Number of Fire Days) by NFDRS Fuel Model and Month for All Fire Types

Acres Burned in and Number of Wild, Prescribed and WFU Fires by Fire Type and Fuel Type

Acres Burned
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

Acres (Number of Events)

		Month									
Fire Type	Fuel Type	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Acres Burned (Number of Events)
Wildfire	Q: Alaskan black spruce	0 (0)	205 (5)	3,533 (20)	290,865 (66)	747,310(106)	1,260,275(145)	886,378 (93)	655 (4)	0 (0)	3,189,222(250)
	S: Tundra	0 (0)	0 (1)	668 (1)	46,273 (13)	126,358 (27)	235,163 (31)	200,353 (13)	0 (0)	0 (0)	608,815 (55)
	G: Short needle (heavy dead)	0 (0)	6 (10)	308 (19)	5,969 (16)	12,953 (15)	210,557 (17)	65,079 (12)	2,397 (1)	232 (0)	297,500 (62)
	F: Intermediate brush	0 (0)	38 (1)	391 (10)	45,807 (8)	52,215 (13)	49,991 (8)	42,156 (4)	0 (0)	0 (0)	190,597 (31)
	A: Western grasses (annual)	0 (0)	0 (1)	6,742 (6)	24,105 (7)	21,226 (6)	101,724 (14)	8,539 (1)	0 (0)	0 (0)	162,336 (26)
	L: Western grasses (perennial)	0 (0)	0 (0)	0 (0)	11,088 (11)	19,187 (19)	5,708 (19)	3,371 (11)	0 (0)	0 (0)	39,353 (37)
	R: Hardwood litter (summer)	0 (0)	223 (7)	3,361 (11)	2,173 (13)	17 (1)	41 (0)	68 (1)	70 (5)	66 (1)	6,019 (30)
Wildfire Total		0 (0)	473 (25)	15,003 (67)	426,279(134)	979,267(187)	1,863,458(234)	1,205,943(135)	3,122 (10)	297 (1)	4,493,842(491)
Prescribed	G: Short needle (heavy dead)	0 (0)	0 (0)	546 (10)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	626 (11)
Prescribed Total		0 (0)	0 (0)	546 (10)	80 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	626 (11)
WFU	Q: Alaskan black spruce	0 (0)	0 (0)	0 (0)	20,105 (7)	38,892 (3)	39,574 (16)	38,297 (1)	7,026 (3)	680 (3)	144,574 (24)
	S: Tundra	0 (0)	0 (0)	0 (0)	3,953 (0)	5,929 (17)	0 (0)	0 (0)	0 (0)	0 (0)	9,882 (15)
	A: Western grasses (annual)	0 (0)	0 (0)	0 (0)	3,799 (0)	5,698 (1)	0 (0)	0 (0)	0 (0)	0 (0)	9,497 (0)
	G: Short needle (heavy dead)	0 (0)	0 (0)	0 (0)	861 (1)	1,482 (4)	1,482 (5)	1,243 (3)	0 (0)	0 (0)	5,069 (9)
	R: Hardwood litter (summer)	0 (0)	0 (0)	0 (0)	0 (0)	164 (3)	195 (1)	189 (1)	195 (22)	182 (1)	925 (24)
WFU Total		0 (0)	0 (0)	0 (0)	28,717 (8)	52,165 (28)	41,251 (22)	39,729 (5)	7,221 (25)	862 (4)	169,946 (72)
Grand Total		0 (0)	473 (25)	15,549 (77)	455,076(145)	1,031,431(215)	1,904,709(256)	1,245,673(140)	10,342 (35)	1,160 (5)	4,664,415(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Months with no fire events do not appear in table.
The data in this table may vary slightly from the inventory because a single fuel is assigned to each fire for this table, whereas the inventory uses multiple fuel types for some fires.

Table 2.7: $PM_{2.5}$ Emissions (and Number of Fire Days) by NFDRS Fuel Model and Month for All Fire Types

PM2.5 Emissions from and Number of Wild, Prescribed and WFU Fires by Fire Type and Fuel Type

PM2.5 Emissions (tons)
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 100,000
100,000 +

PM2.5 Emissions in Tons (Number of Events)

		Month									
Fire Type	Fuel Type	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total Tons PM2.5 (Number of Events)
Wildfire	Q: Alaskan black spruce	0 (0)	49 (5)	1,354 (20)	125,084 (66)	345,034(106)	548,900(145)	392,771 (93)	1,192 (4)	0 (0)	1,414,384(250)
	S: Tundra	0 (0)	0 (1)	116 (1)	31,483 (13)	67,773 (27)	100,815 (31)	85,963 (13)	57 (0)	0 (0)	286,207 (55)
	F: Intermediate brush	0 (0)	3 (1)	120 (10)	24,177 (8)	26,941 (13)	25,003 (8)	21,147 (4)	2 (0)	0 (0)	97,394 (31)
	G: Short needle (heavy dead)	0 (0)	0 (10)	59 (19)	2,064 (16)	4,906 (15)	57,819 (17)	27,539 (12)	781 (1)	73 (0)	93,240 (62)
	A: Western grasses (annual)	0 (0)	0 (1)	2,243 (6)	8,632 (7)	8,863 (6)	29,974 (14)	2,944 (1)	0 (0)	0 (0)	52,656 (26)
	L: Western grasses (perennial)	0 (0)	0 (0)	0 (0)	1,514 (11)	3,570 (19)	1,091 (19)	664 (11)	1 (0)	0 (0)	6,840 (37)
	R: Hardwood litter (summer)	0 (0)	17 (7)	326 (11)	224 (13)	2 (1)	25 (0)	42 (1)	44 (5)	41 (1)	721 (30)
Wildfire Total		0 (0)	69 (25)	4,218 (67)	193,178(134)	457,089(187)	763,628(234)	531,070(135)	2,077 (10)	114 (1)	1,951,443(491)
Prescribed	G: Short needle (heavy dead)	0 (0)	0 (0)	149 (10)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	215 (11)
Prescribed Total		0 (0)	0 (0)	149 (10)	65 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	215 (11)
WFU	Q: Alaskan black spruce	0 (0)	0 (0)	0 (0)	8,750 (7)	17,031 (3)	17,366 (16)	16,805 (1)	3,260 (3)	324 (3)	63,535 (24)
	G: Short needle (heavy dead)	0 (0)	0 (0)	0 (0)	249 (1)	432 (4)	432 (5)	365 (3)	0 (0)	0 (0)	1,479 (9)
	S: Tundra	0 (0)	0 (0)	0 (0)	485 (0)	740 (17)	0 (0)	0 (0)	0 (0)	0 (0)	1,226 (15)
	A: Western grasses (annual)	0 (0)	0 (0)	0 (0)	340 (0)	519 (1)	0 (0)	0 (0)	0 (0)	0 (0)	858 (0)
	R: Hardwood litter (summer)	0 (0)	0 (0)	0 (0)	0 (0)	43 (3)	51 (1)	49 (1)	51 (22)	48 (1)	242 (24)
WFU Total		0 (0)	0 (0)	0 (0)	9,824 (8)	18,765 (28)	17,849 (22)	17,219 (5)	3,311 (25)	372 (4)	67,340 (72)
Grand Total		0 (0)	69 (25)	4,367 (77)	203,067(145)	475,853(215)	781,477(256)	548,289(140)	5,388 (35)	486 (5)	2,018,997(574)

Notes: Precision of reported values are potentially affected by rounding.
Monthly Number of Events will not sum to Total Annual Number of Events if there are fires that span multiple months.
Months with no fire events do not appear in table.
The data in this table may vary slightly from the inventory because a single fuel is assigned to each fire for this table, whereas the inventory uses multiple fuel types for some fires.

SECTION 3

ALASKA FIRE EMISSIONS INVENTORY TEMPLATE

Included as a deliverable for this project is an Emissions Inventory Template (Template) that can be used by the ADEC staff to calculate and report annual fire emissions in future years, as required by the ESMP. The Template is a Microsoft Excel version 2003 workbook that is designed to accept formatted activity data, calculate emissions, and generate relatively simple reports of annual fire statistics. The Template should be considered a "beta version" fire emissions inventory system that ADEC can evaluate, enhance, and update for future years.

The Template implements many of the fire science methods devised for the 2005 emissions inventory (described in the previous section). A list of the Template's key features includes:

- Accommodates fire event data of the type typically reported in the BLM fire data set (e.g., the data that comprise the Event emissions inventory).
- Converts degrees/minutes/seconds input to decimal degrees.
- Performs basic error checks on the input data.
- Performs lookup routines for WRAP-approved emission factors
- Performs lookup routines for seasonal fuel consumption rates based on six moisture regimes.
- Performs lookup routines to apply an Emissions Reduction Technique (ERT) reduction percentage to user-indicated eligible prescribed fires.
- Implements a simple fuel consumption hierarchy (see below).
- Calculates emissions, including smoldering emissions for qualifying events (see Section 1.6).
- Generates summary reports of annual fire activity and emission estimates.

There are a number of fire science methods implemented to develop the 2005 fire emissions inventory that the Template ***does not*** perform. For the most part, the limitations in the Template are compensated for by inputting more complete fire activity data to the Template. Compared to the 2005 fire emissions inventory, the limitations of the Template include:

- Applying any GIS techniques, including:
    - Associating fire location with NFDRS fuel models and fuel consumption rates (therefore, the source data must include a fuel consumption rate [tons/acre] or a CFFDRS/NFDRS fuel model).

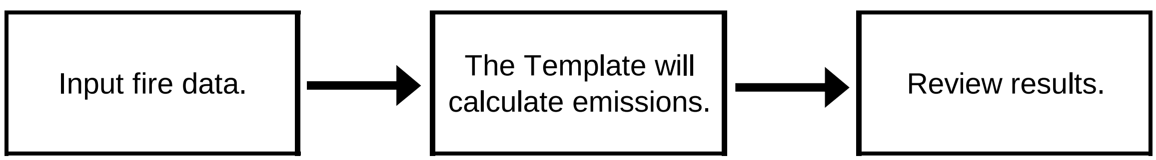
- Associating fire location with county FIPS codes or Fire Management Zone (therefore, the source data must include a county FIPS code or name and fire management zone code).
- Refining fuel consumption estimates.
- Quality control input data (for locations on water, in Canada, etc.).
- Disaggregate multi-day fire events into fire day events.

- Generating summary reports of daily fire activity and emission estimates.

The Template design assumes that users of the Template are familiar with the Microsoft Excel workbook functions and fire inventories.

Figure 3.1 is a simple flow chart that illustrates the main steps in utilizing the Template. The details of executing each step are provided in the sections below.

Figure 3.1: Template Main Steps



3.1 Fire Data Input to the Template

For each fire record, there are 20 pieces of information (fields) that are required for each prescribed fire event (18 pieces of information for wildfires as ERT's do not apply) in order for the Template to calculate emissions and to maintain the spatial and temporal resolution of the Event emissions inventory. These fields are listed Table 3.1.

Table 3.1: Template Fields and Descriptions

Field Name	Description	Example
SOURCE_TYP	Source type as "wildfire", "prescribed," or "WFU"	Wildfire
FIRE_NAME	Fire name	Tracy Ave.
DATA_PROVI	Database from which fire data was obtained	DOF-KKS
OWNER	Lead responding agency/responsible burn agency	PRI
DATA_SOURCE		
LAT	Latitude in Decimal Degrees	59.716670
LON	Longitude in Decimal Degrees	-151.333300
ACRES	Reported burn area in acres	5400
STARTDATE	Day fire started in YYYYMMDD format	20050429
ENDDATE	Day fire ended in YYYYMMDD format	20050621
FIRE_KEY	Code unique to fire event separate from fire name ("RECORD_NUMB" was used in the 2005 emissions inventory)	026
BURN_TYPE	Burn Type as "Broadcast" or "Piled"	Broadcast
RAWCONS/Fuel Class	Either a non-zero positive RAW CONS (fuel consumption rate in tons/acre) or a valid CFFDRS or NFDRS fuel model code is required.	12.37
MOISTURE	Seasonal moisture regime: Very Dry, Dry, Moderate, Moist, Wet, or Very Wet (may be left blank)	Moist
FMZ	Fire Management Zone	KKS
COUNTY	Reported County by (1) valid county FIPS or (2) valid county.	122
APPLY_ERT	Toggle whether ERTs were applied to fire (prescribed fire only) “Y” or “N”	Y
ERT_TYPE	Broad vegetation type classification: Grass, Brush, Timber, Tundra, Crop	Timber
Latitude [Deg|Min|Sec]	Input degrees, minutes, and second in separate columns – converts to decimal degrees	59|36|59
Longitude [Deg|Min|Sec]	Input degrees, minutes, and second in separate columns – converts to decimal degrees	-151|24|02

Several simple data hierarchy rules will be executed by the Template, including:

- Fuel consumption: If no RAWCONS is provided, seasonal fuel consumption (tons/acre) will be looked up from the CFFDRS/NFDRS fuel model code provided. Seasonal fuel loading adjustments are not applied to RAWCONS data.
- ERT fuel type: If no ERT_TYPE is specified by the user, one will be looked up based on the NFDRS fuel model provided. *If a RAWCONS is provided, the user* must *specify ERT_TYPE.*

- If no MOISTURE regime is specified, one will be looked up based on month of STARTDATE provided.
- County: If no county FIPS code is provided, the county will be assumed to be the county name provided.

The template is set up with a limit of 1,000 total fire events (there are 574 events in the 2005 fire emissions inventory). (This can easily be modified.)

USER INSTRUCTIONS:

- ***Make sure to have adequate information about the fire event(s), including all of the information listed and described in Table 3.1.***
- ***Open the Template and select the "INPUT" tab along the bottom of the screen.***
- ***Scroll to the first row that does not contain any fire events. Enter the data by hand or by using the "Paste Special" – "Paste Values" function in Microsoft Excel. (The paste values function will import only the data and remove all formatting from the source.)***

3.1.1 Fire Data Error Checks

In the input sheet of the template, each row has one cell that provides error-checking. The error-checking will warn the user of an input that does not fall within the common sense values as determined by the "valid input" sheet. For example, if neither a valid county FIPS code nor a valid county is entered, the "error with" column will include "COUNTY" to indicate that there is an error with the county input.

USER INSTRUCTIONS:

- ***Push F9 on your keyboard to start the process of error-checking the input.***
- ***If the "Errors With:" column has anything in it for any fire, there could be a problem with that records emissions. Fix any errors before moving on.***

3.2 Calculating Emissions

Once the data is entered into the Template completely, the user will execute the automated process of calculating emissions for all the events in the Template.

USER INSTRUCTIONS:

- ***Push F9 on your keyboard to calculate emissions.***

3.3 Review Results

The results of the fire activity and emissions inventory generated by the Template are presented in the form of summary tables, charts, and in the event-by-event spreadsheet.

USER INSTRUCTIONS:

- ***Select each of the tabs labeled: Summary Chart, Number of Events, Prescribed Temporal, Prescribed FMZ, WFU Temporal, WFU FMZ, WF Temporal, WF FMZ, Pollutants, ERT Statistics, Fed Size Class, NWFCG Size Class, and Summary Tables and review the emissions reported by the Template. Quality-assure the results against known fire data summaries. Check the input data or the "EVENT" tab for more detail.***

SECTION 4

REFERENCES

Air Sciences Inc. 2004. **1996 Emissions Inventory for Wildfire and Prescribed Fire (Draft).** Denver, CO.

Air Sciences Inc. 2005. **Integrated Assessment Update and 2018 Emissions Inventory for Prescribed Fire, Wildfire, and Agricultural Burning.** Denver, CO.

Air Sciences Inc., EC/R Incorporated 2005**. Inter-RPO 2002 National Wildfire Emission Inventory (Draft).** Denver, CO.

Alaska BLM and Alaska Fire Service. 2006. Personal Communication with Parker Martyn. E-mail: 06/13/2006.

Alaska BLM and Alaska Fire Service. 2007. Personal Communication with Parker Martyn. E-mail and Phone: February and March 2007.

Alaska BLM and Alaska Fire Service. 2005. 2005 Annual report, Alaska Fire Service. Online at http://fire.ak.blm.gov/content/news/annual/current.pdf (last accessed June 28, 2006).

Alaska Department of Environmental Conservation (ADEC). 2006. Personal Communication with Joan Hardesty. Faxes: 05/31/2006, 06/14/2006; phone: 06/23/2006.

Alaska Fish and Wildlife Service (FWS). 2006. Personal Communication with Laurie Thorpe. E-mail: 06/14/2006.

Alaska Geospatial Data Clearinghouse. 2006. **Wildland fire data set for Alaska**. Online at http://agdc.usgs.gov/data/blm/fire/index.html (last accessed June 26, 2006).

Alaska National Park Service (NPS). 2006. Personal Communication with Karen LaMay. E-mail: 13/06/2006.

Anderson, H.E. 1982. **Aids to Determining Fuel Models for Estimating Fire Behavior**. USDA Forest Service, General Technical Report INT-122. 22 p.

Battye, W., and R. Battye. 2002. **Development of Emission Inventory Methods for Wildland Fire.** USEPA OAQPS Contract No. 68-D-98-046 Work Assignment No. 5-03.

Burgan, R.E., R.W. Klaver, and J.M. Klaver. 1998. **Fuel Models and Fire Potential from Satellite and Surface Observations.** International Journal of Wildland Fire 8(3):159-170. Fuel Model Map online at http://www.wfas.net/cgi-bin/nav.cgi?pages=wfas&mode=20 not mentioned in report

ENVIRON. 2006. **Revised Final Report - Wyoming 2002 emission Inventory: Mobile and Area Source Emissions.** ENVIRON International Corporation. Novato, CA. not mentioned in report

ERG. 2002. **Summary of Crop Production, Agricultural Burning, and Non-Burning Alternatives for the Western United States (Final).** Lexington, MA. Not mentioned in report.

National Atlas of the United States. 2006. http://nationalatlas.gov/

National Interagency Fire Center, Wildland Fire Statistics, 1960-2006. http://www.n=NIFC.gov/Fire-Info/fire-stats.htm.

APPENDIX A
Assumptions and Glossary

CONTENTS

Page

Tables

APPENDIX A

ASSUMPTIONS AND GLOSSARY

Due to the volume of data compiled and analyzed in an emissions inventory, certain assumptions are made in regards to data quality and completeness. In addition, methods used or concepts mentioned in the report may require additional justification, or simply be unfamiliar to some readers. This appendix is provided to further explicate and document those areas of the report not covered thoroughly elsewhere.

A.1 Data Limitations

Below is a brief list of the limitations of and assumptions made about the data set upon which the inventory is based. While not exhaustive, the authors tried to capture those elements most relevant to this particular inventory and to burning in Alaska, partly based on feedback received during the AWFCG Air Quality Committee Meeting in January 2007.

- Only prescribed data reported in the BLM/AFS database and post-burn reports from ADEC were used to estimate prescribed burning activity. This resulted in only four prescribed burns reported in the inventory, although, according to State FMOs, considerably more burning occurs and some of that information may be available.

- Similarly, only *regulated* (i.e., > 40 acres) prescribed burns are included in the inventory. No attempt was made to estimate smaller burns, private burns, or agricultural burning.

- The administrative end date for all fire events was assumed to be equivalent to the out date (the dates were manually checked for obvious unlikely values).

- Burn type was assumed to be "broadcast" unless "pile" burn was indicated in the source database.

- For any event where primary vegetation type or fuel loading was provided by the Fire Manager, those values superseded the default assigned classification.

- The default fuel classification system used is the latest CFFDRS fuel map created by the Alaska Fire Service. A crosswalk, associating vegetation types with CFFDRS classes, was done with a statewide vegetation map patched together using 30-meter LANDSAT-7 remote sensing images from the 1980's and early 1990's (Parker Martyn, AFS, personal communication 3/9/2007). Details about associating CFFDRS fuel model classes with fuel loadings, and differences between the CFFDRS fuel map and the original 1-km NFDRS map used in the draft report are outlined in Appendix B.

- Emission factors for broadcast burning across all fuel classifications were assumed to be identical. Pile burning had a unique set of emission factors that are also identical across fuel types.

A.2 WRAP-Modified Fuel Loadings

Fuel loading values presented in Table 1.3 were originally derived by the WRAP for the 1996 WRAP-wide emission inventory. Fuel loadings for dead and live fuels originally published as part of the NFDRS (Andersen, 1982) were augmented with fuel loading estimates for two additional fuel layers, crown and duff, shown in Table A.1. These values represent the maximum fuel available for each vegetation type outlined in the NFDRS. With input from David V. Sandberg (USFS – retired, 2001), percent consumption for each fuel layer, outlined in Table A.2, were estimated for wildfire, prescribed fire, and prescribed fire for class Q (black spruce). With the exception of Q, percentages were applied identically over all NFDRS classes. Final fuel consumption estimates, identical to those presented in Table 1.3, are shown in Table A.3 for wildfire and prescribed burning.

A.3 Development of the Emission Reduction Technique Suite

Accounting for emissions reduction and current emission reduction practices is an integral part of the ESMP for Alaska. This appendix presents the results of efforts of ADEC, the AWFCG – Air Quality Committee, and Air Sciences Inc. to develop seasonal suites of Emission Reduction Techniques (ERT) and associated Emission Reduction Factors (ERF) for the state of Alaska.

A method to develop a lookup table of seasonal ERTs and associated ERFs (also known as the "ERT Technical Tool") was developed for the FEJF of the WRAP by Air Sciences. The ERT Technical Tool has been applied to the WRAP's Phase III/IV 2000-04 Baseline Period and 2018 Projection Year Emission Inventories in order to estimate the reduction in $PM_{2.5}$ emissions due to the application of ERTs on planned fire events (prescribed broadcast and pile burns and agricultural burning).

Development of the ERT Technical Tool included a Strawman process over the course of several FEJF meetings, Phase III/IV Task Team breakout sessions, and conference calls. The primary resource document for the work is the Smoke Management Guide for Prescribed and Wildland Fire – 2001 Edition (National Wildfire Coordinating Group, Fire Use Working Team and expert/stakeholder input). In addition, Federal Land Mangers (FLM) from each geographic region in the WRAP for which seasonal suites of ERTs have been developed provided input to complete a lookup table of seasonal suites of ERTs and associated ERFs.

During the development of the ERT Technical Tool for the WRAP, specific conditions and practices in Alaska were not expressly considered. ADEC and members of the AWFCG Air Quality Committee, after review of the WRAP's ERT Technical Tool, directed Air Sciences to develop an ERT suite unique to Alaska. In a meeting on January 25, 2007, with several FMOs from different regions and agencies in Alaska (David Lockwood, FWS; Kato Howard, AFS; and Robert Schmoll, State Department of Forestry) and a representative of ADEC (Joan Hardesty), the WRAP's ERT seasonal suites were reviewed and modified to be more representative for the state of Alaska. Specifically, several modifications were made to the WRAP's seasonal suites of ERTs:

- Three (3) ERTs (numbers 23 – 25 in Table 3 of this memo???) were added to the list of available ERTs.
- Tundra was added as a new vegetation category.
- The definitions of seasons were modified.
- The detailed definitions of ERTs were modified and examples of ERTs were listed.

The seasonal suites of ERTs and the ERFs are not intended to be prescriptive nor precise in representing the application of ERTs in all cases. Furthermore, there are instances of prescribed burning for which no ERT is feasible or warranted.

For each season and vegetation type, ERFs, represented as a percent reduction of $PM_{2.5}$, were developed. The ERFs are intended to be general estimates of the overall, average effectiveness of the seasonal suites of ERTs in reducing emissions of $PM_{2.5}$. ERFs are defined as the percentage of $PM_{2.5}$ emissions averted due to the application of the seasonal suite of ERTs. The factors developed during the January 25, 2007, meeting were compared against ERF information compiled for the effort to develop the seasonal suites of ERTs for the WRAP (Table A.4). This comparison served merely as a general quality control process to confirm the rationality of the ERFs put forth by the Alaska FMOs. Each ERF in Table A.4 is based upon information found in the current literature, estimates of the effectiveness of certain ERTs in reducing available fuel loading, and/or the professional experience of the FLMs who provided input to the matrix table.

Table A.5 presents the seasonal suites of ERTs and the associated ERFs for Alaska. Each event was classified into a season based on the month of event's start date. The seasons and associated months are:

- Winter: November, December, January, February, and March
- Spring: April and May
- Summer: June, July, and August
- Fall: September and October

Seasonal suites of ERTs and the associated ERFs were developed for each of five vegetation categories (grass, brush, tundra, timber, and crop). The vegetation category of a prescribed fire event can be determined from the NFDRS fuel model code (fuel model A though U) or the CFFDRS fuel model. The vegetation categories and associated NFDRS fuel models are:

- Grass –
  - A—western grasses (annual)
  - L—western grasses (perennial)
  - O1a—grass, seasonally cured (standing)
  - O1b—grass, seasonally cured (matted)

- Brush –
  - F —intermediate brush
  - M1—boreal mixed wood – seasonal non-leaf litter (pre-green-up)
  - M2—boreal mixed wood – seasonal non-leaf litter (post-green-up)

- Tundra –
  - S —tundra
  - O1 —tundra/sedge/moss

- Timber –
  - G —short needle (heavy dead)
  - Q —Alaskan black spruce
  - R —hardwood litter (summer)
  - C2 —boreal spruce
  - M1/M2 —boreal mixed wood– seasonal

In the 2005 fire emissions inventory for Alaska and in the Emission Inventory Template developed by Air Sciences for ADEC, application of ERTs is accomplished by reducing emissions according to the appropriate ERF based on the location, timing, and vegetation type of each event.

A.4 Glossary

A few terms are defined in this section to add clarity to the document.

- **Agricultural Burning**—Any fire ignited by management actions to meet specific objectives (i.e., managed to achieve resource benefits) on croplands, rangelands, pasture, and other lands on which crops or livestock are produced.

- ***Event* Fire Emissions Inventory—**A compilation of emissions from individual fires temporally resolved to a start date and end date. Emissions for individual fires are presented as the aggregate of the entire fire event and are not resolved into individual fire days.

- **Prescribed Fire**—Any fire ignited by management actions to meet specific objectives (i.e., managed to achieve resource benefits).
    - Broadcast burn—A burn across a landscape, controlled or uncontrolled, where fuel (e.g., woody debris) has not been gathered together or concentrated into specific sites.
    - Pile burn—Fuel (e.g., woody debris) has been intentionally gathered into a pile or set of piles, and the burn is confined to fuel within that pile or set of piles.
- **Shape files of fire perimeters—**A set of files containing graphical and spatial information of fires that may be displayed, manipulated, and analyzed in a GIS.
- **Smoldering Day—**A method to account for additional emissions from areas that continue to smolder after a fire has moved through or been extinguished. In the context of an emissions inventory, smoldering emissions are estimated by adding an extra day of emissions for each day a fire is reported as active. Emissions on the extra, smoldering days are a fraction—in the range of 10 to 20 percent—of the emissions estimated for each active burn day of a fire.
- **U.S. EPA's Compilation of Emission Factors – AP-42**—The Emission Factor And Inventory Group (EFIG), in the U. S. EPA's Office Of Air Quality Planning And Standards (OAQPS), develops and maintains emission estimating tools to support developing emission control strategies, determining applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and a number of other related applications. The AP-42 series is the principal means by which EFIG can document its emission factors. These factors are cited in numerous other EPA publications and electronic databases, but without the process details and supporting reference material provided in AP-42 (http://www.epa.gov/ttn/chief/ap42/c00s00.pdf).
- **Wildfire**—Any unwanted, non-structural fire.
- **Wildland Fire Use (WFU)—**Management of naturally ignited fires to accomplish specific, pre-stated resource management objectives in predefined geographic areas.

Table A.1: Original NFDRS Fuel Loadings With Duff and Crown Fuel Layers Added

Original NFDRS Fuel Load (ton/acre)

			DEAD				LIVE		OTHER *	
Letter Code	**NFDRS**	**Total**	**1-h**	**10-h**	**100-h**	**1,000-h**	**Wood**	**Herb**	**Duff**	**Crown**
A	**Western grasses (annual)**	**0.50**	0.20	0.00	0.00	0.00	0.00	0.30	0.00	0.00
F	**Intermediate brush**	**15.00**	2.50	2.00	1.50	0.00	9.00	0.00	0.00	0.00
G	**Short needle (heavy dead)**	**59.90**	2.50	2.00	5.00	12.00	0.50	0.50	18.20	19.20
L	**Western grasses (perennial)**	**0.75**	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.00
Q	**Alaskan black spruce**	**96.70**	2.00	2.50	2.00	1.00	4.00	0.50	57.90	26.80
R	**Hardwood litter (summer)**	**3.60**	0.50	0.50	0.50	0.00	0.50	0.50	1.10	0.00
S	**Tundra**	**35.60**	0.50	0.50	0.50	0.50	0.50	0.50	32.60	0.00

Dead and Live fuel source: The National Fire-Danger Rating system: Basic Equations, USDA, 1985.

* Duff and Crown source: David V. Sandberg e-mails, 9/25/01 and 10/04/01.

Table A.2: Percent Fuel Consumed by Fuel Type for WRAP-Modified Fuel Loading Calculations

ETT Defined Percent NFDRS Consumed

	DEAD				LIVE		OTHER	
Fire Type	**1-h**	**10-h**	**100-h**	**1,000-h**	**Wood**	**Herb**	**Duff**	**Crown**
Wildfire consumption - all classes	100%	100%	100%	100%	100%	100%	50%	62%
Prescribed burning consumption - all classes but Q	100%	100%	100%	50%	100%	100%	50%	0%
Prescribed burning consumption - Q	100%	100%	100%	50%	100%	100%	50%	31%

Source: David V. Sandberg e-mail, 9/25/01.

Table A.3: Final Fuel Consumption for Wildfire and Prescribed Burning After Application of Percentages in Table A.2

Wildfire Adjusted Fuel Loading / Fuel Consumption (ton/acre)

			DEAD				LIVE		OTHER	
Letter Code	NFDRS	Total	1-h	10-h	100-h	1,000-h	Wood	Herb	Duff	Crown
A	Western grasses (annual)	0.50	0.20	0.00	0.00	0.00	0.00	0.30	0.00	0.00
F	Intermediate brush	15.00	2.50	2.00	1.50	0.00	9.00	0.00	0.00	0.00
G	Short needle (heavy dead)	43.50	2.50	2.00	5.00	12.00	0.50	0.50	9.10	11.90
L	Western grasses (perennial)	0.75	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.00
R	Hardwood litter (summer)	3.05	0.50	0.50	0.50	0.00	0.50	0.50	0.55	0.00
S	Tundra	19.30	0.50	0.50	0.50	0.50	0.50	0.50	16.30	0.00

Prescribed Burning Adjusted Fuel Loading / Fuel Consumption (ton/acre)

			DEAD				LIVE		OTHER	
Letter Code	NFDRS	Total	1-h	10-h	100-h	1,000-h	Wood	Herb	Duff	Crown
A	Western grasses (annual)	0.50	0.20	0.00	0.00	0.00	0.00	0.30	0.00	0.00
F	Intermediate brush	15.00	2.50	2.00	1.50	0.00	9.00	0.00	0.00	0.00
G	Short needle (heavy dead)	25.60	2.50	2.00	5.00	6.00	0.50	0.50	9.10	0.00
L	Western grasses (perennial)	0.75	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.00
Q	Alaskan black spruce	48.76	2.00	2.50	2.00	0.50	4.00	0.50	28.95	8.31
R	Hardwood litter (summer)	3.05	0.50	0.50	0.50	0.00	0.50	0.50	0.55	0.00
S	Tundra	19.05	0.50	0.50	0.50	0.25	0.50	0.50	16.30	0.00

Table A.4: Emission Reduction Techniques by Season and Fuel Type with Associated Reduction Factors

		Timber				Grass			Crop (ag)				Brush				Tundra	
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
1	Pre-Burn Fuel Removal	% rem	% rem	% rem	% rem								% rem	% rem		% rem		
2	Firewood Sales	% rem	% rem	% rem	% rem								ND			ND		
3	Mechanical Processing	% rem	% rem	% rem	% rem	% rem	% rem		% rem	% rem			% rem	% rem	% rem	% rem		
4	Biomass Utilization	% rem	% rem	% rem	% rem					% rem			% rem			% rem		
5	Mosaic Burning	% nb	% nb			% nb			ND				% nb	% nb			% nb	% nb
6	Ungulates									67%								
7	Burn More Frequently	ND	ND		ND		83%	83%		ND	ND		83%	83%	83%	83%		
8	Underburn Before Litter Fall	ND	ND				ND						ND					
9	Burn Before Green Up	ND				46%			46%				ND					
10	Backing Fire (grass, pine needle litter)	45%	45%			67%	67%		50%	50%			45%				11%	22%
11	Maintain fire line intensity	50%	50%			50%	50%	50%	50%	50%	50%		50%	50%	50%			25%
12	Isolating Fuels	10%	10%			ND	ND		ND	ND			ND	ND				10%
13	Concentration Burning	70%	70%	70%		ND	ND		70%	70%			ND	70%	ND			
14	Chemical Treatment						ND			ND				ND	ND			
15	High Moisture in Large Fuels	43%	43%			ND			ND				ND	ND				
16	Moist Litter and Duff	26%	26%			ND	ND		ND				ND	ND			7%	13%
17	Burn Before Large Activity Fuels Cure	44%	44%			ND			ND				ND	ND			11%	
18	Aerial Ignition/Mass Ignition		10%		10%	10%	10%		10%							10%	5%	10%
19	Rapid Mop-Up	10%	10%		10%	ND			ND				10%	10%	10%	10%		10%
20	Windrow Burning			13%	13%				13%			13%	13%			13%		
21	Pile Burning			70%	70%				70%			70%	70%		70%	70%		
22	Air Curtain Incinerators				ND								ND		ND	ND		
23	Low Moisture Burning		ND											ND				
24	Landscape Burning			ND	ND													ND

Table A.5: Combined Seasonal ERT Suite for Alaska.

	Grass	Ref	Brush	Ref	Tundra	Ref
Seasonal ERT Suites:						
Spring suite (April - May)	55%	3,5,9,10,11,12,13,15,16,17,18,18,19	45%	1,2,3,4,5,7,8,9,10,11,12,13,15,16,17,19,20,21,22	5-10%	5,10,16,17,18
Summer suite (June - August)	60%	3,7,8,10,11,12,13,14,16,18,24	40%	5,12,13,1,3,14,15,16,17,7,11,19,23	15-20%	5,10,11,12,16,18,19,24
Fall suite (September - October)	65%	7,11	45%	13,3,14,7,11,19,21,22		N/A
Winter suite (November - March)		N/A	65%	1,2,3,4,7,18,19,20,21,22		N/A

Timber	Ref	Crop (ag)	Ref
35%	1,2,3,4,5,7,8,9,10,11,12,13,15,16,17,19	55%	3,5,9,10,11,12,13,15,16,17,18,19,20,21
40%	1,2,3,4,5,7,8,10,11,12,13,15,16,17,18,19	60%	3,4,6,7,10,11,12,13,14
35-60%	1,2,3,4,13,20,21	65%	7,11
5-35%	1,2,3,4,7,18,19,20,21,22	25%	20,21

APPENDIX B

Technical Discussion of Modifications

CONTENTS

Page

Tables

Figures

APPENDIX B

TECHNICAL DISCUSSION OF MODIFICATIONS

B.1 Seasonal Fuel Loading Derivation

Seasonal fuel consumption values used in this inventory were originally derived in the Inter-RPO 2002 National Wildfire Emission Inventory (Air Sciences and ECR, 2005). The Inter-RPO fuel consumption values were derived using the FEPS Version 1.0 (USDA – Forest Service, Pacific Northwest Research Station, Fire and Environmental Research Applications Team). Fuel *loadings* by the WRAP-modified NFDRS fuel model as shown in Table A.3 were used as input to FEPS, which then provided estimates of fuel *consumption* values for each of six moisture regimes (very dry, dry, moderate, moist, wet, very wet). FEPS was used to calculate fuel consumption values (in tons-per-acre) for each of the six FEPS moisture regimes for each NFDRS fuel model, shown in Table B.1. The output from FEPS includes flaming fuel consumption and smoldering fuel consumption. Total fuel consumption (tons consumed per acre) is the sum of flaming and smoldering consumption, applied as described in Section 1.4.2 and Section 1.7.

The Inter-RPO emission inventory only compiled estimates for wildfire. Therefore, for the purposes of the 2005 Alaska inventory, seasonal prescribed fire fuel consumption needed to be interpolated from wildfire values. To do this, FEPS-derived wildfire fuel consumption for each moisture regime and NFDRS class was divided by the WRAP-modified fuel loading (upper half of Table A.3) for each NFDRS class to obtain a "percent of original". The "percent of original" values, one for each moisture regime and fuel class, were then multiplied by the WRAP-modified prescribed burning fuel loadings for each NFDRS class (lower half of Table A.3) to obtain the "PRESCRIBED" values in Table B.1. The same procedure was performed for smoldering fuel consumption values.

Figure B.1 compares the total fuel consumption estimates from FEPS (flaming and smoldering) with the original WRAP-modified fuel loadings (wildfire values in Table A.3 + 17% to account for smoldering – see method described in Section 1.7). NFDRS classes not applicable to Alaska are presented as this methodology was originally applied to the entire WRAP region. In some cases, total fuel consumption decreases significantly from the original fuel loading, while class Q (black spruce) is slightly greater than the original for the Very Dry class.

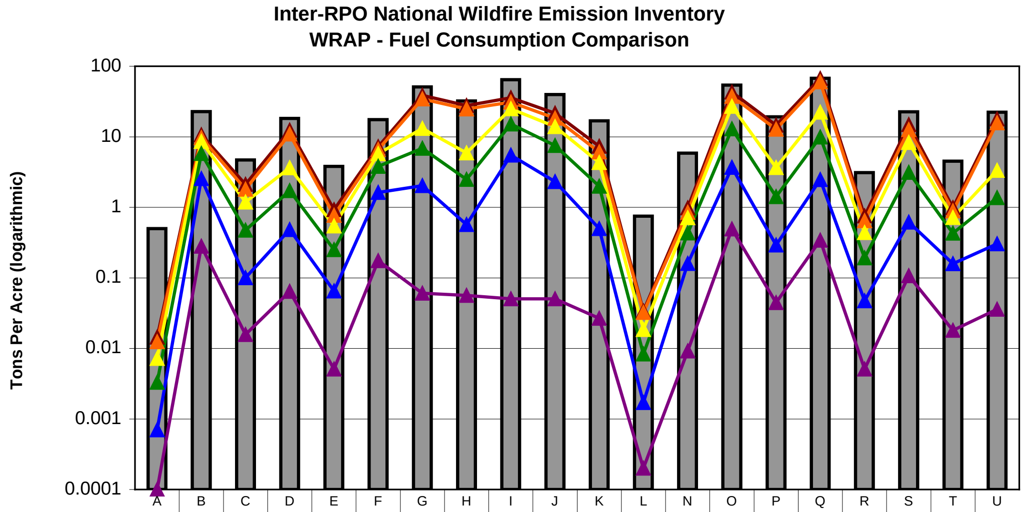
For the 2005 Alaska Emissions Inventory, consumption values were cross-walked to four CFFDRS fuel types available from the 30-meter GIS fuel layer, outlined in Section 1.4. This method combines some NFDRS classes into a single CFFDRS classification, which may not accurately reflect available fuel in some cases. In addition, total available fuel values presented in the Alaska Digital Photo Series (http://depts.washington.edu/nwfire/dps/) are significantly higher then those estimated here. Fuel loadings for Black Spruce (NFDRS class Q or CFFDRS class C-2), for example, range from 60 to 180 tons per acre.

Table B.1: Matrix Wildfire, WFU, and Prescribed Fuel Consumption Values for Six Moisture Regimes, Flaming and Smoldering

FLAMING	NFDRS Class	Very Dry	Dry	Moderate	Moist	Wet	Very Wet
WILDFIRE / WFU	A	0.0144	0.0124	0.0072	0.0033	0.0007	0.0001
	F	7.2473	6.5946	5.7633	3.8149	1.6262	0.1755
	G	35.9636	32.3293	11.9972	6.7100	2.0302	0.0604
	L	0.0339	0.0322	0.0185	0.0083	0.0017	0.0002
	Q	58.5322	53.3731	18.6542	9.3496	2.4555	0.3423
	R	0.5915	0.5149	0.3698	0.1823	0.0470	0.0051
	S	10.0342	8.8606	6.2771	2.8376	0.6117	0.1070
PRESCRIBED	A	0.0144	0.0124	0.0072	0.0033	0.0007	0.0001
	F	7.2473	6.5946	5.7633	3.8149	1.6262	0.1755
	G	21.1648	19.0260	7.0604	3.9489	1.1948	0.0355
	L	0.0339	0.0322	0.0185	0.0083	0.0017	0.0002
	Q	49.5750	45.2054	15.7995	7.9188	2.0797	0.2899
	R	0.5915	0.5149	0.3698	0.1823	0.0470	0.0051
	S	9.9042	8.7458	6.1958	2.8008	0.6038	0.1056

SMOLDERING	NFDRS Class	Very Dry	Dry	Moderate	Moist	Wet	Very Wet
WILDFIRE / WFU	A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	G	2.6934	2.1174	1.1286	0.1639	0.0029	0.0000
	L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Q	8.5686	6.7362	3.5905	0.5213	0.0091	0.0000
	R	0.1628	0.1280	0.0682	0.0099	0.0002	0.0000
	S	4.8245	3.7927	2.0216	0.2935	0.0051	0.0000
PRESCRIBED	A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	G	1.5851	1.2461	0.6642	0.0965	0.0017	0.0000
	L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Q	7.2573	5.7054	3.0410	0.4415	0.0077	0.0000
	R	0.1628	0.1280	0.0682	0.0099	0.0002	0.0000
	S	4.7620	3.7436	1.9954	0.2897	0.0050	0.0000

Figure B.1: Comparison of WRAP-Modified and FEPS-Derived Fuel Loadings for Six Moisture Regimes, Flaming and Smoldering



	A	B	C	D	E	F	G	H	I	J	K	L	N	O	P	Q	R	S	T	U
RPO Consumption	0.5000	22.815	4.7000	18.252	3.8000	17.550	50.895	32.175	64.467	39.780	16.848	0.7500	5.8500	53.937	19.188	67.392	3.1000	22.581	4.5000	22.347
Very Dry *	0.0144	10.626	2.1115	12.373	0.9217	7.2473	38.657	27.778	35.833	21.539	7.3024	0.0339	0.9791	43.087	14.579	67.100	0.7543	14.858	0.9867	17.817
Dry *	0.0124	9.7163	1.8038	10.926	0.7710	6.5946	34.446	24.709	31.014	18.281	6.1028	0.0322	0.8477	37.500	12.756	60.109	0.6429	12.653	0.8859	15.762
Moderate *	0.0072	8.5559	1.1882	3.6288	0.5436	5.7633	13.125	5.8846	24.945	13.902	4.3236	0.0185	0.7111	26.962	3.6479	22.244	0.4380	8.2987	0.7155	3.3474
Moist *	0.0033	5.7860	0.4728	1.7174	0.2512	3.8149	6.8739	2.4922	15.200	7.5163	1.9865	0.0083	0.4330	12.951	1.4195	9.8709	0.1922	3.1311	0.4295	1.3726
Wet *	0.0007	2.5460	0.1006	0.4837	0.0650	1.6262	2.0331	0.5689	5.5011	2.3055	0.5002	0.0017	0.1594	3.6879	0.2928	2.4646	0.0472	0.6168	0.1583	0.3030
Very Wet *	0.0001	0.2811	0.0157	0.0643	0.0051	0.1755	0.0604	0.0562	0.0503	0.0503	0.0268	0.0002	0.0092	0.4930	0.0446	0.3423	0.0051	0.1070	0.0180	0.0358

* Inter-RPO Fuel Consumption

NFDRS Class

B.2 Analysis of Changes in Fuel Consumption Methodology from Draft Report

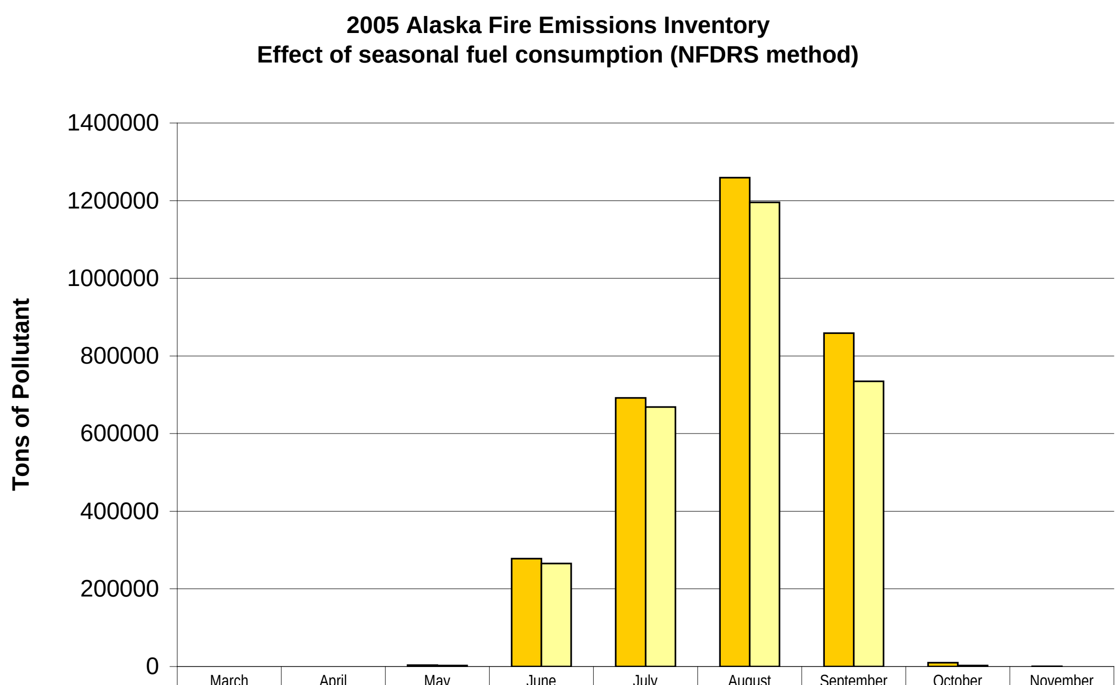
The methodology for deriving fuel consumption in the draft report utilized the NFDRS fuel model, WRAP-modified NFDRS fuel loadings (see discussion above), and a 1-km resolution NFDRS fuel layer GIS map. Based on feedback received, several major changes were implemented:

- A 30-meter resolution CFFDRS fuel layer GIS map replaced the NFDRS map.
- WRAP-modified fuel loadings were cross-walked to CFFDRS classes available in the map layer.
- Seasonality was introduced to fuel consumption calculations for fires with GIS perimeter data. The method, outlined in Section 1.4.2 and Section B.1, utilized results from the 2002 Inter-RPO Wildfire Emissions Inventory.
- Seasonal fuel consumption values, originally derived by NFDRS class, were cross-walked to CFFDRS.

These changes together resulted in a significant drop in emissions, from 3.2 million tons of $PM_{2.5}$ to 2.0 million tons, but also increased the precision of the overall results. The relative accuracy between the two methods remains an open question, as the fuel consumption values associated with the 4 CFFDRS classes used in this inventory may underestimate the total available fuel in many cases. In the future, use of the Alaska Digital Photo Series (http://depts.washington.edu/nwfire/dps/) may provide more reasonable estimates of consumption.

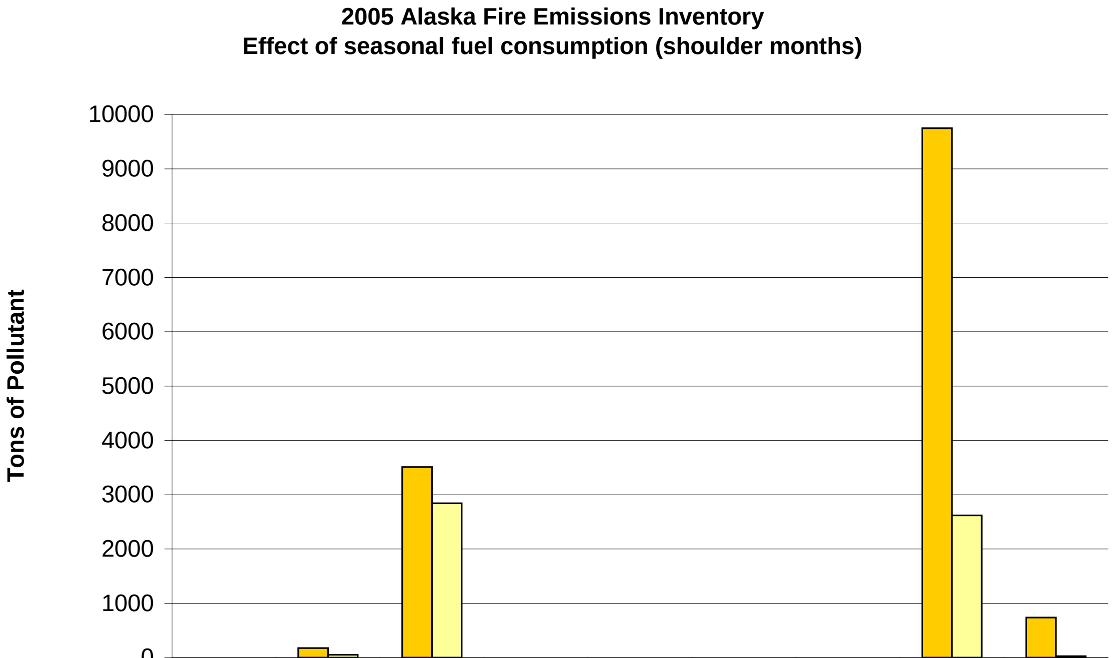
All of the changes made contributed to the drop in emissions. Seasonality contributed a small but significant amount. Figures B.2 and B.3 illustrate the effect of introducing seasonality to fuel consumption estimates. The data presented are from the draft version of the emissions inventory, which used NFDRS fuel classes. In addition, weighted average fuel loadings for fires with perimeter data were not used; instead, a single fuel classification was assigned to each fire. Figure B.3 highlights the "shoulder" months—obscured in Figure B.2—which are (as expected) the most significantly effected by seasonal fuel consumption estimates. In the context of total annual emissions, the influence of seasonal fuel consumption estimates remains small because most fire activity occurs during the driest months. However, for applications using event- or daily-based emissions inventory data the difference can be quite large. Given this significant effect, it is worthwhile—despite being limited to six moisture regimes and not directly tied to moisture conditions of a particular year—to include the seasonal adjustment of fuel consumption outlined here as part of the emissions inventory methods in Alaska.

Figure B.2: Monthly $PM_{2.5}$ Emissions With and Without Seasonal Fuel Consumption



	March	April	May	June	July	August	September	October	November
NFDRS	0	173	3,507	277,985	691,854	1,259,385	858,560	9,748	737
NFDRS Seasonal	0	54	2,842	265,586	668,430	1,195,725	734,756	2,618	28

Figure B.3: Monthly $PM_{2.5}$ Emissions With and Without Seasonal Fuel Consumption, Shoulder Months

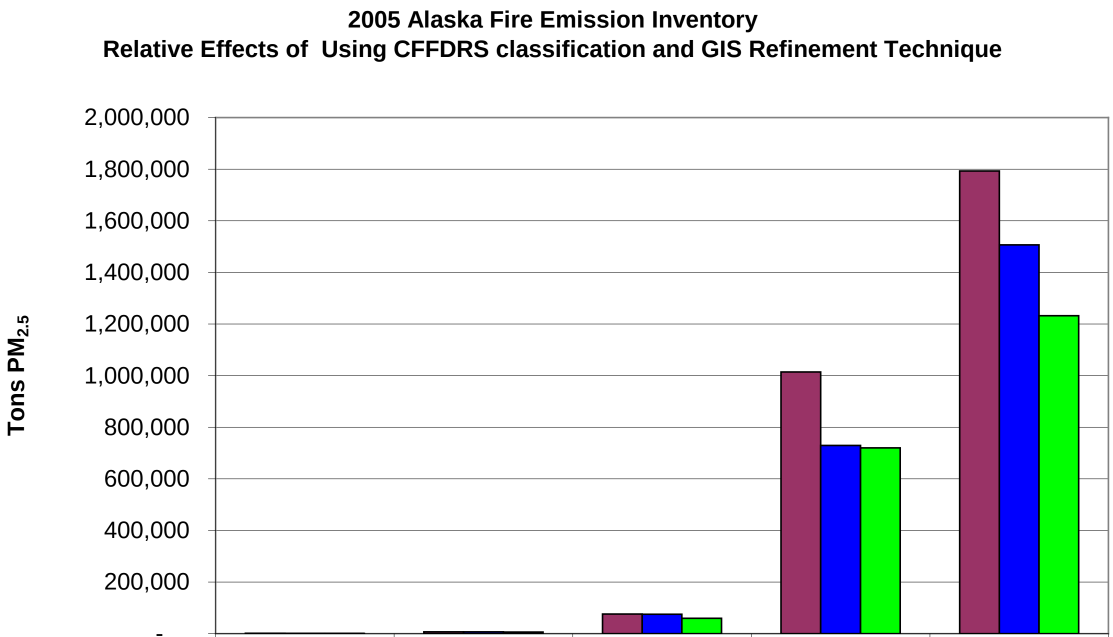


	March	April	May	June	July	August	September	October	November
NFDRS	0	173	3507					9748	737
NFDRS Seasonal	0	54	2842					2618	28

The use of CFFDRS fuel classifications and a high-resolution fuels map had a larger effect than seasonal fuel consumption on total annual emissions. Figure B.4 illustrates the effect of using cross-walked CFFDRS fuel classes as well as using the weighted average refinement technique (Section 1.4.1) with the 30-m CFFDRS fuel map. Compared here are the draft method using NFDRS classes (with seasonal fuel consumption), cross-walked CFFDRS classes with seasonal fuel consumption but without weight average fuel loading, and the final 2005 emissions inventory method with both seasonal fuel consumption and weighted fuel average refinement. Both CFFDRS methods mainly affect larger fires. The most significant effect due to the high resolution map is only for the largest 17 fires, greater than 100,000 acres. This is possibly due to the difference in vegetation distribution between the NFDRS map and the CFFDRS map (discussed below).

In the draft inventory, a 1-km fuel map was used that does not capture water bodies such as rivers and small lakes, nor does it capture nearly as much detail about the distribution of fuels across the landscape, which can lead to a significantly different estimate of fuel consumed. As an example, Figure 1.4 in Section 1.4.1 shows the distribution of CFFDRS fuel classes when using the refinement technique. Table B.2 below compares the distribution to that obtained with the 1-km NFDRS data. There is a marked difference in the fuel distribution, especially the percentage of grass-type fuels and non-fuel areas. The percentage of non-fuel grid cells for all fires was much higher for the CFFDRS layer, as shown in Table B.3. In addition, there was a 73-percent increase in the total area of grass-type fuels for all fires with the CFFDRS fuel map.

Figure B.4: Relative Effect of Using CFFDRS Fuels Classifications and a High Resolution Fuels Map for Weighted Fuel Loading GIS Refinement Technique



	A (0.1 - 100)	B (100 - 1,000)	C (1,000 - 10,000)	D (10,000 - 100,000)	E (> 100,000)
NFDRS Seasonal	1,267	7,114	76,002	1,014,207	1,792,614
CFFDRS Seasonal	1,045	7,100	75,372	729,449	1,507,000
CFFDRS Seasonal+GIS	1,097	6,118	59,892	719,646	1,232,362

Table B.2: Comparison of Fuel Type Distribution for the George Using 1-km and 30-Meter Data

Fuel Type	NFDRS 1 km	CFFDRS 30 m
Q [C2]	37%	43%
A/L [O1a/O1b]	12%	23%
F/G [M1/M2]	52%	31%
S [O1]	0%	1.0%
Null [Non-fuel]	0%	2.3%

Table B.3: Total km^2 of Non-Fuel Grid Cells for NFDRS GIS Layer and CFFDRS Layer

		Out of Bounds	Non-Fuel	Water	Undet.	Total km^2	Percent of all Fires
CFFDRS	km^2	0.0738	706	200	443	1,350	7.2%
	%	0.01%	52%	15%	33%		
NFDRS	km^2	29.4	80.3			110	0.6%
	%	27%	73%				

The 1-km resolution of the NFDRS fuels map used in the draft emissions inventory has a diminished accuracy in the context of the weighted fuel average refinement technique (outlined in Section 1.4.1) as fire sizes approach the resolution limit of 1 km^2 (242 acres). This is evident when comparing Figure 1.5 in Section 1.4.1 with the equivalent figure created from the 1-km map, shown below in Figure B.5. In Figure B.5, the change in total consumption with the refinement technique is solely due to the largest fires, >50,000 acres for wildfire and >20,000 acres for WFU. In contrast, the reduction in total consumption continues to grow down to fires >100 acres for the refinement technique using the 30-meter GIS data (Figure 1.5). This, combined with the capturing of non-fuel data missed by the 1-km data, illustrates the enhanced precision of using the CFFDRS data layer.

Figure B.5: Equivalent of Figure 1.5 in Section 1.4.1 Using the NFDRS 1-km GIS Data Layer