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TECHNICAL MEMORANDUM

FIRE EMISSIONS INVENTORY – PHASE III BASE-CONTROL CASE

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This Technical Memorandum presents the methodology used to develop the Base-Control Case emission inventory for fire in support of the Western Regional Air Partnership's (WRAP) development of the Phase III (Base 2000-2004) inventory. In addition, summary statistics for the Base Control case for fire are presented. The Phase III Base Control case for fire is the Phase III Base case with emission reduction techniques (ERTs) applied to prescribed fire and agricultural burning. Simultaneous with the delivery of this memo, the appropriate Phase III Base Control fire emission inventory files will be posted on the Phase III/IV Fire emissions webpage.

Defining Emission Reduction Techniques and Their Effectiveness

A method to develop a lookup table of seasonal ERTs and associated emission reduction factors (ERF) 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 this work is the Smoke Management Guide for Prescribed and Wildland Fire – 2001 Edition (National Wildfire Coordinating Group, Fire Use Working Team). From this document and expert/stakeholder input, several EXCEL worksheet tables were developed. In addition, Federal Land Mangers (FLM) from each geographic region for which seasonal suites of ERTs have been developed provided input to complete the lookup table of seasonal suites of ERTs and the associated ERFs.

The lookup table of ERTs and ERFs generally characterize ERTs by season (winter, spring, summer, fall), by vegetation type category (grass, brush, timber, crop), and by geographic region (northwest [NW], southwest [SW], and intermountain west [IMW]). Air Sciences and the FLMs who provided input to prepare the lookup table recognize that that the ERT seasonal suites are representative of ERTs (and combinations of ERTs) that are typically implemented for the regions and vegetation categories. The ERFs are intended to be general estimates of the overall, average effectiveness of the seasonal suites of ERTs in reducing emissions of $PM_{2.5}$. Each ERF that has been assigned to a seasonal ERT suite for a geographic region is based upon ERF information found in the current literature, estimates of the effectiveness of certain ERTs in reducing available fuel loading, and the professional experience of the FLMs who provided input to the lookup table. 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.

Applying Emission Reduction Factors to the Emission Inventory

Accounting for the implementation of ERTs in the Phase III Base Case (2000-2004) fire emissions inventory was accomplished by reducing emissions according to the appropriate ERF based on the location, timing, and vegetation type of each event. The seasonal suites of ERTs and associated ERFs are listed in Table 1. ERFs are defined as the percentage of $PM_{2.5}$ emissions averted due to the application of the seasonal suite of ERTs.

Table 1 ERFs (percent $PM_{2.5}$ emissions averted) for Seasonal Suites of ERTs

Region	**Season**	**Vegetation Category**			
		Grass	Brush	Timber	Crop
SW	Spring	55%	45%	45%	50%
SW	Summer	55%	40%	30%	50%
SW	Fall	55%	45%	45%	70%
SW	Winter	55%	45%	60%	70%
NW	Spring	55%	70%	40%	0%
NW	Summer	65%	45%	45%	30%
NW	Fall	65%	65%	52.5%	70%
NW	Winter	10%	70%	25%	75%
IMW	Spring	55%	40%	40%	50%
IMW	Summer	60%	40%	45%	40%
IMW	Fall	65%	60%	60%	70%
IMW	Winter	25%	50%	20%	0%

ERFs were applied to all agricultural burning events, which have all been categorized as "anthropogenic" in the Base Case inventory. ERFs were also applied to prescribed *broadcast* fires categorized as "anthropogenic" in the Base Case inventory. Prescribed *pile* burning events in the inventory, also categorized as "anthropogenic," did not have ERFs applied

because a unique suite of emission factors for pile burning events (which accounts for the emissions control associated with pile burning) was already applied to burning events in the Base Case prescribed fire inventory. The application of ERFs to prescribed broadcast and agricultural burning event was dependent upon specific data contained in each fire record: location (state, cross-walked to ERT region), time of burn (month, cross-walked to season), and fuel type (NFDRS, cross-walked to fuel category [grass, brush, timber, crop]).

Seasonal suites of ERTs and the associated ERFs were developed for three regions of the WRAP. Each event was classified into a region based on the event's location (state). The regions and associated states are:

- **Northwest region (NW)** - Alaska, Oregon, and Washington
- **Southwest region (SW)** - Arizona, California, New Mexico, Nevada, and Utah
- **Inter-Mountain West region (IMW)** - Colorado, Idaho, Montana, North Dakota, South Dakota, and Wyoming

Seasonal suites of ERTs and the associated ERFs were developed for each of the four seasons. Each event was classified into a season based on the event's date of burn (month). The seasons and associated months are:

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

Seasonal suites of ERTs and the associated ERFs were developed for each of four vegetation categories (grass, brush, timber, crop). The fuel category of a prescribed event was determined by the National Fire Danger Rating System (NFDRS) fuel model code (fuel model A though U) assigned to each event in the Base Case fire inventory. All agricultural burning events were assigned the "crop" fuel type. The vegetation categories and associated NFDRS fuel models are:

- **Grass** –
  - **A** - western grasses (annual),
  - **L** – western grasses (perennial),
  - **N** - sawgrass, and
  - **S** - tundra
- **Brush** –
  - **B** - California chaparral,
  - **F** - intermediate brush,
  - **O** - high pocosin, and
  - **T** - Sagebrush grass
- **Timber** –
  - **C** – pine grass savanna,

- **D** - southern rough,
- **E** - hardwood litter (winter),
- **G** - short needle (heavy dead),
- **H** - short needle (normal dead),
- **I** - heavy slash,
- **J** - intermediate slash,
- **K** - light slash,
- **P** - southern pine plantation,
- **Q** - Alaskan black spruce,
- **R** - hardwood litter (summer), and
- **U** - western pines

The Base Control case emissions were calculated by applying the by-region, by-season, by-fuel category ERF to the $PM_{2.5}$ emissions from each qualifying event in the Base (2000-2004) fire inventory. The application of the ERF is shown in Equation 1.

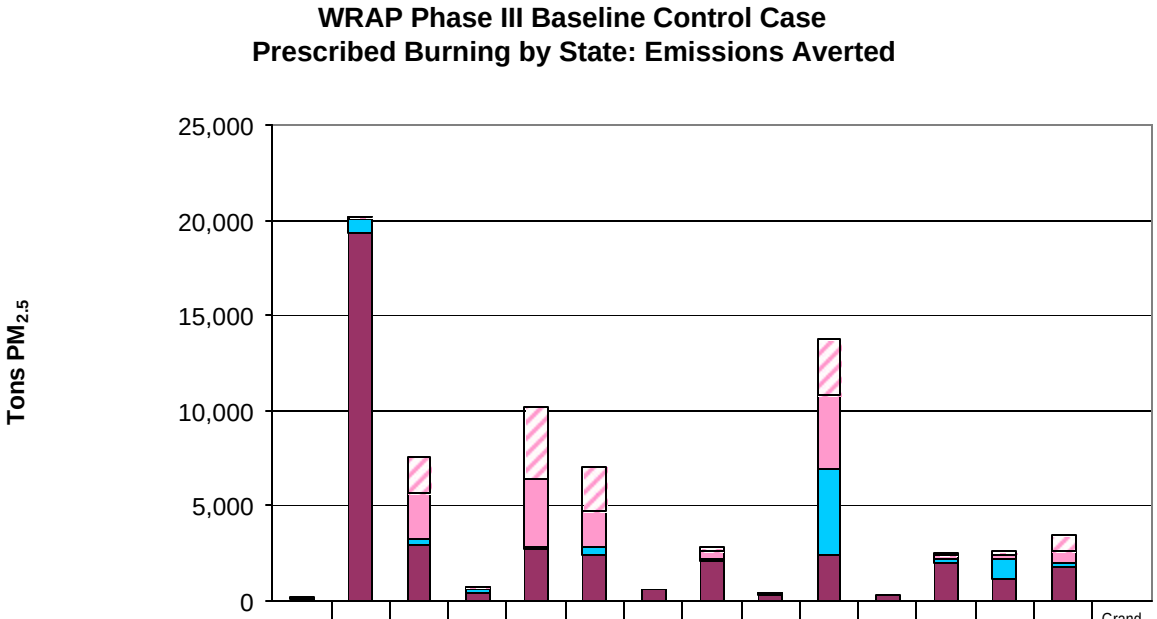
$$\text{Emissions}_{(\text{Base Control})} = \text{Emissions}_{(\text{Base})} \times (1 - \text{ERF}) \qquad (1)$$

A step-by-step example of the Base Control emissions calculation for a hypothetical prescribed burning broadcast event is shown below:

1. Base $PM_{2.5}$ emissions from single prescribed broadcast burn event:
    a. Fire type – prescribed fire; broadcast; anthropogenic.
    b. Emissions – 100 tons $PM_{2.5}$.
    c. Fire location – Southwest (Arizona).
    d. Fire timing – Spring (April).
    e. Vegetation category – Grass (NFDRS fuel model A).
2. Look up ERF in the ERT Seasonal Suite lookup Table: 55% (Southwest, spring, grass fire).
3. Calculate PM2.5 emissions:
    a. Equation - $\text{Emissions}_{(\text{Base Control})} = 100 \text{ tons } PM_{2.5} \times (1 - 0.55)$
    b. Result - $\text{Emissions}_{(\text{Base Control})} = 45 \text{ tons } PM_{2.5}$
    c. Emissions Averted = 55 tons $PM_{2.5}$

Applying Emission Reduction Factors to the Emission Inventory

Figures 1 through 3 display the effectiveness in reducing $PM_{2.5}$ emissions due to the application of ERFs associated with the seasonal suites of ERTs to the qualifying events in the Base Control fire inventory.



	AK	AZ	CA	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY	Grand Total
Averted (ERTs on Broad-ANTH)	79	30	1,944	39	3,784	2,395	0	214	16	2,955	0	136	163	840	12,595
Broadcast - ANTH	88	37	2,395	56	3,594	1,857	0	353	19	3,840	0	155	167	587	13,148
Piled - ANTH	4	814	276	273	162	453	0	166	44	4,512	0	195	1,123	296	8,318
Broadcast - NAT	8	19,337	2,955	339	2,688	2,361	556	2,064	319	2,447	333	2,003	1,105	1,708	38,221

Figure 1. WRAP Phase III Base Control case. Wildland prescribed burning $PM_{2.5}$ emissions by state with emissions averted due to the implementation of ERTs.

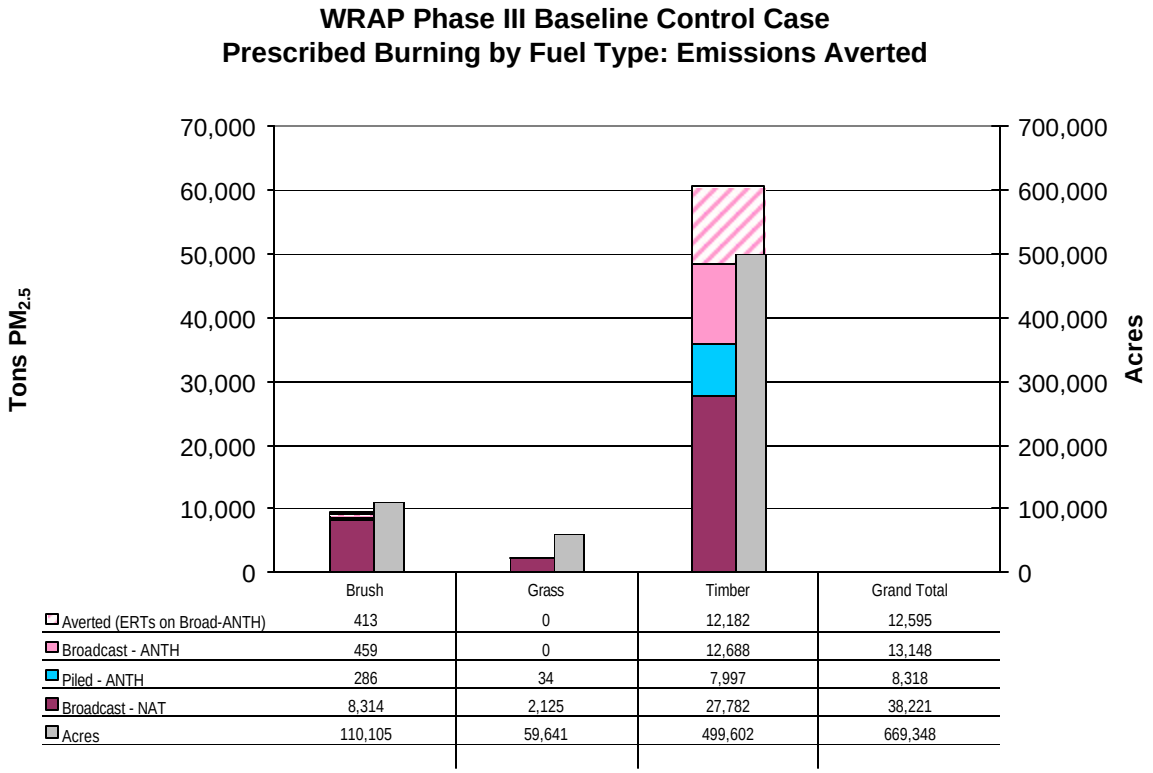


Figure 2. WRAP Phase III Base Control case. Wildland prescribed burning $PM_{2.5}$ emissions and acres by vegetation category with emissions averted due to the implementation of ERTs.

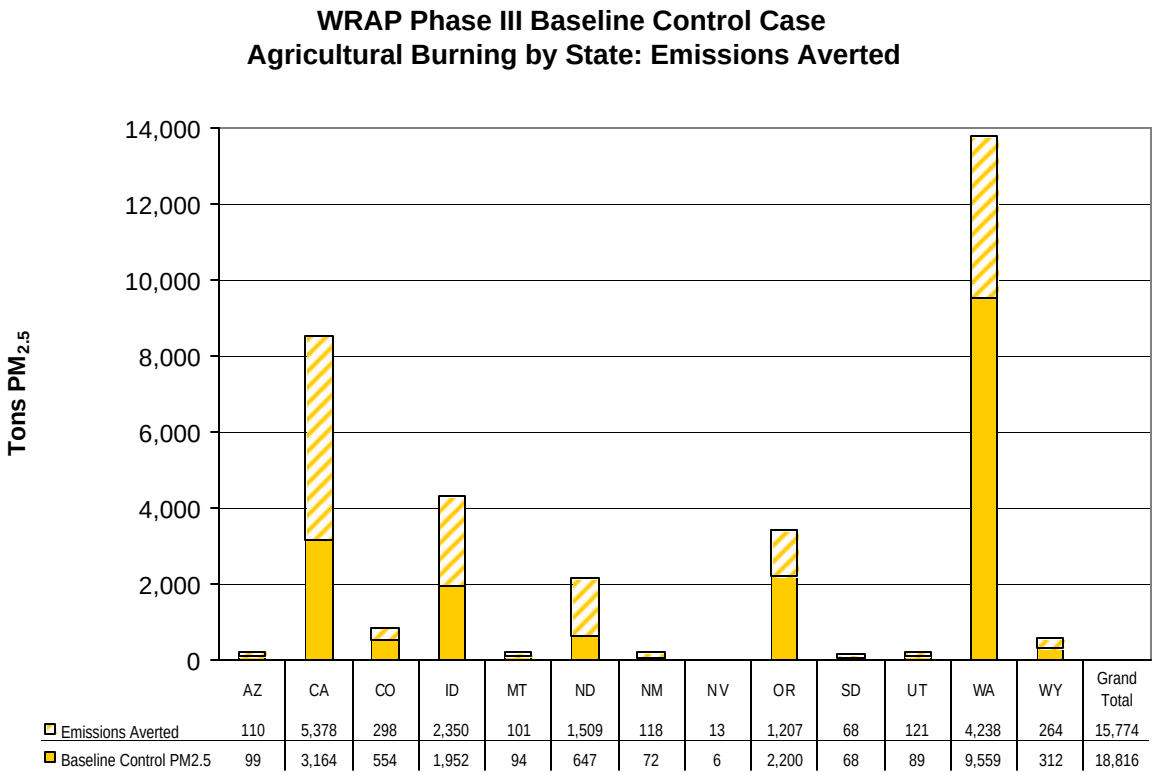


Figure 3. WRAP Phase III Base Case control. Agricultural burning $PM_{2.5}$ emissions by state with emissions averted due to the implementation of ERTs.