Methodology for Estimating Emissions from Waste Burning
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Background

This document describes the methods used to estimate emissions from waste burning. Emissions in this source category come from the open burning of agricultural residues (such as crop stubble and orchard pruning), weed abatement (such as ditch and canal bank burning), range improvement (such as chaparral and grass land burning), and other materials. See Table 1 below for the emission inventory categories (EIC) updated.

Waste burning is a district reported emissions inventory category. While several districts have updated this category in the recent past, others have not. This update provides default emission estimates for those districts that will be required to do federal ozone and particulate matter State Implementation Plans (SIP) and are not currently updating this category (Attachment A - Map of updated areas). Emission estimates are provided in this update for the: Mojave Desert Air Basin (Antelope Valley, East Kern and Mojave Desert districts), South Coast Air Basin, San Diego, Salton Sea Air Basin, and part of the Mountain Counties (Amador and Nevada Counties).

Table 1. Updated Waste Burning and Disposal Emissions Inventory Categories

EIC category	EIC Code
Agricultural Burning – Prunings	670-660-0262-0000
Agricultural Burning – Field Crops	670-662-0262-0000
Range Improvement	670-660-0200-0000
Weed Abatement	670-668-0200-0000
Waste Burning (unspecified)	670-995-0240-0000

Source Data

Waste burn information was gathered from the districts based on their permit data. How individual districts permit, manage, and submit waste burn information varied significantly from district to district. As a result, a significant amount of work was done to organize, categorize, and format the waste burn information for emission inventory purposes.

There were two primary data gathering efforts. The first was done via contract. UC Berkeley's Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER), in cooperation with Les Fife of Fife Environmental, gathered 2000 waste burn data for several counties in California (Scarborough et al. 2002). This update uses the CAMFER 2000 waste burn data for San Diego and Imperial Counties. Please note that the emission estimates reported in the referenced CAMFER report may not match the emission estimates reported here. That is because data provided by the CAMFER study was further refined to apply the expanded suite of crop specific emission factors

(Attachment B - Emission Factors Table). For the remaining areas, ARB staff compiled 2002 waste burn information either by directly contacting the individual districts or from the annual reports submitted to ARB. These districts include Amador County, Nevada County, Eastern Kern District, Antelope Valley District, Mojave Desert District, and South Coast Air Basin.

Emissions Estimation

The districts provided the amount of material burned in either acres or tons burned, though acres were the most common. Emissions were calculated by multiplying the acres reported by the crop specific fuel loading factors and then by multiplying the calculated tons of material by the crop specific emission factors. If tons of material were provided, emissions were calculated by multiplying the reported tons by the crop specific emission factors. Emissions were then converted from pounds (lbs) to tons, and then summed by county, air basin, and district area. Table 2 below lists the emissions estimated by county, air basin, and district as well as the total tons of material burned by EIC category. Table 2 also shows the source data year, indicating if the data were compiled by CAMFER (2000) or by ARB (2002).

Emission Factors

Emissions are calculated for PM10, PM2.5, NOx, SO2, VOC, and CO. Background information for emission factors and fuel loading is explained in the Agricultural Burning Emission Factors memo dated August 17, 2000 (Attachment C - Memo). The San Joaquin Valley Air Pollution Control District further expanded the suite of crop specific emission factors using the same approach outlined in the memo. Emission factors come from the measurements conducted at the University of California at Davis in 1992 and 1993 (Jenkins, B., 1996). Where the more recent Jenkins data are not available for specific materials burned, default emission factors are used from the U.S. EPA's "Compilation of Air Pollutant Emission Factors," which is often referred to as AP-42. These emission factors are based on ARB sponsored tests performed in 1974 and 1977.

Changes

As described above, the specific crops that have emission factors and fuel loading values were expanded to include the varied suite of crops burned. There are no changes to the underlying methodology used to estimate emissions for these categories (see sample equations). All districts use the same set of emission factors, fuel loading assumptions and methodology described here to estimate emissions for waste burning.

Projections

The agricultural burning projection factor is based on California Department of Conversation's Farmland Mapping and Monitoring Program irrigated and non-irrigated acreage.

Uncertainty

The permitted acres burned do not necessarily reflect the actual acres burned, therefore waste burning emissions may be overestimated. A burner sometimes overestimates acreage for the permit to ensure they remain within their permit even if they vary their burn. They may also retain a permit for more acres then they can burn so that they don't have to go through the permit process again if they want to burn additional acres. There is not an effective feedback loop in place that requires the burner to report back to the district the actual acres they burned. One solution would be to require that burners report to the district the actual acres they burned.

Sample Equations

*Crop acres * FL (tons fuel/crop acres) * EF (lbs pollutant/tonsl) * tons/2000 lbs*

EF - emission factor
FL - fuel loading

Example Equation for PM10 Emissions

ABC County burned 250 acres of Almond orchard:

Fuel Loading - 1.00 ton/acre
PM10 Emission Factor - 7.00 lbs PM10/ton

$$\left(250 \text{ ac Almond}\right) * \left(\frac{1.00 \text{ ton Almond pruning}}{1 \text{ ac Almond orchard}}\right) * \left(\frac{7.00 \text{ lbs PM10}}{\text{tons Almond pruning}}\right) * \left(\frac{\text{tons}}{2000 \text{ lbs}}\right) = 0.875 \text{ tons PM10}$$

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Table 2. Emissions and Tons Burned by EIC for the South Coast, Salton Sea, Mojave Desert, San Diego and part of the Mountain Counties Air Basins.

					Tons/Year						
Year of Data	County	Air Basin	Air District	EIC Description	Total Tons Burned	PM10	PM2.5	NOx	SO2	VOC	CO
2002	AMADOR	MC	AMA	Field Crops	998.34	5.691	5.441	1.647	0.200	3.295	35.391
2002	AMADOR	MC	AMA	Prunings	703.50	1.705	1.602	1.810	0.038	1.364	18.373
2002	AMADOR	MC	AMA	Weed Abatement	6,557.68	58.771	53.155	13.173	1.178	40.934	436.521
2002	AMADOR	MC	AMA	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	AMADOR	MC	AMA	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	NEVADA	MC	NSI	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	NEVADA	MC	NSI	Prunings	71.40	0.278	0.261	0.186	0.004	0.225	2.356
2002	NEVADA	MC	NSI	Weed Abatement	3,124.28	28.098	25.374	6.253	0.549	19.587	208.897
2002	NEVADA	MC	NSI	Range Improvement	3.20	0.025	0.024	0.007	0.001	0.017	0.182
2002	NEVADA	MC	NSI	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	KERN	MD	Ker	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	KERN	MD	Ker	Prunings	58.00	0.177	0.167	0.151	0.003	0.133	1.614
2002	KERN	MD	Ker	Weed Abatement	7,309.85	65.775	59.385	14.623	1.281	45.857	489.079
2002	KERN	MD	Ker	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	KERN	MD	Ker	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	LOS ANGELES	MD	AV	Field Crops	3,000.00	42.750	40.800	6.750	0.900	32.550	178.500
2002	LOS ANGELES	MD	AV	Prunings	2,057.00	8.022	7.508	5.348	0.103	6.480	67.881
2002	LOS ANGELES	MD	AV	Weed Abatement	7,645.12	60.779	58.026	17.163	2.332	41.016	435.581
2002	LOS ANGELES	MD	AV	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	LOS ANGELES	MD	AV	Unspecified	11,136.00	88.531	84.522	25.000	3.396	59.745	634.474
2002	SAN BERNARDINO	MD	MD	Field Crops	1,094.00	15.590	14.878	2.462	0.328	11.870	65.093
2002	SAN BERNARDINO	MD	MD	Prunings	106.25	0.414	0.388	0.276	0.005	0.335	3.506
2002	SAN BERNARDINO	MD	MD	Weed Abatement	22,169.77	176.250	168.269	49.771	6.762	118.941	1,263.123
2002	SAN BERNARDINO	MD	MD	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	SAN BERNARDINO	MD	MD	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	LOS ANGELES	SC	SC	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	LOS ANGELES	SC	SC	Prunings	17.00	0.066	0.062	0.044	0.001	0.054	0.561
2002	LOS ANGELES	SC	SC	Weed Abatement	2,397.30	21.576	19.478	4.795	0.420	15.043	160.439
2002	LOS ANGELES	SC	SC	Range Improvement	1,495.00	15.025	12.932	2.616	0.075	10.764	114.891
2002	LOS ANGELES	SC	SC	Unspecified	13.05	0.104	0.099	0.029	0.004	0.070	0.744
2002	ORANGE	SC	SC	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	ORANGE	SC	SC	Prunings	10.20	0.040	0.037	0.027	0.001	0.032	0.337
2002	ORANGE	SC	SC	Weed Abatement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	ORANGE	SC	SC	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	ORANGE	SC	SC	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	RIVERSIDE	SC	SC	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	RIVERSIDE	SC	SC	Prunings	1,100.05	4.862	4.582	2.860	0.055	4.570	43.262
2002	RIVERSIDE	SC	SC	Weed Abatement	3,654.90	32.894	29.696	7.310	0.640	22.934	244.604
2002	RIVERSIDE	SC	SC	Range Improvement	161.00	1.618	1.393	0.282	0.008	1.159	12.373
2002	RIVERSIDE	SC	SC	Unspecified	30.45	0.242	0.231	0.068	0.009	0.163	1.735
2002	SAN BERNARDINO	SC	SC	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	SAN BERNARDINO	SC	SC	Prunings	212.80	0.618	0.581	0.553	0.011	0.454	5.733
2002	SAN BERNARDINO	SC	SC	Weed Abatement	6,364.38	57.268	51.705	12.731	1.115	39.927	425.828
2002	SAN BERNARDINO	SC	SC	Range Improvement	414.00	4.161	3.581	0.725	0.021	2.981	31.816
2002	SAN BERNARDINO	SC	SC	Unspecified	176.17	1.401	1.337	0.396	0.054	0.945	10.038
2000	SAN DIEGO	SD	SD	Field Crops	177.20	1.409	1.345	0.398	0.054	0.951	10.096
2000	SAN DIEGO	SD	SD	Prunings	2,061.70	11.580	10.917	5.360	0.103	10.921	92.335
2000	SAN DIEGO	SD	SD	Weed Abatement	12,102.50	101.223	94.410	26.002	3.071	69.270	736.999
2000	SAN DIEGO	SD	SD	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2000	SAN DIEGO	SD	SD	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2000	IMPERIAL	SS	IMP	Field Crops	51,956.55	388.299	373.876	112.772	21.292	390.164	3,248.634
2000	IMPERIAL	SS	IMP	Prunings	7.00	0.021	0.020	0.018	0.000	0.024	0.284
2000	IMPERIAL	SS	IMP	Weed Abatement	59,793.20	476.030	454.174	134.078	18.153	321.375	3,413.104
2000	IMPERIAL	SS	IMP	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2000	IMPERIAL	SS	IMP	Unspecified	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	RIVERSIDE	SS	SC	Field Crops	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	RIVERSIDE	SS	SC	Prunings	2,043.30	5.543	5.215	5.313	0.102	4.594	58.555
2002	RIVERSIDE	SS	SC	Weed Abatement	1,028.08	9.177	8.315	2.074	0.189	6.386	68.090
2002	RIVERSIDE	SS	SC	Range Improvement	0.00	0.000	0.000	0.000	0.000	0.000	0.000
2002	RIVERSIDE	SS	SC	Unspecified	632.92	5.032	4.804	1.421	0.193	3.396	36.061

References

Scarborough, J.; Gong, P. "Creating a Statewide Spatially and Temporally Allocated Agricultural Burning Emissions Inventory Using Consistent Emission Factors", May 2002. Report. Center for the Assessment and Monitoring of Forest and Environmental Resources (CAMFER); College of Natural Resources, UC Berkeley. ARB Contract Number: 99-714.

Jenkins, B., "Atmospheric Pollutant Emissin Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulation", April 1996. UC Davis. ARB Contract Number A932-126.

Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, AP-42, January 1995, U.S. EPA. Table 2.5-5. Fuel loadings and EFs. AP-42 values are used where Jenkins data are not available. Section 13.1 used for forest burning.