

Technical Memorandum

June 30, 2011

STI-910221-4159

To: Venkatesh Rao, U.S. EPA

From: Erin K. Pollard, Yuan Du, and Stephen B. Reid

Re: Preparation of Wildland and Agricultural Fire Emissions Inventories for 2008

The U.S. Environmental Protection Agency's (EPA) Emissions Inventory and Analysis Group (EIAG) compiles the National Emissions Inventory (NEI) and disseminates inventory data, summaries, model-ready files, and analyses based on the NEI. To support this program and analyses conducted by a variety of users, it is necessary to develop an emissions inventory for the year 2009. An important part of this inventory development is the estimation of emissions from fires, as was previously done by Sonoma Technology, Inc. (STI) for the years 2006 through 2008 via Work Assignment (WA) 5-17 under Contract No. EP-D-05-004 and via an addendum to WA 5-17 to develop 2008 fire inventories in EPA's Emissions Inventory System (EIS) "Events" format.

In addition to developing the 2009 fire emissions inventory, STI is revisiting the 2008 fire inventories to address issues with the ICS-209 fire report data that were used to prepare the original 2008 inventories. This document summarizes methods used to revise the 2008 fire inventories as well as differences between the revised and original 2008 fire inventories. Development of the 2009 fire inventories will be documented in a separate deliverable.

Background

Using the Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) as the fire activity source in the BlueSky Framework, STI prepared three years' (2006-2008) worth of daily emission estimates for wildland fires for the lower 48 states, including wildfire, wildland fire use (WFU), and prescribed burns. STI also prepared activity data for fires in agricultural areas for EPA's use in estimating emissions. The latest updated versions of the Fuel Characteristic Classification System (FCCS), CONSUME 3.0, and the Fire Emission Production Simulator (FEPS) models were used within the BlueSky Framework to model vegetation distribution, fuel consumption, and emission rates, respectively.

SMARTFIRE, an algorithm and database system, uses both satellite-detected and ground-reported fires to produce daily fire information (locations and area burned). SMARTFIRE currently reconciles ICS-209 ground reports and hot spots from the National

Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS) (Ruminski et al., 2006).

For large wildfires and WFU fires for which there is a federal response, ICS-209 reports are created on a near-daily basis. ICS-209 reports contain useful information about particular fires or fire complexes from the incident command team on the ground, such as descriptions of the fuel loading, growth potential, and type of fire. Previous fire emissions inventories were prepared using an extract of the available ICS-209 data that included only the report date and start date for each fire event. As presently configured, STI's SMARTFIRE program assumes that the fire occurred on the report date, which is incorrect for final reports that may be submitted post-event. This issue will be resolved in SMARTFIRE 2, a new version of the program that is currently under development. In the interim, a method was developed to remove the fires that may be double-counted.

HMS data consist of compiled fire detection information from three different instruments on board seven satellite platforms enhanced by human quality control. Individual detections are inspected by a trained analyst for false detects and inaccurate geolocation. The HMS product relies on data from Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Very High Resolution Radiometer (AVHRR), and Geostationary Earth Observing Satellite (GOES) instruments. Satellite fire data were categorized as "wildland" or "agricultural" fires by intersecting the fire data with FCCS gridcode $\neq 0$ (wildland) and FCCS gridcode = 0 (agricultural) (see **Figure 1**). This fire-typing process was accomplished using the FCCS module in the BlueSky Framework. After fire-typing, wildland and agricultural fires were processed separately.

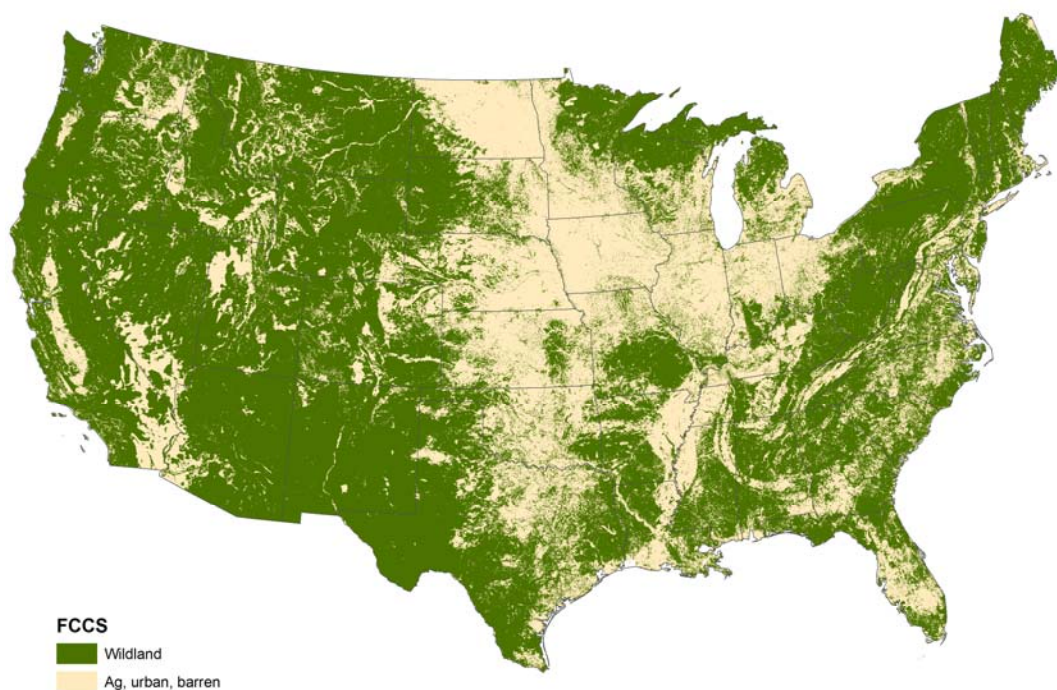


Figure 1. Distribution of wildlands in the FCCS database.

Technical Approach

Due to the ICS-209 date issue described above, revisions were made to the 2008 fire emissions inventories previously developed by STI for incorporation into the 2008 NEI. SMARTFIRE 2 was not ready for use in the development of the revised 2008 fire inventory; therefore, STI performed post-processing steps on the existing 2008 inventories to identify, flag, and remove fire events that have apparent date mismatches and may have been double-counted in the inventory because of satellite detection on the actual fire date and subsequent inclusion in a final ICS-209 report.

Fire events with incorrect dates were identified by comparing the report date from the ICS-209 extract with complete ICS-209 reports provided by the USDA Forest Service (USFS). These reports contain detailed information about fire complexes from the ground, such as start, control, and report date for each fire, report status (initial, update, or final), location, wind speed and direction, and area burned. Below are the steps followed to revise the 2008 fire emissions inventories:

1. We identified ICS-209 fires in the 2008 emissions inventory using the new, more complete data from the ICS-209 reports. Joining the new data set will give each fire, in addition to the current report date, a fire start date and control date (date the fire was under control), if available.
2. For the ICS-209 fires in the 2008 emissions inventory, we flagged the fire as suspect if the report date was after both the start and control dates. Of these flagged fires, if the acres burned were greater than 1,000 and an HMS detection did not occur at the same location on its associated start date, the report date of the fire was changed to the start date. All other flagged fires were removed if they were less than 1,000 acres or were detected by HMS.
3. For the ICS-209 fires in the 2008 emissions inventory, we removed the report date if it was earlier than the start date because a report cannot occur before the start of the fire it describes.
4. For the ICS-209 fires in the 2008 emissions inventory, we manually evaluated the fire if the report date was after the start date but before or equal to the control date, or the control date was missing, to determine whether any double-counting occurred.
5. For the ICS-209 fires in the 2008 emissions inventory, we spatially reviewed the fires in Google Earth and BlueSky Gateway if the area burned was greater than or equal to 5,000 acres. Fires were reviewed to ensure they were not located in a populated area, consistent with the corresponding ICS-209 report, and whether there were HMS detections nearby. **Figure 2** shows an accurate ICS-209 report because the location shown is geographically near the area burned and just outside the urban area. **Figure 3** illustrates an inaccurate ICS-209 report showing the urban area of Oroville; because the BTU Complex fire was large, the report is expected to show a larger HMS-detected burn area.

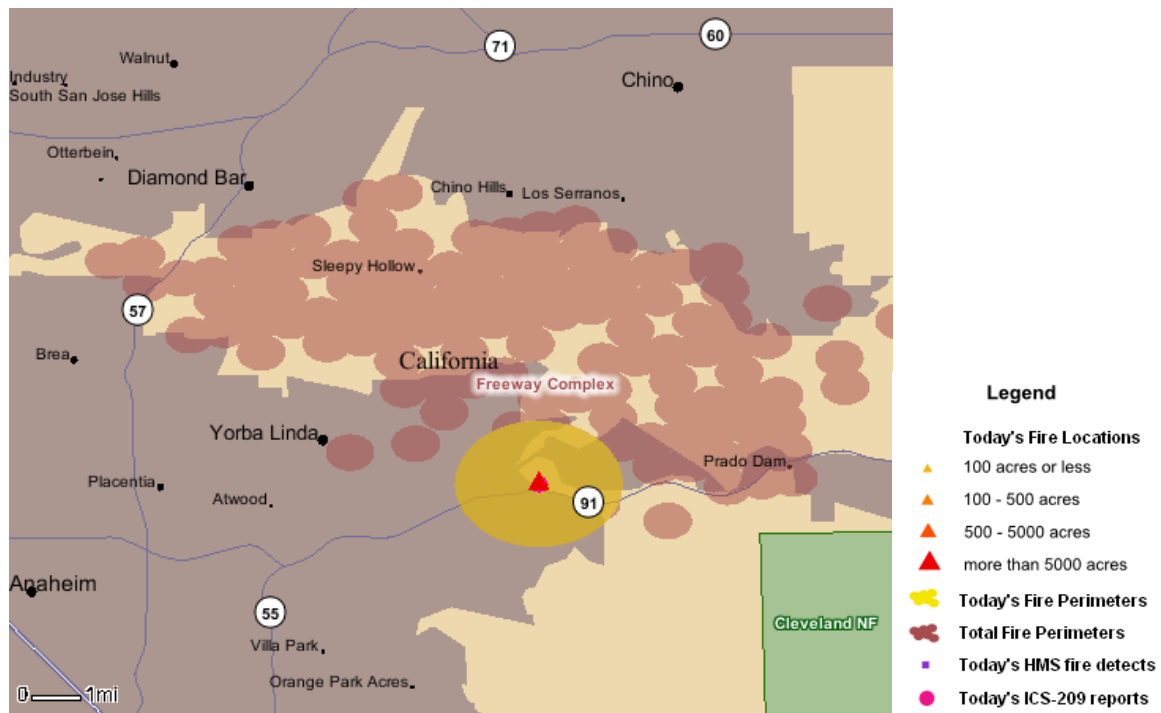


Figure 2. Freeway Complex fire on November 17, 2008.

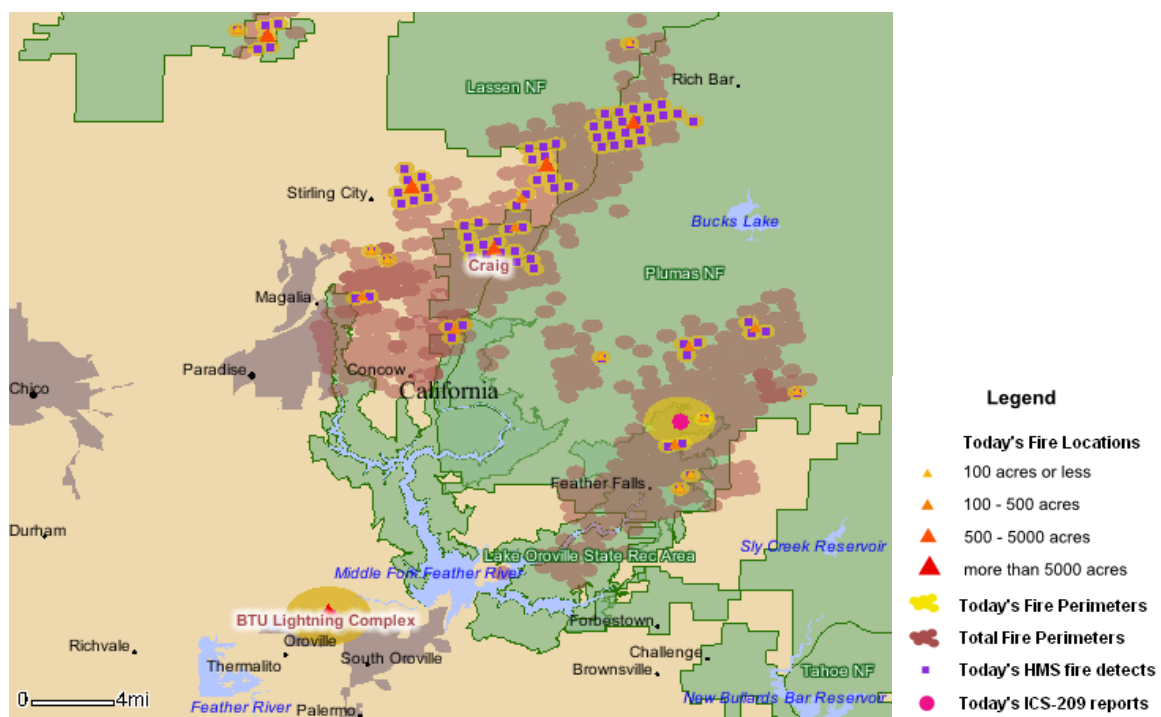


Figure 3. BTU Lightning Complex fire on June 27, 2008.

6. Using ArcGIS, we flagged 2008 agricultural fires as occurring on cropland land use, rangeland land use, or other land use according to the U.S. Geological Survey (USGS) 2006 National Land Cover Database (http://www.mrlc.gov/nlcd2006_downloads.php).
7. After suspect fires were flagged and removed from the 2008 emissions inventory, we created the revised 2008 inventory files in Microsoft Access, SMOKE ORL format, and EIS event format.

Emissions QA/QC

For the 2008 fire data produced with the current version of SMARTFIRE, several steps were taken to quality control (QC) the data and confirm the removal of fires that may have been double-counted in the original 2008 inventories.

- During the process of removing select fires described above, all flagged fires greater than or equal to 5,000 acres were manually examined to confirm accuracy. Of the fires examined, 33 were removed because of location issues.
- Also, during the development of the original 2008 fire emissions inventory, only one “blank” day, January 27 (i.e., no fires throughout the entire U.S.), was identified and the previous day was used to fill the gap.
- The following section documents the production and review of maps and summary graphs of the original 2008 fire emissions inventory and the revised inventory.

Summary of Differences Between the Revised and Original 2008 Fire Inventory

The revised 2008 wildland fire emissions inventory (blank day filled and double-counted fires removed) was compared with the original 2008 inventory (with blank day and duplicate fires) to ensure that the above changes were reasonable. **Figures 4 through 7** illustrate the annual PM_{2.5} emissions inventories for wildland fires for both fire inventories. In California, several large fires (Ukonom-South Complex, 29,544 acres, and SHU Lightning Complex, 18,600 acres) were removed due to delayed ICS-209 reporting and incorrect locations in populated areas. For the other states, the differences between the two inventories were minor.

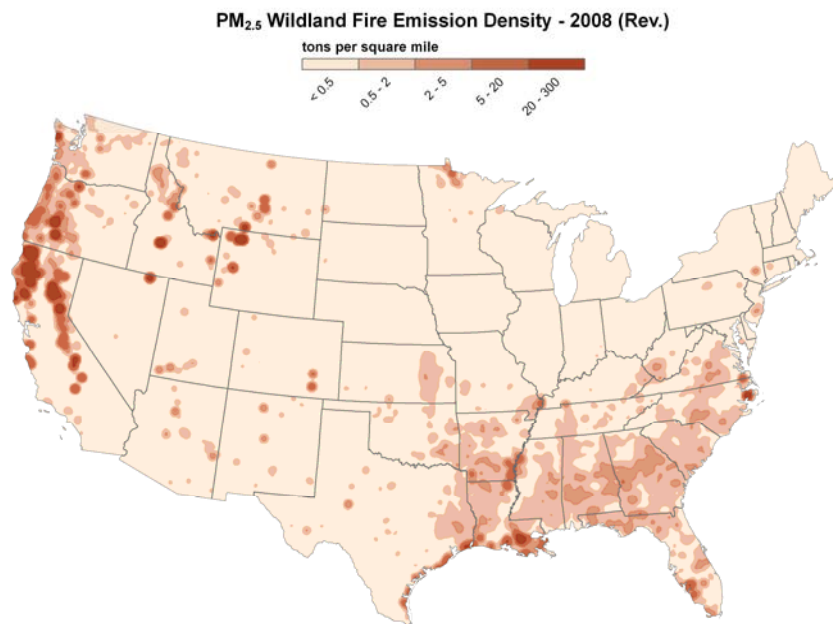


Figure 4. The revised 2008 annual PM_{2.5} emissions density estimate.

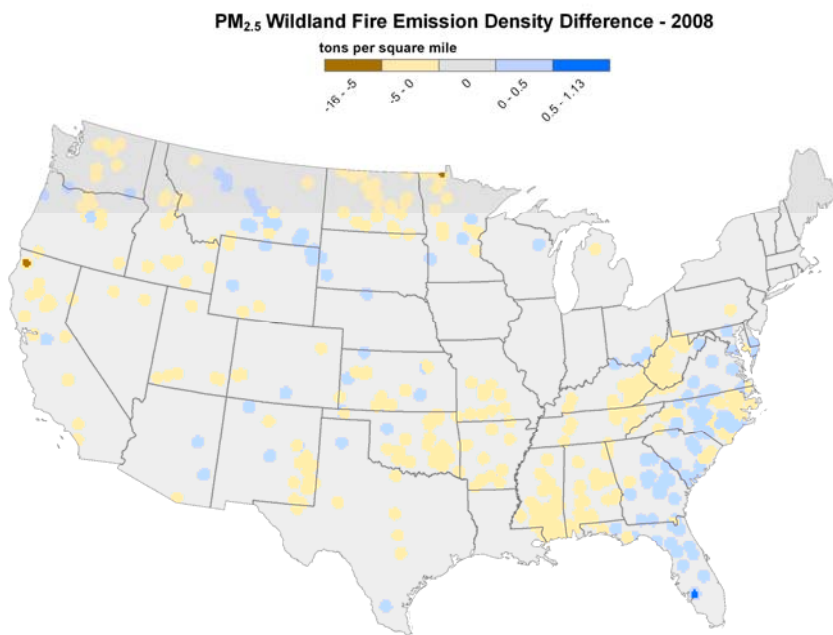


Figure 5. Difference between the revised and original 2008 annual PM_{2.5} emissions densities.

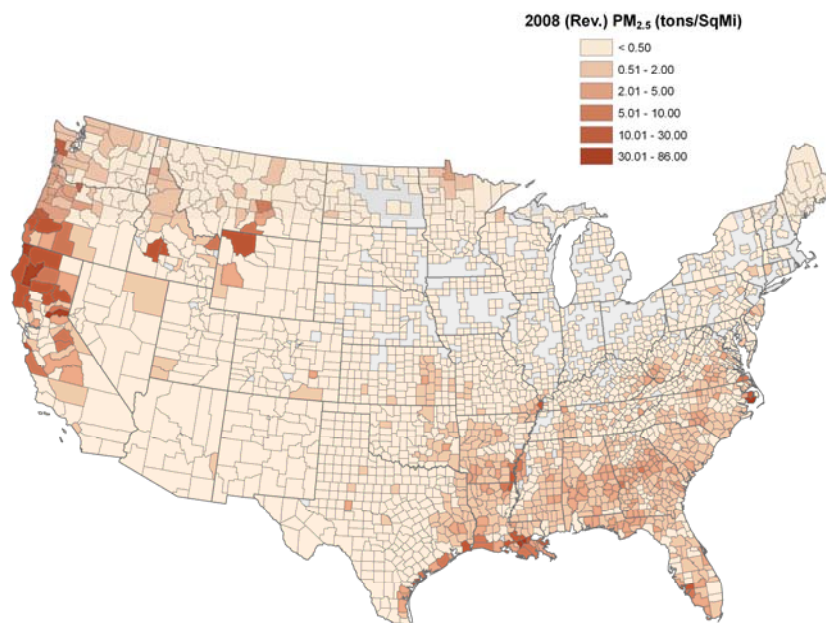


Figure 6. The revised county-level 2008 annual PM_{2.5} emissions density estimate.

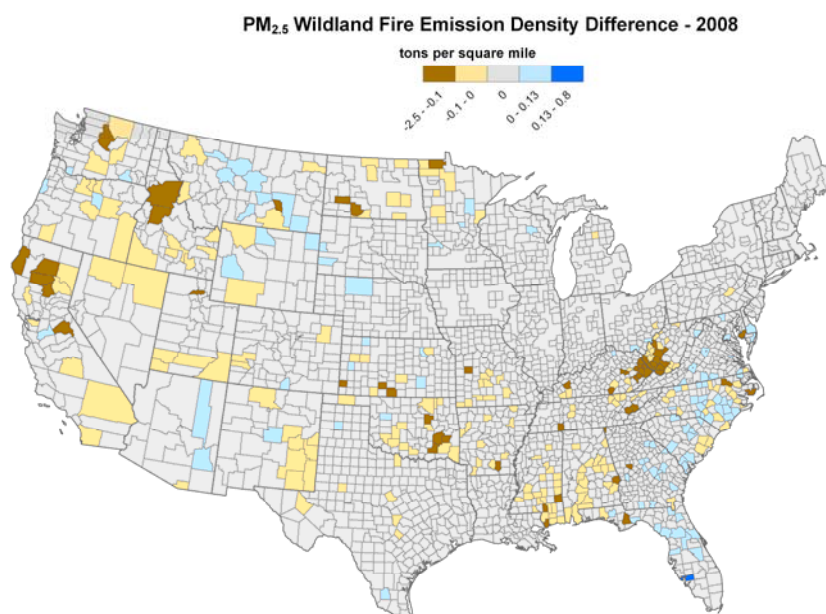


Figure 7. Difference between the revised and original county-level 2008 annual PM_{2.5} emissions densities.

To directly evaluate the effects of removing the double-counted fires, we compared the previous 2008 fire emissions inventory (with the blank day filled) to the revised 2008 fire emissions inventory. The findings are as follows:

- On a national scale, the effects of removing fire events on the original 2008 fire emissions inventory were less than 3% for all pollutants (from 0.67% to 1.7%) and a 2.55% reduction in acres burned, as shown in **Table 1**.
- The states with the largest percentage of removed acres burned were North Dakota (32.31%), West Virginia (11.7%), and Kentucky (11.1%), as shown in **Table 2**. A full list of fires that were removed is included in the attached Excel document, "2008_Flagged_Fires_Removed.xls".

Table 1. Effects of removing fire events from the 2008 wildland fire emissions inventory.

2008	Percentage Removed
Area	2.55
Consumption	0.67
Number of Fires	0.64
PM _{2.5}	1.31
PM ₁₀	1.31
CO	1.26
CO ₂	1.53
CH ₄	1.29
NO _x	1.70
NH ₃	1.27
SO ₂	1.49
VOC	1.27
HAPs	1.49

Table 2. State-specific effects of removing fire events from the 2008 wildland fire emissions inventory.

State	Number Removed	Total Fires	Area Removed (acres)	Total Area (acres)	Percentage of Fires Removed	Percentage of Area Removed
Alabama	25	4,707	5,279	646,567	0.53%	0.82%
Arizona	1	1,374	150	365,126	0.07%	0.04%
Arkansas	12	2,239	1,495	324,356	0.54%	0.46%
California ^a	40	10,036	169,729	2,965,958	0.40%	5.72%
Colorado	3	790	1,028	182,707	0.38%	0.56%
Florida	5	4,370	639	771,534	0.11%	0.08%
Georgia	3	6,828	958	921,716	0.04%	0.10%
Idaho	12	2,095	15,567	487,107	0.57%	3.20%
Kansas	11	4,571	17,529	671,477	0.24%	2.61%
Kentucky	50	719	10,526	94,788	6.95%	11.10%
Maryland	1	138	1,205	16,876	0.72%	7.14%
Michigan	1	95	245	12,856	1.05%	1.91%
Minnesota	13	668	3,536	84,273	1.95%	4.20%
Mississippi	62	3,262	6,668	415,087	1.90%	1.61%
Missouri	12	2,200	2,477	258,192	0.55%	0.96%
Montana	8	1,891	1,196	349,073	0.42%	0.34%
Nevada	2	413	415	149,648	0.48%	0.28%
New Mexico	17	1,175	26,394	542,109	1.45%	4.87%
North Carolina	26	2,843	5,078	576,463	0.91%	0.88%
North Dakota	21	207	13,452	41,757	10.14%	32.21%
Ohio	1	99	30	11,314	1.01%	0.27%
Oklahoma	31	2,591	19,195	406,883	1.20%	4.72%
Oregon	12	3,152	39,848	663,851	0.38%	6.00%
Pennsylvania	1	178	3	25,464	0.56%	0.01%
South Carolina	4	2,361	1,223	310,247	0.17%	0.39%
South Dakota	1	530	650	68,627	0.19%	0.95%
Tennessee	16	876	3,747	128,099	1.83%	2.93%
Texas	6	7,863	11,624	1,839,410	0.08%	0.63%
Utah	6	555	4,102	109,912	1.08%	3.73%
Virginia	1	1,199	40	200,702	0.08%	0.02%
Washington	7	1,219	5,719	248,542	0.57%	2.30%
West Virginia	82	571	7,876	67,314	14.36%	11.70%
Wyoming	4	867	424	253,207	0.46%	0.17%

^a For California, 30 out of 40 fires (123,492 acres out of 169,731) were removed due to incorrect locations

Summary

Previous fire emissions inventories were prepared using an extract of the available ICS-209 data that were missing key fields. A more detailed set of ICS-209 reports were provided by the USFS. These detailed reports were used to revise the previous 2008 wildland fire emissions inventory by identifying and flagging fires that may have been double-counted in the previous emissions inventory. Overall, on a national scale, the effect of removing the select fire events from the original 2008 fire emissions inventory was less than 3% for all pollutants (from 0.67% to 1.7%) and a 2.55% reduction in acres burned.

Deliverables

STI is providing the revised inventories in the following formats:

- Microsoft Access files formatted identically to those prepared for the previous effort (WA 5-17 under Contract No. EP-D-05-004).
- SMOKE ORL format, as described in Section 2.2 of the work plan.
- EIS Events Format, which consists of Microsoft Access-based “staging tables” that can be converted to XML format by EPA’s Consolidated Emissions Reporting Schema (CERS) XML file generator and uploaded to EIS. STI populated the Access staging tables with revised 2008 fire emissions data and produced separate Access databases for each state.
- Microsoft Excel file listing the fires that were flagged and removed from the original 2008 wildland emissions inventory.

In addition, STI is providing all relevant daily and aggregated data and metadata in Microsoft Access or Excel tables.

References

Ruminski M., Kondragunta S., Draxler R.R., and Zeng J. (2006) Recent changes to the Hazard Mapping System. *15th International Emission Inventory Conference, New Orleans, LA*. Available on the Internet at <http://www.epa.gov/ttn/chief/conferences.html>.