

TECHNICAL MEMORANDUM

DRAFT WHITE PAPER: WRAP'S FIRE EMISSIONS TRACKING SYSTEM - CURRENT FUNCTIONS & NEXT STEPS

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Note: Substantive changes to the first draft of the FETS White Paper appear in italics in this version.

Introduction

The FETS was developed and became operable in mid-2007. At its most basic level, the FETS was built to accept and serve as a stable repository for all fire activity and emissions data from states and Tribes within the WRAP region. In addition, data submitted on a near real-time basis would be made available for regional coordination purposes for Smoke Management Programs (SMP). The basic features and functions included,

- Web-based manual data entry pages.
- Several options for automated data upload, including: FTP, Web Services, and email.
- A web-based map tool displaying planned and accomplished fire events for all fire types and showing the locations of satellite fire detections for the previous 48 hours.
- A pop-up table showing the current status of fire data submittals to the FETS.
- Two draft report functions.
- Critical documentation and metadata.

The FETS currently has 35 registered users, and sees approximately 20-25 unique visitors per day.

Current Functionality**Data Coverage**

Table 1 summarizes the current list of known data sources. Existing data streams are marked 'OK'; un-activated data streams are marked 'XX'; if a fire type is not covered by a

data stream, the cell is left blank; if a fire type has not been confirmed for a data stream, the cell is marked '??'.

Table 1. Comprehensive list of known sources of fire data within the WRAP region (and beyond).

<i>Data Source</i>	<i>Rx</i>	<i>WF/WFU (ICS-209)¹</i>	<i>WF/WFU (State)²</i>	<i>Ag</i>	<i>NFR</i>	<i>Data Acquisition Comments</i>
Alaska						
Alaska Interagency Fire Center	OK	OK	OK			
Arizona						
Dept of Environmental Quality	XX	N/A	??	??	??	Awaiting response fr. DEQ. Mtg. on 7/17/08
California						
Rx Fire Incident Reporting System	XX	N/A	??	XX		to discuss progress.
Colorado						
Air Pollution Control Division	XX	N/A	XX			Last contact 9/4/2008.
Idaho						
MT/ID Airshed Database	OK	N/A				
Dept of Environmental Quality		N/A		XX		New rule takes effect in fall..
Montana						
MT/ID Airshed Database	OK	N/A				
Nevada						
NDEP, Bureau of Air Quality		N/A				
New Mexico						
NMED / AQB	OK	N/A	OK		OK	
North Dakota						
AQ Div., St. Dept. of Health	XX	N/A		??	??	Made initial contact.
Oregon						
OR Dept. of Forestry (RX)	OK	N/A				
OR Dept. of Forestry (WF/WFU)		N/A	XX			Made initial contact.
OR Dept. of Ag.		N/A		XX		Receiving hard-copies
Eastern OR Rangeland burning					XX	
Central OR individual Counties				XX		
South Dakota						
		N/A				
Utah						
		N/A				
Washington						
Department of Natural Resources	OK	N/A	XX			
Department of Ecology		N/A		XX		Request out for data.
Washington individual Counties				XX		May get through DOE
Wyoming						
WISE Database	XX	N/A				Made initial contact.
Nez Perce Tribe						
Nez Perce ERWM AQ Program	OK	N/A		OK		
National						

¹ Includes all federally coordinated wildfire and WFU. Minimum size: forest fires > 100 acres and grassland fires > 300 acres.

² Wildfire and WFU event controlled by state agencies and not entered into ICS-209 reports. The size of these fires varies widely between states.

<i>Data Source</i>	<i>Rx</i>	<i>WF/WFU (ICS-209)¹</i>	<i>WF/WFU (State)²</i>	<i>Ag</i>	<i>NFR</i>	<i>Data Acquisition Comments</i>
NIFC ICS-209			OK			
North America						
MODIS MOD14 Imaging Product		Fire Detections. No analysis applied to classify fire type or source type.				

Data Acquisition Summary

The FETS is capable of acquiring data by the methods outlined below. Data acquired automatically are processed on a regular daily schedule.

- Data mining FTP servers. Data files posted by agencies are gathered from external FTP servers.
- FTP batch upload. Files are posted to an FTP server hosted by the FETS.
 - Files are sent in a format specified on the FETS website.
 - Files are sent in an agency-specific format, and translated by the FETS.
- Web Services. The FETS digests a Web Service created by an agency to query data from their fire activity database.
- Email. An agency sends a data file via email; the FETS extracts the attachment.
- Manual Data Entry. Fire activity data are entered via the FETS website.

Automated QC routines are performed on each acquired data set. Data that pass the automated QC routines are immediately available for viewing on the FETS map tool.

Emissions Estimates Summary

Emissions estimates are stored concurrently in the FETS from three sources:

- User-provided. Estimates are submitted by SMPs with activity data.
- Modified AP-42. Modified version of [EPA's AP-42 guidelines](#) outlined in the [2002 Fire Emission Inventory for the WRAP Region](#). Estimates are calculated for all records upon entry. Fuels data and associated loadings are based on [FCCS 1.1](#).
- [CONSUME 3.0](#). CONSUME is run once weekly for all accomplished acres. Fuel moisture information is gathered from the Weather Information Management System (WIMS).

Map Tool Summary

All fire activity data stored in the FETS are viewable as point locations on the [map tool](#). In addition to basic functions to pan and zoom, the map has the following capabilities:

- Select a custom date range. A calendar pop-up assists with date selection.

- Click on an event to view activity metadata and an emissions estimate.
- Summarize activity by county or by state. Events, acres, and emissions are summed.
- Control 'layers' on the map, Tribal lands, Mandatory Class I areas, and [MODIS fire detections](#) for the previous 48 hours (updated every four hours).
- View a status table depicting data coverage. Date of last submit, and for what fire types, is shown for each data source.
- Choose between a Street map, a satellite image, or a topographical/terrain map.

Quality Control Summary

Several levels of QC for fire activity and emissions data are being developed for the FETS (see next section), identified by QC Levels 0-3. Currently, QC Levels 0 and 1 exist in the FETS.

Level 0. As data are submitted to the FETS, basic QC checks are performed, outlined in Table 2. Planned or proposed fire activity data, although permanently stored in the FETS, are not used in QC levels 1-3.

Table 2. Summary of QC procedures upon submittal.

<i>Internal QC Procedure</i>	ICS-209	Batch Upload	Manual Entry
Duplicity	X	X	
Data Types (e.g. proper date formats)	X	X	X
Range checks (e.g. negative area?)	X	X	
Location checks		X	

Level 1. Data begin immediately past the regional coordination FETS function, using accomplished acres, and have the following attributes:

- Activity data – as reported in accomplished acres/day by state and tribal smoke management programs and the federal ICS-209 tracking system.
- Emissions (2 options) – For all records, the FETS applies stored emissions factors to make uniform emissions estimates following a modified version of EPA's AP-42 guidelines. FETS users may also directly report emissions.
- Fuels information – is based on FCCS 1.1 and corresponding fuel loadings provided by the USFS Pacific Northwest Research Station.

Chemical speciation – FETS estimates PM_{2.5} and PM₁₀ mass emissions in Level 1.

FETS Future Development

Important considerations are emerging for WRAP's Data and Decision Systems such as the FETS as the mission of WRAP evolves from a focus on regional haze planning to implementation of regional haze plans, and to providing regional analysis support for other transport issues such as ozone, nitrogen deposition, and mercury deposition. *In addition, EPA's new Emission Inventory System (EIS) places new reporting requirements on states and tribes for compiling and submitting fire activity data on an annual basis.*

In this context, future development of the FETS will strive to better serve data providers and users of the FETS in the following ways:

- 1. Fully integrate the FETS with WRAP's other decision support systems (such as the Emissions Data Management System (EDMS) and the Technical Support System (TSS)).*
- 2. Provide the most complete and comprehensive data set possible including augmenting the FETS to estimate emissions from additional pollutants.*
- 3. Create and maintain a comprehensive, coherent data set that is transparent, accessible, and reflects the awareness of the limitations and heterogeneity of ground-based fire-tracking across states and tribes.*
- 4. Serve as the portal for all sources of fire activity within (and perhaps beyond) the WRAP modeling domain. The goal of developing the FETS to serve as the portal for all sources of fire activity is to reduce reporting obligations for states and tribes down to a single data submittal. Ultimately, though the development of electronic handshakes to other systems (such as the EIS), the FETS would pass off data to other systems and provide fire emissions data for further analysis.*
- 5. Augment the FETS data by using one of several available fire activity data sets developed from satellite imagery. The potential benefits of augmenting ground-based fire data with satellite fire detection data include higher spatial and temporal accuracy and the addition of fire activity data not necessarily collected and stored by smoke management programs or federal land management agencies.*

The intent is to implement a sequence of technical data processing steps that incorporate data and fire science knowledge gained from the operation of air quality and smoke forecasting efforts by others in order to build highly refined datasets for air quality management and planning. Air regulators will be able to use these datasets as analyses are prepared to address the many requirements of state and federal air laws and regulations (e.g., the regional haze rule, ambient air quality standards, Exceptional Events Policy).

Integrate Satellite Fire Detects

There are currently three classes satellite remote sensing instruments producing fire detection products: [MODIS](#), [AVHRR](#), and [GOES](#). These products are available individually, and are also combined into a single QC'd dataset by the [NOAA Hazard Mapping System \(HMS\)](#).

There are several research groups using one or more of these products to build temporary inventories of fire emissions for operational, short-term forecasting in North America and beyond. Researchers at NCAR³ and NOAA^{4,5} have used the above datasets to create top-down annual and daily emission inventories based on day-to-day changes in area burned statistics for North America. The partners of [BlueSky-RAINS](#) have developed [SMARTFIRE](#) (Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation), which combines the ICS-209 daily fire reports (ground-based data) with the HMS dataset to characterize WF and WFU activity data over space and time, using the daily change in area burned. *The USDA Forest Service's [Remote Sensing Applications Center \(RSAC\)](#) generates daily active fire maps for the United States and Canada using ICS-209 and similar Canadian reports, and the MODIS MOD14 fire product.* For a summary of the various methods, see Appendix A.

Satellite fire detects will continue to be used in the FETS. Several uses of satellite data are being considered.

1. As a visual QC tool (current use in the FETS).
2. For more rigorous QC of ground-based fire activity data.
3. As a supplemental data source for areas where ground-based data are not available.

Currently, the FETS displays the latest fire detections from MODIS around North America (including Canada and Mexico) on the map tool as a visual reference only – data do not persist in the database. FETS developers have met with researchers at NCAR to learn about the process of creating top-down emission inventories from satellite data. FETS developers also met with developers of BlueSky-RAINS and attended the annual BlueSky-RAINS meeting to discuss the potential of integrating the two systems to enhance each.

³ Wiedenmyer, Christine, et al. (2006). Estimating emissions from fires in North America for air quality modeling. *Atmospheric Environment* 40, 3419-3432.

⁴ Zhang, Xiaoyang and S. Kondragunta (2008). Temporal and spatial variability in biomass burned areas across the USA derived from the GOES fire product. *Remote Sensing of Environment* 112, 2886-2897.

⁵ Zhang, Xiaoyang and S. Kondragunta (2006). Estimating forest biomass in the USA using generalized allometric models and MODIS land products. *Geophysical Research Letters* 33, L09402.

Other Satellite Products

There are additional satellite products that may aid with emissions estimates. Currently, the FETS uses fuel moisture reports from the [Weather Information Management System \(WIMS\)](#) and interpolates the reports into surface moisture maps. One of a series of products developed through NOAA's [Center for Satellite Applications and Research \(STAR\)](#) is a daily [Vegetation Health Index](#), which measures daily 'greenness' over North America and could be adapted as a proxy for fuel moisture. While not available real-time, this product could be useful retrospectively for building inventories as the maps become available. Another product, developed at the University of Wisconsin, depicts agricultural land speciated by crop type; the maps have not been updated since the 1990s.

Quality Control Levels

The Quality Control Summary in the previous section introduced the concept of QC levels in the FETS, Levels 0-3. Currently, QC Levels 0 and 1 exist in the FETS.

Level 0. As data are submitted to the FETS, basic QC checks are performed, outlined in Table 2 (previous section). Planned or proposed fire activity data, although permanently stored in the FETS, are not used in QC levels 1-3.

Level 1. Data begin immediately past the regional coordination FETS function, using accomplished acres, and have the following attributes:

- Activity data – as reported in accomplished acres/day by state and tribal smoke management programs and the federal ICS209 tracking system.
- Emissions (3 options) – For all records, the FETS applies stored emissions factors to make uniform emissions estimates following a modified version of [EPA's AP-42 guidelines](#) outlined in the [2002 Fire Emission Inventory for the WRAP Region](#). The FETS also calculates emissions using CONSUME 3.0 and FCCS 1.1 land cover data. FETS users may also directly report emissions.
- Fuels information – Based on [FCCS 1.1](#) and corresponding fuel loadings provided by the USFS Pacific Northwest Research Station.
- Chemical speciation – FETS estimates PM_{2.5} and PM₁₀ mass emissions in Level 1.

Level 2. The primary goal of the Level 2 analysis and QA is to fill in spatial, temporal, and fire type gaps in the FETS Level 1 database, and periodically estimate a more complete robust historical fire EI across western North America. This could be accomplished by combining the ground-based information from the FETS Level 0 and 1 inventories with other products such as the satellite-derived methods described above. This geographic region includes southwestern Canada, northern Mexico, and the region of the U.S. west of

the 100th meridian of longitude. The Level 2 database would be published for each calendar quarter, 6 to 8 weeks after the end of the quarter. The Level 2 fire EI data will enhance the Level 1 dataset with the following *additional* attributes:

- Activity data – Detects from one or more satellite products would be used to QA and improve the daily spatial location and extent of each Level 1-reported fire event and improve the completeness of the number of fire events across the region on each day. Land use and land cover data will be used to classify “unknown” fire events detected by satellites, but unreported by SMPs. A revised formula for calculating the daily acres burned would be developed.
- Fuels information – For Ag and NFR fire EI data, amend and augment fuels information and temporal patterns using satellite and land use/cover data to estimate fuels information. Develop a first principles estimate of fire emissions and fire type assignment for “unknown” fire events. The change in fire emissions by county and 36km grid cell will be reported for the changes and additions to accomplished acres/day going the state and tribal smoke management programs and the federal ICS-209 tracking system data reported in Level 1 to the Level 2 database.
- Emissions – Evaluate the existing emissions calculation methods and consider possibilities for improvement and/or augmentation. For example, replace the current FCCS 1.1 map with a more recent fuels layer such as LANDFIRE. Potential sources of data will be evaluated for technical data quality, completeness, stability, and availability.

Level 3. The primary goal of the Level 3 analysis and QA is to create a highly-refined historical annual fire emissions inventory product with 3-dimensional hourly resolution, chemically speciated, and gridded fire emissions inventory from the Level 2 data, suitable for regional air quality historical and prospective modeling and other air quality planning analyses. The Level 3 product could be a free-standing replacement for the SMOKE emissions modeling currently used to process fire EIs for air quality modeling for air quality planning and analysis requirements such as regional haze implementation, source-receptor analysis of natural event episodes, and regional transport (source-receptor) analyses needed to develop National Ambient Air Quality Standard (NAAQS) implementation plans.

The Level 3 QA and analysis to be completed prior to executing the fire emissions modeling would primarily address chemical speciation specific to fuel loading and fuel characteristics for each fire event at the best available temporal and spatial resolution. The Level 3 fire EI data products will have the following *additional* attributes beyond Level 2:

- Emissions factors and Emissions – FETS would report QA and analysis steps to prepare Level 3 data, report those data, and disclose the calculation method for estimating speciated fire emissions in the Level 3 fire emissions modeling products.
- Chemical composition of fire emissions – as noted above, chemical speciation specific to fuel loading and fuel characteristics for each fire event at the best available temporal and spatial resolution would be achieved.

The FETS Level 2 and 3 products do not conflict with the related efforts by operational forecasting of smoke and air quality, but include their methods in a systematic and repeatable fashion for air quality management and planning related to regional haze implementation, natural event analyses, and NAAQS planning.

National Emissions Inventory and the FETS

EPA's 2008 National Emissions Inventory (NEI) introduces a new source category for fire activity data through the Emission Inventory System (EIS): [EIS Events](#). The Events category addresses unique aspects of fire such as changes in location, area, and emissions over time; the previous format of fire data in the EIS was to report all fire activity as point sources. As a part of the new (proposed) system, EPA will utilize the [SMARTFIRE](#) system, a system that includes algorithms to reconcile satellite-based and ground-based fire activity data and to attempt to capture more details about changes in fire activity through space and time. Currently, SMARTFIRE processes ground-based data for federal wildland fires greater than 100 acres. EPA expects individual States, Local Agencies, and Tribes (S/L/Ts) to supplement this dataset with ground-based activity data for prescribed, agricultural, and Native American fire use fires.

For S/L/Ts to submit data, the EPA is proposing one of two methods:

- *Submit data directly to SMARTFIRE (details of this method are not available in the guidance available as of the preparation of the November 10, 2008 version of the FETS White Paper).*
- *Submit data to the EIS gateway in XML format using a schema determined by EPA.*

One of the goals of the FETS is to serve as the portal for all sources of fire activity in order to reduce reporting obligations for S/L/Ts. A way to accomplish this would be to develop a standard method of reporting in the FETS in recognition of the differences in reporting procedures and capabilities among SMPs. The FETS continues to establish unique data handshakes with SMPs based on the needs of the data providers and data users. Because of this, the FETS is in a unique position to serve as a portal for S/L/Ts to submit their fire activity data to the NEI-EIS. There are several advantages to this:

- *S/L/Ts (SMPs) will only submit data once, using a handshake appropriate for each agency.*
- *All submitted data are routinely accessible for viewing and editing.*

- Submitted data will be systematically built into comprehensive inventories, described above, and available for regional analyses beyond the scope of the NEI.

EIS Events reporting is capable of handling many details related to fire activity; Table 3 summarizes data storage capabilities of the NEI-EIS and the FETS.

Table 3. Comparison of parameters capable of being stored in the NEI-EIS and FETS.

Parameter	NEI-EIS	FETS
Geospatial shape file	X	
Point location with area	X	X
Fire Type (e.g. WFU, agricultural)	X	X
Source Classification (Nat./Anth.)	X	X
Smoldering emissions	X	
Fuel Type	X	X
Fuel loading / Fuel consumed	X	X
10-hr, 1000-hr, duff moisture	X	X
Heat Release	X	
Ignition method	X	
Ignition time	X	X
Blackened Acres	X	

The NEI-EIS is capable of handling several parameters not currently addressed in the FETS. Information such as blackened acres and smoldering emissions will be addressed in the FETS as QC levels 2 and 3 are developed. As part of the Scope of Work for development of the FETS in 2009, developers of the FETS will identify to what extent the SMARTFIRE system will supplement missing ground-based data (e.g., blackened acres, fuel type, fuel loading, fuel consumption, and smoldering emissions) using algorithms or other techniques. Some of the approaches that could be incorporated in the FETS to support users in their efforts to provide fire emissions data to the NEI-EIS include:

- Add an export function, according to the XML schema required by the EIS, to provide NEI-EIS-ready files to S/L/Ts for submittal of fire activity and emissions data to the EIS. SMPs will then be responsible for submitting data to the NEI-EIS.
- Create a handshake with SMARTFIRE. This could include a one-way submittal, or a two-way synchronization to supplement spatial and temporal activity information in the FETS. In both cases, the routines in the FETS would be developed to use FETS and SMARTFIRE to prepare NEI-EIS-ready fire data for S/L/Ts.

APPENDIX A

Table A.1. Summary of satellite fire detection products and applications.

<i>Method or System Name</i>	<i>Affiliation</i>	<i>Satellite Product Used</i>	<i>Ground-based Data</i>	<i>Other Analysis/ Data Sources</i>	<i>Fuels Information</i>	<i>Notes</i>
Hazard Mapping System	NOAA	MODIS, AVHRR, GOES	N/A	Manual vetting by analysts	N/A	Does not calculate emissions. Provides QC'd fire detection location maps. Converts fire detections to actual burned area over space and time.
SMARTFIRE	PNW Research Station/ Sonoma Technologies	HMS Product	ICS-209	Same as HMS	N/A	
Wiedinmyer, et al.	NCAR	MODIS	QC purposes only.		GLCC ¹ ; MODIS VCF ²	Paper describing emissions inventory is here . References 4 and 5 above describe how satellite products were applied.
Zhang, et al.	NOAA	GOES; MODIS	QC purposes only.		Various MODIS Land products	
Fire Sciences Laboratory	USDA-FS, Rocky Mtn. Research Station	MODIS	N/A	N/A	FCCS; FOFEM	Presentation on methods is here .
Remote Sensing Applications Center	USDA-FS	MODIS	ICS-209 and Canadian Equivalent	?	N/A	Unclear if ICS-209 data are reconciled with satellite data.

¹ [Global Land Cover Characteristics Map \(2000\)](#).

² [MODIS Vegetation Continuous Fields Product](#).