2020 National Emissions Inventory Technical Support Document: Fires – Wild, Prescribed, and Agricultural Field Burning

EPA-454/R-23-001g
March 2023

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U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC

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7 Fires – Wild, Prescribed, and Agricultural Field Burning

7.1 Sector Descriptions and Overview

Wildfires and prescribed burns (Wildland Fires in sum, WLFs) that occur during the inventory year are included as "non-point" sources beginning with the 2020 NEI. Previous NEIs had wildland fires labeled as "events" sources. Emissions from these fires, as well as agricultural fires, make up the National Fire Emissions Inventory (NFEI). Agricultural field burning has been treated as non-point sources in previous NEIs and has had a separate section in the NEI Technical Support Document. All these fire types will be combined into one section of this TSD beginning with this 2020NEI.

Estimated emissions from all these fire types in the 2020 NEI are calculated from burned area data. Input data sets are collected from State/Local/Tribal (S/L/T) agencies and from national agencies and organizations. S/L/T agencies that provide input data were also asked to complete the NEI Wildland Fire Inventory Database Questionnaire, which consists of a self-assessment of data completeness. Raw burned area data compiled from S/L/T agencies and national data sources are cleaned and combined to produce a comprehensive burned area data set. Emissions are then calculated using fire emission tools/models that rely on burned area as well as fuel and climatological weather information. These emissions tools/models will be described later in this section. The resulting emissions are compiled by date and location as day-specific emission estimates.

For purposes of emission inventory preparation, wildland fire (WLF) is defined as "any non-structure fire that occurs in the wildland (an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities). Wildland fire activity is categorized by the conditions under which the fire occurs. These conditions influence important aspects of fire behavior, including smoke emissions. In the 2020 NEI, data processing is conducted differently depending on the fire type, as defined below:

Wildfire (WF): Any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire.

Prescribed (Rx) fire: Any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific land or resource management objectives. Prescribed fire is one type of fuels treatment. Fuels treatments are vegetation management activities intended to modify or reduce hazardous fuels. Fuels treatments include prescribed fires, wildland fire use, and mechanical treatment.

Agricultural burning: A type of prescribed fire, specifically used on land used or intended to be used for raising crops or grazing.

Pile burning is a type of prescribed fire in which fuels are gathered into piles before burning. In this type of burning, individual piles are ignited separately. Pile burn emissions are not currently included in the NEI due to lack of usable data and default methods. EPA continues to work to develop methods for estimating emissions of this source type.

Table 7-1 lists the Source Classification Codes (SCCs) that define the different types of WLFs in the 2020 NEI, both for EPA data and for S/L/T agency data. The leading SCC description for these SCCs is "Miscellaneous Area Sources; Other Combustion - as Event". Since the 2014 NEI, the EPA has compiled WLF emissions by smoldering and flaming phases. The SCCs shown in Table 7-1 are used to denote this differentiation. There are five valid

SCCs for wildland fires in EIS for the 2020 NEI, and EPA reports estimates into each of these SCCs. One difference to note for the 2020 NEI is that we have included a specific SCC (2801500170) that houses only the grassland fires of “Flint Hills,” which occur over much of KS and a small part of OK. In addition, other grassland fires (other than “Flint Hills” fires) are processed via the SmartFire2/BlueSky Pipeline (SF2/BSP) process described below and inventoried along with other wildland fires.

Table 7-1: SCCs for wildland fires

SCC	Description
2811020002	Prescribed Rangeland Burning
2811021000	Prescribed Rangeland Burning - Tallgrass Prairie
2810001001	Forest Wildfires; Smoldering; Residual smoldering only (includes grassland wildfires)
2810001002	Forest Wildfires: Flaming (includes grassland wildfires)
2811015001	Prescribed Forest Burning; Smoldering; Residual smoldering only
2811015002	Prescribed Forest Burning; Flaming

Agricultural burning refers to fires that occur over lands used for cultivating crops and agriculture. Another term for this sector is crop residue burning. In past NEIs for this sector, it was exclusively limited to emissions resulting in the burning of crops. However, in the 2014 NEI, we included grass/pasture burning SCCs into this sector. However, for technical reasons, we have moved the grass/pasture burning to the wildland fires category for the 2017 NEI and 2020 NEI, thereby causing this sector to once again only house emissions resulting from burning of crops.

Table 7-2 shows, the agricultural field burning SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The leading SCC description is “Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire;” for all SCCs in the table. Note that many general crops are included in the SCC 2801500000, and it also is the SCC to report into for “crops unknown.”

Table 7-2: Nonpoint Agricultural Field Burning SCCs in the 2020 NEI

SCC	SCC Description	EPA	S/L/T
2801500000	Unspecified crop type and Burn Method	X	X
2801500112	Field Crop is Alfalfa: Backfire Burning		X
2801500130	Field Crop is Barley: Burning Techniques Not Significant		X
2801500141	Field Crop is Bean (red): Headfire Burning	X	X
2801500142	Field Crop is Bean (red): Backfire Burning		X
2801500150	Field Crop is Corn: Burning Techniques Not Important	X	X
2801500160	Field Crop is Cotton: Burning Techniques Not Important	X	X
2801500171	Fallow	X	X
2801500182	Field Crop is Hay (wild): Backfire Burning		X
2801500192	Field Crop is Oats: Backfire Burning		X
2801500202	Field Crop is Pea: Backfire Burning		X
2801500220	Field Crop is Rice: Burning Techniques Not Significant	X	
2801500250	Field Crop is Sugar Cane: Burning Techniques Not Significant	X	X
2801500262	Field Crop is Wheat: Backfire Burning	X	X
2801500264	Double Crop Winter Wheat and Soybeans	X	X
2801500600	Forest Residues Unspecified		X
2801600300	Orchard Crop Other Not Elsewhere Classified		X
2801600320	Orchard Crop is Apple		X
2801600330	Orchard Crop is Apricot		X
2801600350	Orchard Crop is Cherry		X
2801600410	Orchard Crop is Peach		X
2801600420	Orchard Crop is Pear		X
2801600430	Orchard Crop is Prune		X
2801600500	Vine Crop Other Not Elsewhere Classified		X

7.2 Sources of year-2020 data

7.2.1 SLT direct emissions submittals -wildfires and prescribed burning

Only two agencies submitted emissions for wildland fires: Georgia and Washington. These data were formatted and merged into the EPA the EPA dataset created from SMARTFire version 2 (SF2/BSP), which used available state inputs, and (discussed in Section 7.3.3) a PM2.5 speciation file that contains the five components of PM2.5 for each fire. This merged information is the basis of the WLF 2020 NEI. The NEI includes only Georgia and Washington-provided data for that S/L/T; in other words, there were no additions with any EPA-based data based on the questionnaire GA and WA submitted that indicated their submissions were complete for each of these states. Both Georgia and Washington were supplied HAP to VOC ratios by EPA, which they used to estimate HAPs based on their VOC emissions to calculate HAP emissions, so that these emissions calculations were used consistent with what was used for the remainder of the U.S. via the EPA methods. For other State and tribal regions, EPA used the nationwide NEI WLF emission estimates and developed tribal land emission estimates using appropriate shapefiles and GIS. These estimates over tribal lands are available as part of the public release of 2020 Nonpoint data.

7.2.2 SLT direct emissions submittals -agricultural field burning

As an example of what agencies submitted, the agencies listed in Table 7-3 submitted PM2.5 emissions for this sector; agencies not listed used EPA estimates for the entire sector. As we will discuss below, some agencies provided agricultural field burning activity that was used in estimating emissions using EPA's methodology. Some agencies submitted emissions for the entire sector while others submitted only a portion of the sector. When an agency submits less than 100%, their Nonpoint Survey responses, along with other general business rules for building the NEI, are used to backfill with EPA estimates as appropriate.

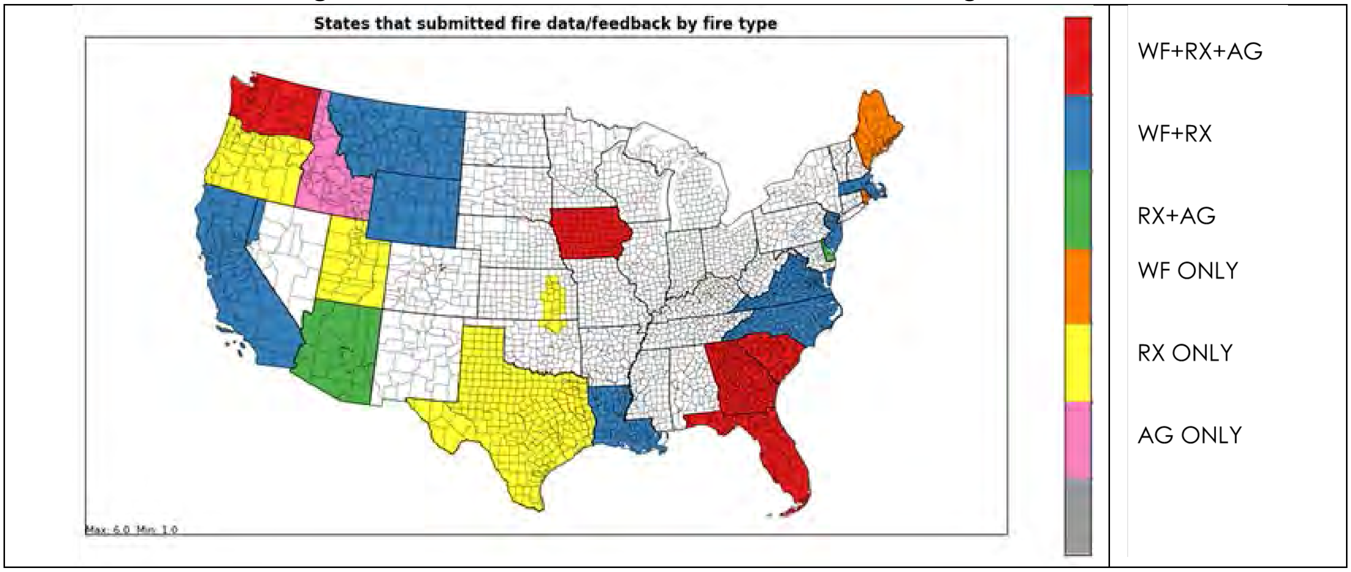
Table 7-3: PM2.5 emissions submitted by reporting agency for agricultural field burning

Region	Agency	S/L/T
2	New Jersey Department of Environment Protection	State
4	Georgia Department of Natural Resources	State
9	California Air Resources Board	State
10	Coeur d'Alene Tribe	Tribe
10	Idaho Department of Environmental Quality	State
10	Kootenai Tribe of Idaho	Tribe
10	Nez Perce Tribe	Tribe
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe
10	Washington State Department of Ecology	State

7.2.3 SLT activity data and feedback submittals -all fires

As in previous NEI years and building off the 2016 modeling platform [ref 1]collaborative efforts, S/L/Ts were asked to submit fire occurrence/activity data for the 2020 NEI. A template form containing the desired format for data submittals was provided to S/L/T air agencies. A map of all states that returned the template form is shown in Figure 7-1. States that did not return the template form are shown in gray and had emissions based only on national default data. In total, 23 states returned the template form for the EPA's 2020 NEI wildland fire emissions estimates processing. The states that returned the forms directly to the EPA are Alaska, Arizona, California, Delaware, Georgia, Florida, Idaho, Iowa, Kansas, Louisiana, Maine, Massachusetts, Montana, New Jersey, Nevada (Washoe County only), North Carolina, Oregon, Rhode Island, South Carolina, Utah, Virginia, Washington, and Wyoming. Texas Parks and Wildlife Department provided prescribed fire activity for their state lands. In addition to supplying activity data, S/L/Ts that supplied such data were also requested to complete a questionnaire to help EPA determine how complete their activity data submissions were.

Figure 7-1: 2020 NEI Wildland Fire Data Sources including S/L/Ts



When fire activity or emissions were provided by S/L/Ts the data were evaluated by EPA and further feedback on the data submitted by the state was requested at times. Table 7-4 provides a summary of the type of data submitted by each S/L/T agency and includes spatial, temporal, acres burned, and other information provided by the agencies.

Table 7-4: SLT fire activity information and feedback submitted for 2020 NEI inventory use

S/L/T name	Fire Types	Description
Alaska	WF/RX	Latitude-longitude, Fuel Characteristic Classification System (FCCS) fuel beds, and acres burned for wildfire and prescribed burns
Arizona	WF/RX/AG	Day-specific, latitude-longitude, and acres burned for prescribed burns. Feedback on specific agricultural burns and wildfires in their state.
California	WF/RX	Day-specific, latitude-longitude data for prescribed burns as well as shapefiles for wildfires.
Delaware	RX/AG	Day-specific, latitude-longitude for prescribed burns and agricultural burns.
Florida	WF/RX/AG	Start and end dates, latitude-longitude, and acres burned for wildfire, prescribed burns, and agricultural burns.
Georgia	WF/RX/AG	Emissions data submitted included all fire types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources but were summed by EIS to the county level for 2020NEI use. Also provided activity data. Provided agricultural burn emissions at county level.
Iowa	WF/RX/AG	Day-specific, latitude-longitude, and acres burned for prescribed burns as well as feedback on wildfires and agricultural burns in their state.
Idaho	AG	Day-specific, latitude-longitude, acres burned for agricultural burns. This included activity data from Nez Perce tribe in this state.
Kansas	RX	Day-specific, county-centroid, and acres burned for Flint Hills-only prescribed grassland burning
Louisiana	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
Maine	WF	Day-specific, latitude-longitude, and acres burned for wildfires.

S/L/T name	Fire Types	Description
Massachusetts	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
Montana	WF/RX	Day-specific, latitude-longitude and acres burned information for prescribed burns. Provided feedback on wildfires in their state.
New Jersey	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
North Carolina	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
Nevada (Washoe County)	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfires and prescribed burns.
Oklahoma	RX	Day-specific, county-centroid, and acres burned for Flint Hills-only prescribed grassland burning (thru the Kansas data mentioned in table above)
Oregon	RX	Day-specific, latitude-longitude, acres burned for prescribed burns.
Rhode Island	WF	Day-specific, latitude-longitude, acres burned for wildfires.
South Carolina	WF/RX/AG	Day-specific, latitude-longitude, and acres burned for wildfire, prescribed burns, and agricultural burns.
Texas	RX	Day-specific, latitude-longitude, acres burned for prescribed burns for burns located on Texas Parks and Wildlife Department lands only.
Utah	RX	Day-specific, latitude-longitude, and acres burned for prescribed burns
Virginia	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
Washington	WF/RX	Emissions data submitted included all fire types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources. EIS was used to sum to county and annual/monthly scales for nonpoint category in 2020NEI. County emissions provided for agricultural burns.
Wyoming	WF/RX	Day-specific, latitude-longitude, acres burned for prescribed burns and wildfires.

In order to develop a format that could be ingested into SMARTFire2 or directly into Bluesky Pipeline certain preprocessing steps were taken with the S/L/T submitted datasets. The names of columns and formats were changed to match what the processors required. Additionally, all datasets were reviewed for invalid locations or those that were spatially identified as occurring outside the submitting state. Obvious location errors, such as those where the latitude and longitude were swapped or a sign was missing, were fixed. Without additional information identifying an activity location within the respective state, these records were dropped. Overall, the records dropped accounted for a very small portion of the total activity.

The temporal approach for the S/L/T varied based on the information provided in the submitted data and direction from the individual agencies. Some states submitted activity without end dates. Each of these states provided direction to assume that all fires lasted for a single day. Where a multi-day event could be matched to

HMS detections the number of HMS detections on each day within the event were used to apportion the total event activity. When a spatial and temporal match could not be made between the submitted data a flat approach was used for the multi-day event.

The following states required additional preprocessing steps:

- **Kansas and Oklahoma Flint Hills Regions:** The activity for the Flint Hills region was spatially reapportioned from the county-level to 2011 NLCD grass land area at centroids of 4 km grid cells. Weighting of activity was done using the area of overlap between the grass land grid cells and the respective county.

7.3 EPA Methodology

7.3.1 Wildfires

Preparation of the EPA WLF emissions begins with raw input data and ends with daily estimates of emissions from flaming combustion and smoldering combustion phases. The daily estimates were summed to monthly and annual for use in the NEI. Flaming combustion is combustion that occurs with a flame. Flaming combustion is more complete combustion and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion is combustion that occurs without a flame. Smoldering combustion is less complete and produces some pollutants, such as $PM_{2.5}$, VOCs, and CO at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface–to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions). In the 2020 NEI, all flaming emissions are made up of any component that has a flaming component to it while the smoldering emissions are the residual smoldering component that is generated by the CONSUME model, as described further below. The emissions estimates were estimated and compiled separately for flaming and smoldering combustion phases of fire to facilitate air quality modeling and fine-scale research in areas such as health impacts of smoke emissions, where the known impacts of varying PM and VOC composition by combustion phase likely play a role.

In the 2020 NEI process, EPA developed draft 2020 emission estimates based just on default information. S/L/Ts had an opportunity to review these estimates and: 1) accept them as final, 2) submit activity data and a questionnaire (as detailed below), or 3) provide comments. In developing final 2020 WLF estimates, EPA took into consideration all 3 of these items. If an S/L/T accepted the draft estimates, those estimates were not changed in the process to develop final estimates.

7.3.1.1 *National Fire Information Data*

Numerous fire information databases are available from U.S. national government agencies. Some of the databases are available via the internet while others must be obtained directly from agency staff. Table 7-5 provides the national fire information databases that were used for the EPA's 2020 NEI methods for wildland fire emissions estimates, including the website where the 2020 data were downloaded.

Table 7-5: National fire information databases used in EPA's 2020 NEI wildland fire emissions estimates

Dataset Name	Fire Types	Format	Agency	Coverage	Source
Hazard Mapping System (HMS)	WF/ RX	CSV	NOAA	North America	Hazard Mapping System Fire and Smoke Product
National Incident Feature Services (NIFS) (formerly GeoMAC) wildland fire perimeter polygons	WF	SHP	Multi	Entire US	https://data-nifc.opendata.arcgis.com/
Incident Command System Form 209: Incident Status Summary (ICS-209)	WF/ RX	CSV	Multi	Entire US	FAMWEB website: https://famit.nwcg.gov/applications/FAMWeb
Forest Service Activity Tracking System (FACTS)	RX	SHP	USFS	Entire US	Hazardous Fuel Treatment Reduction: Polygon
US Fish and Wildland Service (USFWS) fire database	WF/ RX	CSV	USFWS	Entire US	Direct communication with USFWS
US Department of Interior	RX	CSV	DOI	Entire US	Direct communication with DOI

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as a tool to identify fires over North America in an operational environment. The system utilizes geostationary and polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. When possible, HMS data analysts apply quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery.

The HMS product used for the 2020 NEI inventory consisted of daily comma-delimited files containing fire detect information including latitude-longitude, satellite used, time detected, and other information. Landcover was spatially associated with each HMS detects using the Cropland Data Layer (CDL). HMS detects over croplands were removed from the input files so that only wildland fires are included. All grassland fire HMS satellite detects were included in the EPA's 2020 NEI wildland fire emissions estimates. These grassland fires were processed through SmartFire2 and BlueSky Pipeline with the other wildland fires.

National Incident Feature Services (NIFS) (formerly GeoMAC (Geospatial Multi-Agency Coordination)) is an online wildfire mapping application designed for fire managers to access maps of current U.S. fire locations and perimeters. The wildfire perimeter data is based upon input from incident intelligence sources from multiple agencies, GPS data, and infrared (IR) imagery from fixed wing and satellite platforms. Fires in the year-specific NIFS shapefile with dates outside of 2020 were removed. Some polygons have geometries which cause errors in SmartFire2 processing. These problematic polygons were simplified using standard GIS methods.

The Incident Status Summary, also known as the "ICS-209" is used for reporting specific information on significant fire incidents. The ICS-209 report is a critical interagency incident reporting tool giving daily 'snapshots' of the wildland fire management situation and individual incident information which include fire behavior, size, location, cost, and other information. Data from two tables in the ICS-209 database were merged and used for the EPA's 2020 NEI wildland fire emissions estimates: the SIT209_HISTORY_INCIDENT_209_REPORTS table contained daily 209 data records for large fires, and the SIT209_HISTORY_INCIDENTS table contained summary data for additional smaller fires. Some entries in the ICS-209 database contained location and date errors. In situations where the errors were obvious in nature, such as swapped latitude and longitudes or a typo in the year of the data, then appropriate corrections were made. Fires with unclear location and date issues or those fires without an associated burned area were removed. Some fires had unreasonable lengths in the reports based on the available fields. Estimated fire lengths were adjusted based on fire size.

The US Forest Service (USFS) compiles a variety of fire information every year. Year 2020 data from the USFS Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS) were acquired and used for 2020 NEI emissions inventory development. This database includes information about activities related to fire/fuels, silviculture, and invasive species. The FACTS database consists of shapefiles for prescribed burns that provide acres burned and start and ending time information. As detailed earlier, all fires labeled as pile burns were removed because the EPA does not currently develop emissions for pile burning.

The US Fish and Wildland Service (USFWS) and Department of Interior (DOI) also compiles wildfire and prescribed burn activity on their federal lands every year. Year 2020 data were acquired from USFWS and DOI through direct communication with USFWS and DOI staff and were used for 2020 NEI emissions inventory development. The USFWS fire information provided fire type, acres burned, latitude-longitude, and start and ending times. As with the FACTS dataset, fires labeled as pile burns were removed because the EPA does not currently develop emissions for pile burning.

7.3.1.2 *Emissions Estimation Methodology*

The national and S/L/T data mentioned earlier were used to estimate daily wildfire and prescribed burn emissions from flaming combustion and smoldering combustion phases for the 2020 NEI inventory. Flaming combustion is more complete combustion than smoldering and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion occurs without a flame, is a less complete burn, and produces some pollutants, such as PM2.5, VOCs, and CO, at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface-to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for the purposes of the 2020 NEI inventory the residual smoldering emissions were allocated to the smoldering SCCs ending in “1”, while the lofted smoldering emissions were assigned to the flaming emissions SCCs ending in “2”.

Figure 7-2 is a schematic of the data processing stream for the 2020 NEI inventory for wildfire and prescribe burn sources. The EPA’s 2020 NEI wildland fire emissions estimates were estimated using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Pipeline (BSP) system. SMARTFIRE2 is an algorithm and database system that operate within a geographic information system (GIS). SMARTFIRE2 combines multiple sources of fire information and reconciles them into a unified GIS database. It reconciles fire data from space-borne sensors and ground-based reports, thus drawing on the strengths of both data types while avoiding double-counting of fire events. At its core, SMARTFIRE2 is an association engine that links reports covering the same fire in any number of multiple databases. In this process, all input information is preserved, and no attempt is made to reconcile conflicting or potentially contradictory information (for example, the existence of a fire in one database but not another). Further details of the SMARTFIRE2 process as applied to NEI development can be found in the literature [ref 2].

For the 2020 NEI inventory, the national and S/L/T fire information was input into SMARTFIRE2 and then merged and reconciled together based on user-defined weights for each fire information dataset. The relative weights used for the national data stream are shown in Table 7-6. A dataset type with a higher ranking gets preference for that attribute in the reconciled activity. The output from SMARTFIRE2 was daily acres burned by fire type, and latitude-longitude coordinates for each fire. The fire type assignments were made using the fire information datasets. If the only information for a fire was a satellite detect for fire activity, then Figure 7-3 was used to make fire type assignment by state and by month.

Figure 7-2: Processing flow for fire emission estimates in the 2020 NEI inventory

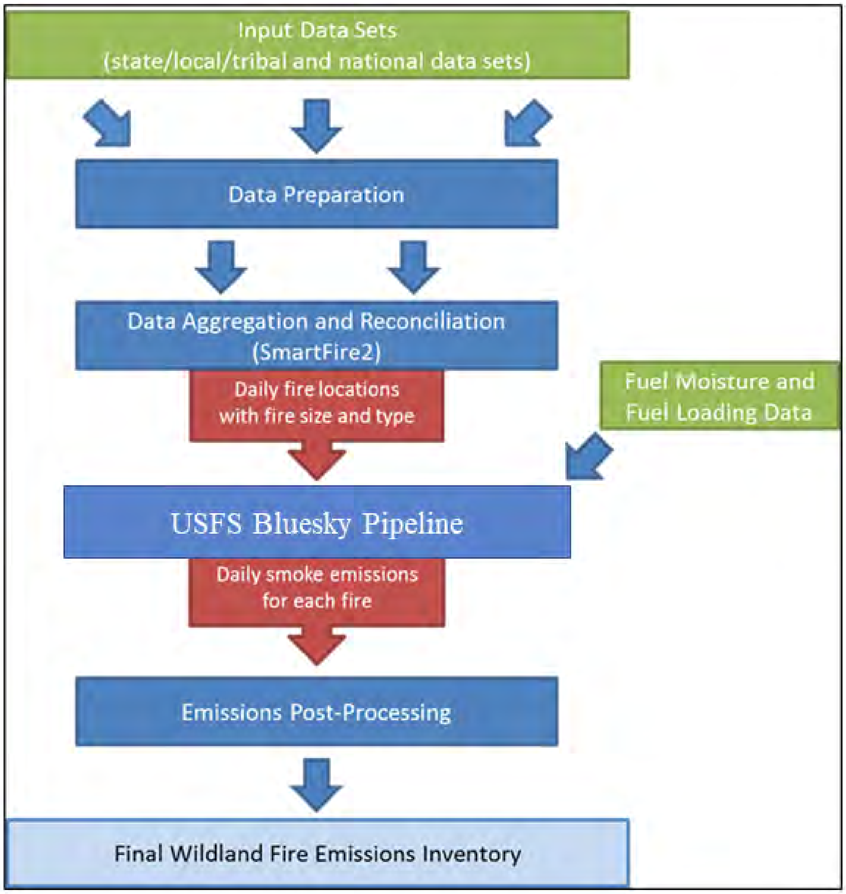


Figure 7-3: Default fire type assignment by state and month in cases where a satellite detect is only source of fire information

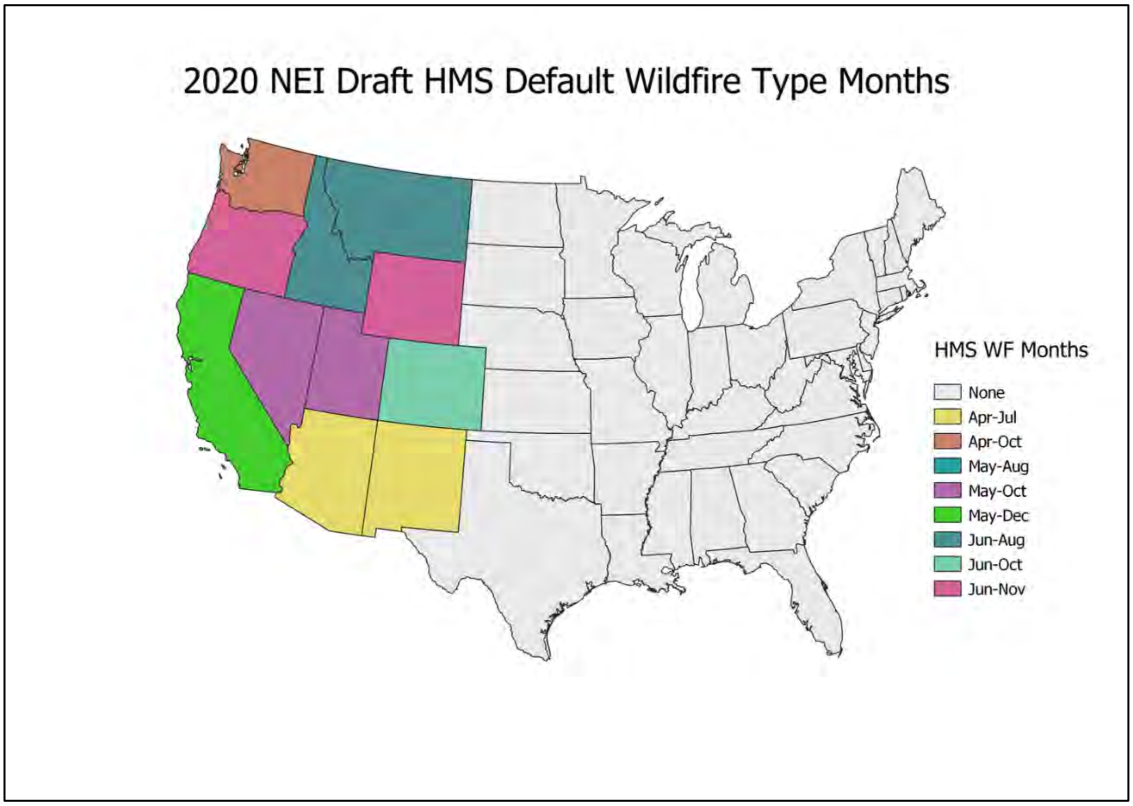


Table 7-6: 2020 National SmartFire2 Reconciliation Weights

Rank	Location Weight	Size Weight	Shape Weight	Growth Weight	Name Weight	Fire Type Weight
1	SLT Supplemental Data	SLT Supplemental Data	NIFS	HMS	SLT Supplemental Data	SLT Supplemental Data
2	NIFS	NIFS	FACTS	NIFS	NIFS	NIFS
3	HMS	FACTS	HMS	STL Supplemental Data	ICS-209	FACTS
4	FACTS	ICS-209	ICS-209	DOI	FACTS	ICS-209
5	ICS-209	DOI	SLT Supplemental Data	PFIRS	DOI	DOI
6	DOI	PFIRS	DOI	USFWS	PFIRS	PFIRS
7	PFIRS	USFWS	PFIRS	ICS-209	USFWS	USFWS
8	USFWS	HMS	USFWS	FACTS	HMS	HMS

Supplemental S/L/T activity from Arizona, Idaho, Montana, Nevada, Oregon, and Wyoming were incorporated with the national defaults into the national data reconciliation stream. States that submitted complete activity datasets were not processed through SmartFire2 with the default national activity. An exception is for those states that used HMS fire detections for daily apportionment of activity data. Alaska, Florida, and Utah all had their submitted data reconciled against the HMS fire detections. All resulting activity that was identified only through HMS was removed from the final activity dataset so that only state-submitted event values were used for emissions estimates. State-submitted activity from Iowa, Kansas, Massachusetts, North Carolina, and South Carolina were not processed through SmartFire2. Instead, each activity dataset was converted into daily activity files in a format that can be read directly by Bluesky Pipeline.

The BlueSky Pipeline (BSP version 4.2.13) was used to calculate fuel loading and consumption, and emissions using various models depending on the available inputs as well as the desired results. BSP is open source at https://github.com/pnwairfire/bluesky. The contiguous United States and Alaska, where Fuel Characteristic Classification System (FCCS) fuel loading data are available, were processed using the modeling chain described in Figure 7-4. The Fire Emissions Production Simulator (FEPS) in the BSP generated all the CAP emission factors for wildland fires used in the 2020 NEI inventory [ref 3]. The HAP emission factors used in this work came from Urbanski, 2014 [ref 4]. These emission factors were regionalized and handled differently by wild and prescribed fire. Table 7-7 below outlines the regionalization scheme used while Table 7-8 and Table 7-9 show the HAP EFs employed in this work separately for wild and prescribed fires. Note the differences, in bold in Table 7-7, for wildfires and prescribed burning region assignments for Alaska and Wisconsin.

Table 7-7: Emission factor regions used to assign HAP emission factors for the 2020 NEI

Region	Wildfires	Prescribed burning
Region 1	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX
Region 2	**AK**, AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, **WI**, WV	AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, WV
Region 3	CO, ID, MT, ND, NE, OR, SD, UT, WA, WY	**AK**, CO, ID, MT, ND, NE, OR, SD, UT, WA, **WI**, WY

Table 7-8: Prescribed fire HAP emission factors (lb/ton fuel consumed) for the 2020 NEI

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1,3-Butadiene (HAP 106990)	0.272326792	0.516619944	0.362434922	0.272326792	0.516619944	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.283540248	2.240688827	1.678013616	1.283540248	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.064076892	0.43051662	0.322386864	0.064076892	0.43051662
Acrolein (HAP 107028)	0.512615138	0.646776131	0.684821786	0.512615138	0.646776131	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.058069684	0.094112936	0.070084101	0.058069684	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
Benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	0.566680016	0.600720865	0.450540649	0.566680016	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026

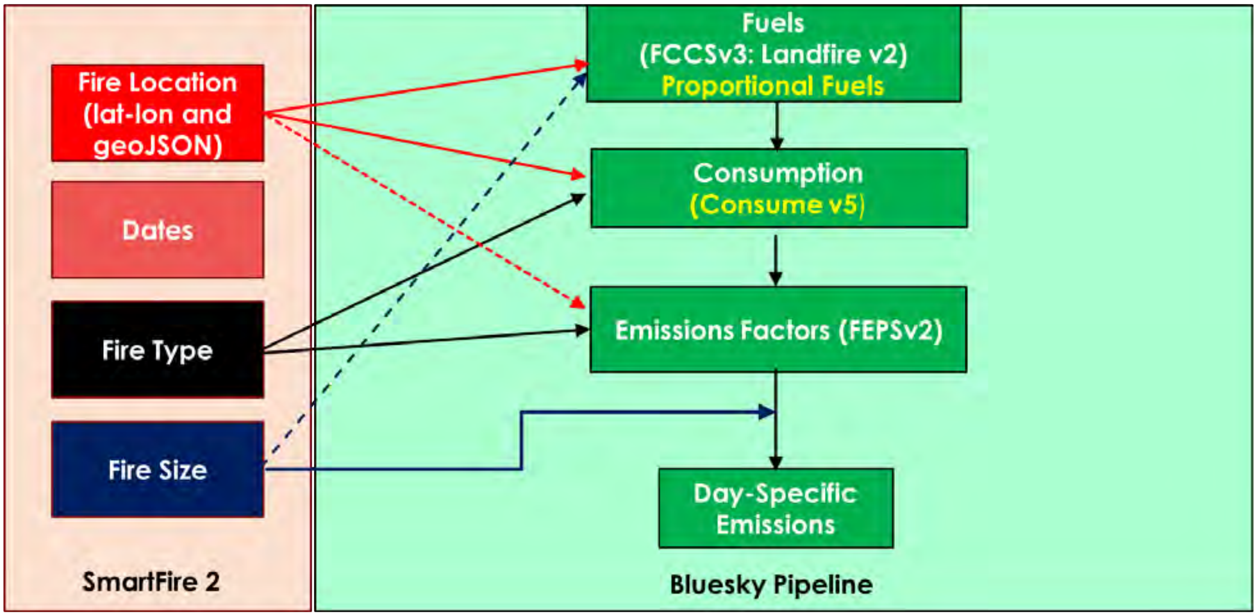
HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.366039247	4.475370445	2.515018022	3.366039247	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.160192231	0.288346015	0.216259511	0.160192231	0.288346015
Methanol (HAP 67561)	2.306768122	1.974369243	5.036043252	2.306768122	1.974369243	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
Methylpyrene, fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.024028835	0.064076892	0.048057669	0.024028835	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.398478174	0.650780937	0.486583901	0.398478174	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.050060072	0.100120144	0.07609131	0.050060072	0.100120144
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.080096115	0.138165799	0.10412495	0.080096115	0.138165799
Toluene (HAP 108883)	0.344413296	0.398478174	0.45855026	0.344413296	0.398478174	0.45855026

Table 7-9: Wildfire HAP emission factors (lbs/ton fuel consumed) for the 2020 NEI

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1,3-Butadiene (HAP 106990)	0.272326792	0.140168202	0.362434922	0.272326792	0.140168202	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.908289948	2.240688827	1.678013616	1.908289948	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.600720865	0.43051662	0.322386864	0.600720865	0.43051662
Acrolein (HAP 107028)	0.512615138	0.582699239	0.684821786	0.512615138	0.582699239	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.080096115	0.094112936	0.070084101	0.080096115	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	1.101321586	0.600720865	0.450540649	1.101321586	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.954745695	4.475370445	2.515018022	3.954745695	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.120144173	0.288346015	0.216259511	0.120144173	0.288346015
Methanol (HAP 67561)	2.306768122	2.613135763	5.036043252	2.306768122	2.613135763	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
Methylpyrene,-fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.054064878	0.064076892	0.048057669	0.054064878	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.554665599	0.650780937	0.486583901	0.554665599	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.054064878	0.100120144	0.07609131	0.054064878	0.100120144
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.11814177	0.138165799	0.10412495	0.11814177	0.138165799
Toluene (HAP 108883)	0.344413296	0.480576692	0.45855026	0.344413296	0.480576692	0.45855026

Figure 7-4: BlueSky Pipeline modules



For the 2020 NEI inventory, the FCCSv3 spatial vegetation cover was upgraded to the LANDFIRE v2.0 fuel vegetation cover. The FCCSv3 fuel bed characteristics were implemented along with LANDFIREv2.0 to provide better fuel classification for the BlueSky Pipeline. The LANDFIREv2.0 raster data were aggregated from the native resolution and projection to 120-meter resolution using a nearest-neighbor methodology. Aggregation and reprojection was required to allow these data to work in the BlueSky Pipeline.

Outputs from each BlueSky Pipeline processing stream were aggregated into an annual file. Fires identified as being over water by FCCS were removed because they produce no fuel consumption in the CONSUME model and thus no emissions.

7.3.2 Agricultural Field Burning

By way of history for this sector, in the 2008 NEI, crop residue emission estimates were developed using satellite detects occurring over land types classified as "agricultural" and uncertain field sizes or were sporadically reported by a handful of states. In the 2011 NEI, the method described in McCarty et al. 2009 [ref 6] and McCarty 2011 [ref 7] was employed to estimate the emissions from this sector with the exception that states could submit their own estimates. However, this produced significant state to state variability between states that submitted their own data and states that did not. In addition, we received comments that many false detects (EPA emission estimates were too high) occurred using this method (due to dark fields resulting from irrigation) Therefore, a consistent methodology across multiple years for the CONUS has not yet been developed for this sector. To address these issues, in the 2014 NEI, a simple and efficient method was developed to estimate emissions from crop residue that can easily be applied across multiple years over the CONUS at minimal cost. The method was developed by EPA Office of Research and Development and the reader is directed to a paper in press for details on the methods described below [ref 8]. This is the basic method used for the 2020 NEI, with the changes/improvements made as noted below.

The approach developed for use in the 2014 NEI and 2017 NEI, and used again for the 2020 NEI, already improves on previous estimates [ref 6, ref 7] as follows:

- Multiple satellite detections are used to locate fires using an operational product

- Field Size estimates are based on field work studies in multiple states (rather than a one size fits all approach)
- This method allows for intra-annual as well as annual changes in crop land use
- Additional processing of the HMS data was done to remove 2 types of duplicates
- This method uses USDA NASS Cropland Data Layer (CDL) (USDA, 2015a) [ref 9] information to separate grass/pasture lands, which include Pasture/Grass, Grassland Herbaceous, and Pasture/Hay lands from all other agricultural burning and to identify the crop type
- Removal of agricultural fires from the Hazard Mapping System (HMS) dataset before the application of the SMARTFIRE2 system for wildfires and prescribed fires to eliminate double counting in the NEI and the use of state information to further identify fires as crop residue burning rather than another type of fire
- To further identify fires as crop residue burning rather than some type of wildfire. Our approach complements the method used to estimate emissions from wildfires and prescribed fires because we use crop level land use information to identify crop residue fires and grassland ('rangeland') fires. The remaining fire detections are used in SMARTFIRE to estimate emissions in forested areas where fuel loadings are available from the National Forest Service.

7.3.2.1 *Improvements/Changes in the 2020 NEI*

For the 2020 NEI, we have made a few revisions to the method used to estimate this sector compared to the 2017 NEI and will summarize them here. For details of the 2017NEI methods see Section 7 of our 2017 NEI Technical Support Document.

- To avoid double counting with the wildfire inventory, all grassland detections of fires outside of the Flint Hills in Kansas and Oklahoma have been incorporated into the wildfire and prescribed fire inventory process and are not part of this database. These fires are included as appropriate in our wildland fire inventory.
- EPA worked with the state of Iowa to move some fires very near agricultural lands to the prescribed burn and wildfire types to take into account for the months where agricultural burns were not expected in the Midwest states.
- In the 2020 NEI, for the first time, we have also included Pb as a pollutant for WLFs. The emission factors that were used to estimate Pb come from a recently completed EPA test program (Reference = A. L. Holder, V. Rao, K. Kovalcik, and L. Virtaranta, "**Particulate Pb emission factors from wildland fires in the United States," submitted to Atmospheric Environment X, March 2023. In sum, we find that WLFs contribute 13 tons of Pb nationwide.** The 2020NEI total for Pb emissions from wildland fires is about 16 tons which about 5% of all Pb emissions in the entire 2020NEI.

7.3.2.2 *Activity Data*

As with the 2017 process, the HMS satellite product is the main system used for the 2020 NEI. The HMS satellite product is an operational satellite product showing hot spots and smoke plumes indicative of fire locations. It is a blended product using algorithms for the Geostationary Operational Environmental Satellite (GOES) Imager, the Polar Operational Environmental Satellite (POES) Advanced Very High-Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS) and more recently the Visible Infrared Imaging Radiometer Suite (VIIRS). These satellite detections are provided at 0.001 degrees latitude or longitude, but they are derived from active fire satellite products ranging in spatial accuracy from 375 m to 4km. To identify the crop type and to distinguish agricultural fires from all other fires in the HMS product, the USDA Cropland Data Layer (CDL) (USDA, 2015a) [ref 9] was employed. This dataset is produced annually by the USDA National Agricultural

Statistics Service and provides high resolution (30 meter) detailed crop information to accurately identify crop types for agricultural fires. Based on field reconnaissance of McCarty (2013) [ref 10], a "typical" field size was assumed for each burn location, which varied by region of the country. The assumed field sizes by state are shown in Table 7-10. For the S/L/T agencies that submitted agricultural field burning activity that include acres burned those data were used instead of the data shown in Table 7-10..

Table 7-10: Assumed agricultural field sizes burned by state in 2020NEI

State	FIPS code	Average Field Size (Acres)	State	FIPS code	Average Field Size (Acres)
AL	1	40	NE	31	60
AZ	4	80	NV	32	40
AR	5	40	NH	33	40
CA	6	120	NJ	34	40
CO	8	80	NM	35	80
CT	9	40	NY	36	40
DE	10	40	NC	37	40
FL	12	60	ND	38	60
GA	13	40	OH	39	40
ID	16	120	OK	40	80
IL	17	60	OR	41	120
IN	18	60	PA	42	40
IA	19	60	RI	44	40
KS	20	80	SC	45	40
KY	21	40	SD	46	60
LA	22	40	TN	47	40
ME	23	40	TX	48	80
MD	24	40	UT	49	40
MA	25	40	VT	50	40
MI	26	40	VA	51	40
MN	27	60	WA	53	120
MS	28	40	WV	54	40
MO	29	60	WI	55	40
MT	30	120	WY	56	80

7.3.2.3 *Emission Factors*

Emission Factors for CO, NOx, SO_2, $PM_{2.5}$ and PM_{10} were based on Table 1 from McCarty (2011) [ref 7]. The emission factors in McCarty (2011) were based on mean values from all available literature at the time. Emission Factors for NH_3 were derived from the 2002 NEI crop residue emission estimates using the ratio of NH_3/NOx and the NOx emission factor in Table 1 from McCarty (2011). These emission factors are shown in the 2014 NEI TSD. As discussed above the VOC EFs were improved for the 2017 NEI and 2020NEI, as shown below in Table 7-11**.**

A subset of the HAP emission factors is shown in Table 7-12. These are based on updated VOC work mentioned above. The full set of HAP emission factors, available on the 2020 NEI Supplemental data FTP site, also includes the following HAPs: isopropylbenzene, n-hexane, o-xylene, propionaldehyde, styrene, toluene, 2,2,4-trimethylpentane, and m, p-xylenes. The sugarcane emissions factors were updated for the 2020NEI.

Table 7-11: Revised Ag Burning Emission factors (lbs/ton) for VOC

Crop Type	Emission Factor
Corn	18.47
Wheat	18.69
Soybean	18.47
Cotton	18.47
Fallow	18.47
Rice	18.26
Sugarcane	14.70
All Other crops/Default	18.47
Double Crop Wheat/Soybeans	18.58
Double Crop Corn/Soybeans	18.47
Double Crop Wheat/Cotton	18.58

Table 7-12: Select HAP Emission factors (lb/ton) used in EPA Methods by crop type for entire US

Crop Type	SCC	Acetaldehyde	Benzene	1,3-butadiene	Ethylbenzene	Formaldehyde
Unspecified/General/ Default	2801500000	1.521677	0.227658	0.161739	0.026645	1.025634
Red Bean	2801500141	1.521677	0.227658	0.161739	0.026645	1.025634
Red Bean	2801500142	1.521677	0.227658	0.161739	0.026645	1.025634
Corn	2801500150	1.521677	0.227658	0.161739	0.026645	1.025634
Wheat and Corn	2801500151	1.311003	0.224041	0.144669	0.020768	1.19077
Corn and Soybeans	2801500152	1.521677	0.227658	0.161739	0.026645	1.025634
Cotton	2801500160	1.521677	0.227658	0.161739	0.026645	1.025634
Fallow	2801500171	1.521677	0.227658	0.161739	0.026645	1.025634
Rice	2801500220	1.943024	0.234892	0.195879	0.038401	0.695364
Sugarcane	2801500250	0.238933	0.58	0	0.92	0.8
Wheat	2801500262	1.10033	0.220424	0.127599	0.01489	1.355905
Wheat and Cotton	2801500263	1.311003	0.224041	0.144669	0.020768	1.19077
Wheat and Soybeans	2801500264	1.311003	0.224041	0.144669	0.020768	1.19077

7.3.3 PM speciation for all fires

The S/L/Ts were not permitted to submit PM2.5 speciated emissions, which are required in the NEI. These PM species pollutants include EC, OC, SO4, NO3, and "other" (PMFINE). These were estimated for all nonpoint data - including those states that submitted direct emissions by EPA using the fractions from SPECIATE v5.0 [ref 5] shown in Table 7-13.

Table 7-13: PM species for all wildland fires, computed as fraction of total PM2.5

Species	Fraction
PEC	0.0323
POC	0.4688
PNO3	0.0003
PSO4	0.0013
PMFINE	0.4973

7.3.4 Quality Assurance (QA) of Final Results

7.3.4.1 *Wildfires and prescribed burning*

Different types of QA were generally applied with the different parts of the process described above. The summary below briefly describes the QA checks used in these processes.

7.3.4.1.1 Input Fire Information Data Sets

- Reviewed input data sets to identify data gaps.
- Identified fire incidents that appeared to be double counted in individual data sets and removed duplicate records.
- Examined fires with long durations or conflicts between date fields such as start date and report date to identify fires that may have erroneous dates and made necessary corrections.
- Reviewed fire locations to ensure that they fell within the United States. Obvious errors in data entry such as the reversal of latitude and longitude were corrected where possible.
- Reviewed large and small fires in each data set for validity.
- Modified distant fires (in different states) with the same names to ensure that the events were not associated.

7.3.4.1.2 Daily Fire Locations from SmartFire2

Quality assurance actions applied to daily fire locations from SmartFire2 included:

- Checked the location, fire type, duration, underlying fire activity input data, final shape, and final size for large fire events (i.e., area burned >10,000 acres) to ensure that the results were reasonable.
- Checked large fire events by state and by name, removed duplicate events, and renamed fires as needed.
- Reviewed large fire events with multiple data sources to ensure that SmartFire2 reconciliation rankings were correct and produced sensible results.
- Identified and removed fire event duplicates incorrectly created by the SmartFire2 reconciliation process.
- Checked fire events with large differences between the calculated fire area and the geometric fire area. Since the shape and area are calculated separately in SmartFire2, a large discrepancy can indicate errors in reconciliation.

7.3.4.1.3 Emissions Estimates

Quality assurance actions applied to resulting emissions estimates included:

- Checked the location of all final fires and emission estimates. Fires falling outside of the United States were removed. Some fires near the border were retained if fuel information was available in that location.
- Identified fire records that were incorrectly associated and adjusted fire event size and emissions proportionally.
- Produced and reviewed summary tables and plots of the 2020 fire inventory data.
- Compared wildfire acres burned by state to National Interagency Fire Center (NIFC) data to ensure the summary values were within reasonable range.

7.3.4.1.4 Additional quality assurance on results, and some post-final corrections

WLF emissions developed using the methods described above were compared to 2017NEI estimates, and all the way back to 2006, since the models used are similar. The spatial (and temporal) patterns seen in the data correspond to what was expected in 2020. In general, 2020 was a “worse” fire year than many previous years as more acres were burned, so the emissions are expected to be higher. However, a large portion of the wildfire acres burned took place in California in 2020 (over 4 million acres burned). The trends graphic shown in Section 7.4 (see Figure 7-5 and Figure 7-6) indicates how the 2020 PM2.5 estimates compare to other years (using similar methods). These trends represent only the lower 48 states.

These revisions were processed through the Emissions Inventory System (EIS) and summary files were posted on the 2020 NEI Data website on January 10, 2023.

7.3.5 Agricultural field burning

Review of the quality of EPA’s data included addressing of S/L/T comments as we received them during the 2020 NEI process. In addition, the following checks were done on EPA data:

- Comparison to past NEI estimates, and explaining differences noted
- Check of diurnal profile using day specific data generated by EPA methods with existing profiles used for air quality modeling
- Using past comments received from S/L/Ts for this sector to ground truth estimates
- Ensuring HAPs and VOC speciation line up as expected

The QA of S/L/T-submitted data included checking with EPA estimates, working with S/L/Ts to understand why differences exist, and making sure pollutant coverage is complete. We do not expect to make any major changes or improvements (e.g., methodology, pollutants expected) to this sector for the 2023 NEI. We will respond to specific comments we do receive for this sector.

7.4 Emissions Summaries

7.4.1 Wildland fires

This section shows several graphics and tables that describe emissions of wild and prescribed fires in the 2020 NEI based on the methods discussed above.

In Figure 7-5 and Figure 7-6, the trend in PM2.5 emissions and acres burned is shown from 2006 to 2020. Over this 15-year time frame similar SF2/BS frameworks were used to estimate these emissions. However, it should be noted that the estimates are much more robust for NEI years (2008, 2011, 2014, 2017 and 2020) since S/L/T involvement and data acquisition from S/L/Ts is much higher. In addition, year 2016 was generated with more S/L/T involvement as part of an Emissions Modeling Platform Collaboration. It can be noted from both these graphics that the year-to-year variability is more controlled by wildfire activity. The amount of prescribed fire activity does vary from about 8-16 million acres burned as seen in Figure 7-5 and Figure 7-6. At this point, it is unclear whether this range is due to either the true increases/decreases in prescribed fire activity across the US, or due to the lack of or changes in prescribed fire activity available for some states for some years or the change in satellite technology (e.g. Visible Infrared Imaging Radiometer Suite (VIIRS) instrument) used in the HMS fire detect methodology or the acres burned assumptions used in SF2 for a fire detect where there is no other fire activity data available. In the 2020NEI, about 5 million of the 13 million (~40%) estimated acres burned for prescribed fires did not have any other fire activity data available except HMS to estimate acres burned and therefore had to use the acres burned assumption method in SF2.

Figure 7-5: Annual comparison of $PM_{2.5}$ emissions for lower 48 states

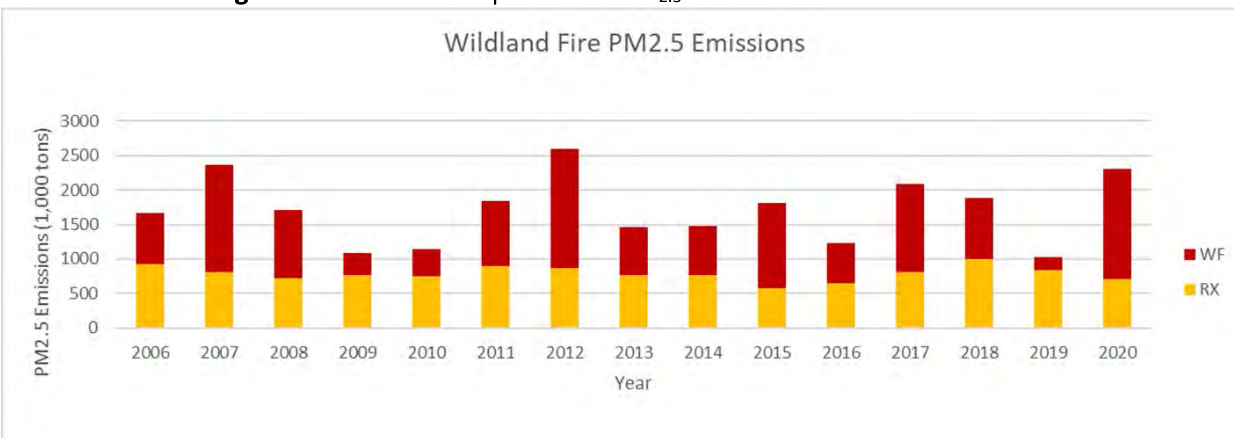


Figure 7-6: Annual comparison of area burned for lower 48 states

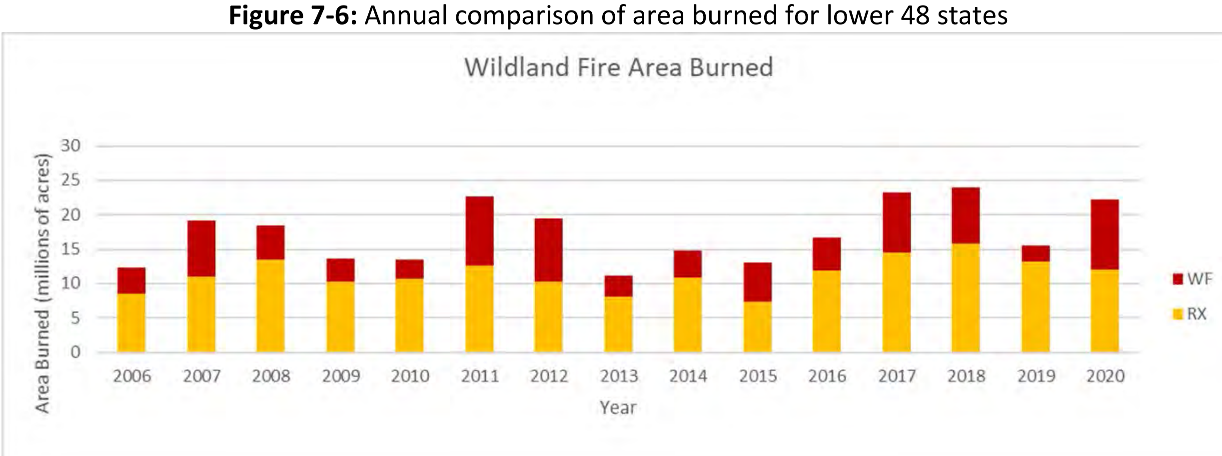


Table 7-14 shows acres burned, PM2.5, NOx, and VOC emissions by the states of AK, HI, and all the lower 48 states combined. Years 2017 and 2020 were generally bad wildfire years compared to the other 15 years shown in the trend lines above.

Table 7-14: CONUS (lower 48 states) and Alaska and Hawaii fire type information for 2020 NEI WLFs

Fire Type	Millions of Acres	PM2.5 (Tons)	NOx (Tons)	VOC (Tons)
CONUS Wildfires	10.08	1,598,052	239,542	4,399,270
CONUS Prescribed	13.23	681,958	140,719	1,655,184
Alaska All	0.26	172,073	14,287	497,265
Hawaii All	0.02	1,390	380	3,476
Total	23.60	2,453,473	394,929	6,555,195

Figure 7-7 and Figure 7-8 show acres burned and PM2.5 emissions for all fires by month in 2020. The total emissions that result from month-to-month result from a combination of different fuels that burn in different fires. It is seen that wildfires are more prevalent in the hotter months, and prescribed fires occur more often in the cooler months of 2020.

Figure 7-7: Monthly acres burned by fire type for 2020 NEI CONUS Wildland Fires

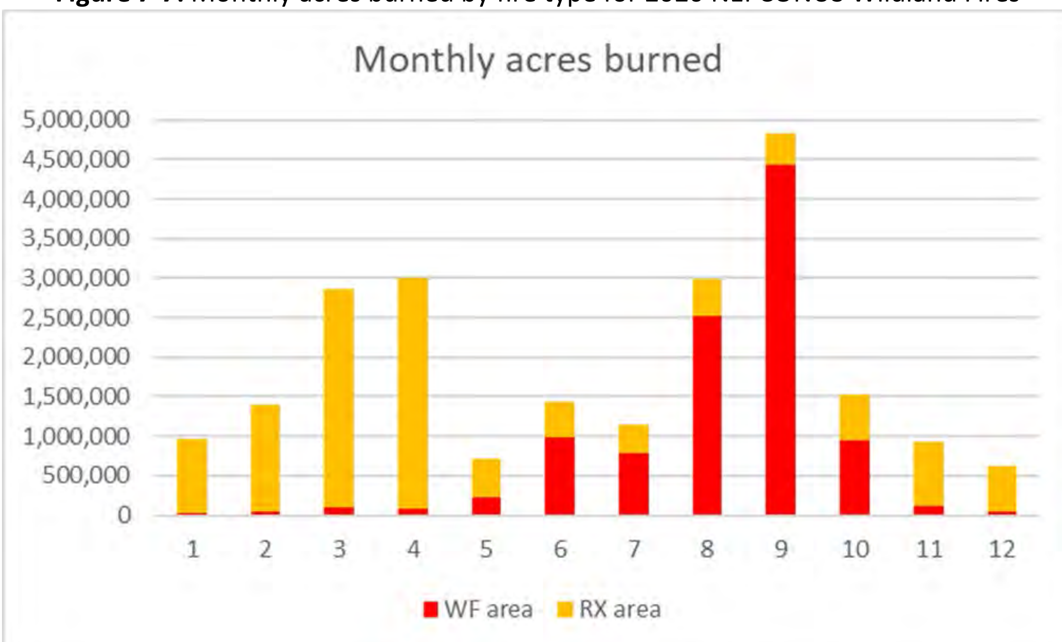
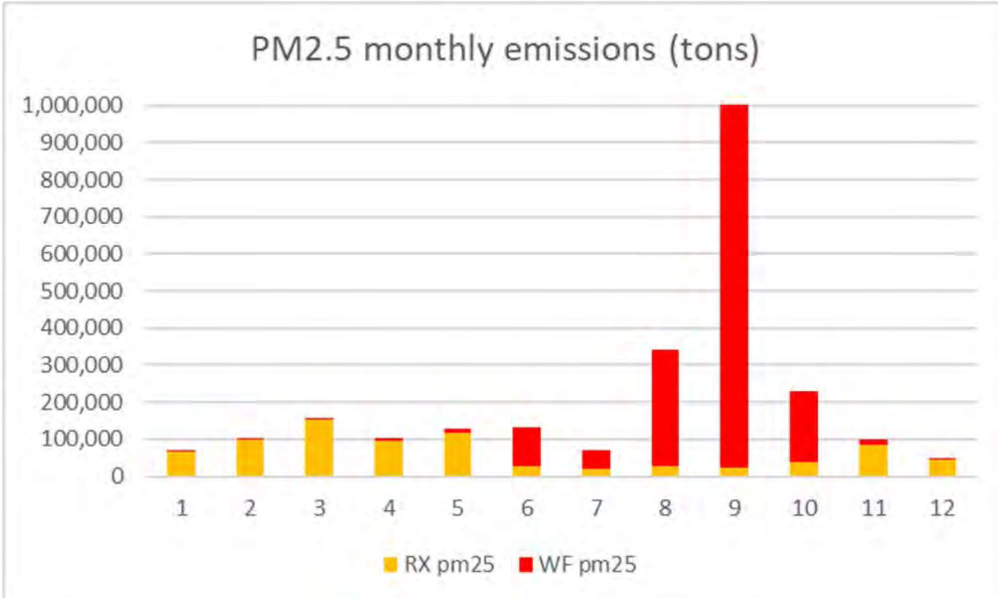


Figure 7-8: Monthly $PM_{2.5}$ by fire type for 2020 NEI CONUS Wildland Fires



Next, Table 7-15 shows a summary of acres burned and PM2.5 by state, fire type and combustion phase. In terms of total WLF acres burned, several states are shown to have more than one million acres burned in 2020, with CA, GA, and KS being the highest acres burned states. However, due to the nature of fuels burned and the type of fire that occurs in the various States, CA and OR are highest for estimated PM2.5 emissions**.**

Table 7-15: Summary of acres burned and $PM_{2.5}$ emissions by state, fire type, and combustion phase

State	Area (acres)			PM2.5 Emissions (tons)					
	Prescribed	Wildfire	Total	Prescribed			Wildfire		
				Flaming	Smoldering	Total	Flaming	Smoldering	Total
Alabama	673,865	3,065	676,930	40,557	4,289	44,846	255	25	280
Alaska	79,966	178,948	258,913	68,041	27,336	95,377	47,135	29,560	76,696
Arizona	20,816	990,864	1,011,680	522	112	634	40,454	8,188	48,642
Arkansas	410,213	1,634	411,847	35,324	5,809	41,133	294	47	341
California	159,448	4,124,077	4,283,525	7,800	1,602	9,402	448,245	114,212	562,456
Colorado	12,212	707,261	719,473	284	88	371	95,767	59,323	155,091
Connecticut	468	-	468	32	6	39	-	-	-
Delaware	1,736	-	1,736	171	89	260	-	-	-
Florida	1,386,808	113,112	1,499,920	85,495	10,221	95,716	7,006	400	7,407
Georgia	2,254,166	8,320	2,262,486	42,985	5,551	48,536	427	44	471
Hawaii	9,362	14,166	23,528	583	14	598	787	5	792
Idaho	46,108	337,629	383,737	2,536	897	3,433	37,136	21,389	58,525
Illinois	95,592	5,135	100,727	5,151	786	5,937	113	1	114
Indiana	30,175	1,713	31,888	1,391	198	1,588	88	10	98
Iowa	164,596	12,100	176,696	6,496	907	7,403	470	76	546
Kansas	2,653,259	30,925	2,684,184	61,909	2,531	64,440	897	40	937
Kentucky	89,909	2,481	92,391	5,917	692	6,609	402	47	448
Louisiana	389,916	7,306	397,222	28,015	4,090	32,105	691	82	774
Maine	2,361	837	3,198	199	65	264	124	30	154
Maryland	10,576	6	10,582	812	133	945	1	0	1
Massachusetts	1,236	410	1,646	103	18	121	57	10	67
Michigan	13,974	892	14,866	763	175	938	62	12	74
Minnesota	75,374	8,853	84,227	3,587	1,506	5,093	439	131	570
Mississippi	334,932	18,411	353,344	17,954	1,775	19,729	1,221	95	1,316
Missouri	405,937	12,501	418,437	31,021	4,957	35,979	633	71	704
Montana	79,835	342,310	422,145	4,392	1,775	6,167	21,663	5,704	27,367
Nebraska	129,177	15,658	144,834	6,447	1,393	7,840	889	233	1,122

State	Area (acres)			PM2.5 Emissions (tons)					
	Prescribed	Wildfire	Total	Prescribed			Wildfire		
				Flaming	Smoldering	Total	Flaming	Smoldering	Total
Nevada	4,690	254,927	259,617	77	7	84	5,763	761	6,524
New Hampshire	1,818	14	1,832	111	26	138	2	0	3
New Jersey	26,139	4,780	30,919	2,170	460	2,629	604	128	732
New Mexico	39,355	155,002	194,357	659	190	849	9,577	3,236	12,812
New York	24,057	162	24,219	1,678	410	2,088	28	5	33
North Carolina	100,715	11,476	112,191	5,113	713	5,826	611	60	671
North Dakota	67,348	2,779	70,126	2,330	457	2,786	144	25	170
Ohio	19,446	888	20,334	1,093	185	1,279	51	5	56
Oklahoma	1,039,072	87,444	1,126,516	44,796	3,998	48,794	5,208	519	5,727
Oregon	162,152	1,101,771	1,263,923	32,988	13,131	46,119	414,480	155,367	569,847
Pennsylvania	26,364	929	27,293	1,733	296	2,030	138	20	158
Rhode Island	39	84	123	4	0	4	10	2	11
South Carolina	314,497	2,761	317,258	16,972	2,211	19,183	199	22	221
South Dakota	37,381	16,297	53,678	1,717	377	2,094	2,127	587	2,714
Tennessee	128,903	908	129,811	8,622	1,108	9,731	143	15	158
Texas	1,530,896	209,545	1,740,442	66,020	17,104	83,124	6,406	927	7,332
Utah	17,208	310,404	327,612	756	479	1,235	24,528	16,738	41,266
Vermont	1,638	4	1,642	91	19	110	1	0	1
Virginia	98,344	7,279	105,623	6,350	909	7,259	1,025	115	1,140
Washington	91,447	843,176	934,623	2,152	-	2,152	36,255	8,577	44,832
West Virginia	29,232	385	29,616	2,507	411	2,918	80	10	90
Wisconsin	18,858	2,631	21,488	1,187	338	1,525	167	24	191
Wyoming	9,984	323,747	333,731	310	164	473	25,522	10,337	35,860
Grand Total	**13,321,598**	**10,276,007**	**23,597,606**	**657,922**	**120,012**	**777,934**	**1,238,325**	**437,215**	**1,675,540**

Figure 7-9 and Figure 7-10 show 2020 total area (acres) burned and PM2.5 emissions by state, respectively. It summarizes the data in Table 7-15 in map format. The Southeast states are seen to be dominated by prescribed fires and the western states by wildfires. This is a typical pattern we see from NEI-to-NEI. In addition, for acres burned, CA and KS are seen to dominate and for PM2.5 emissions, CA and OR and other western states are seen to be dominant.

Figure 7-9: Total 2020 NEI area burned by state -wildland fires

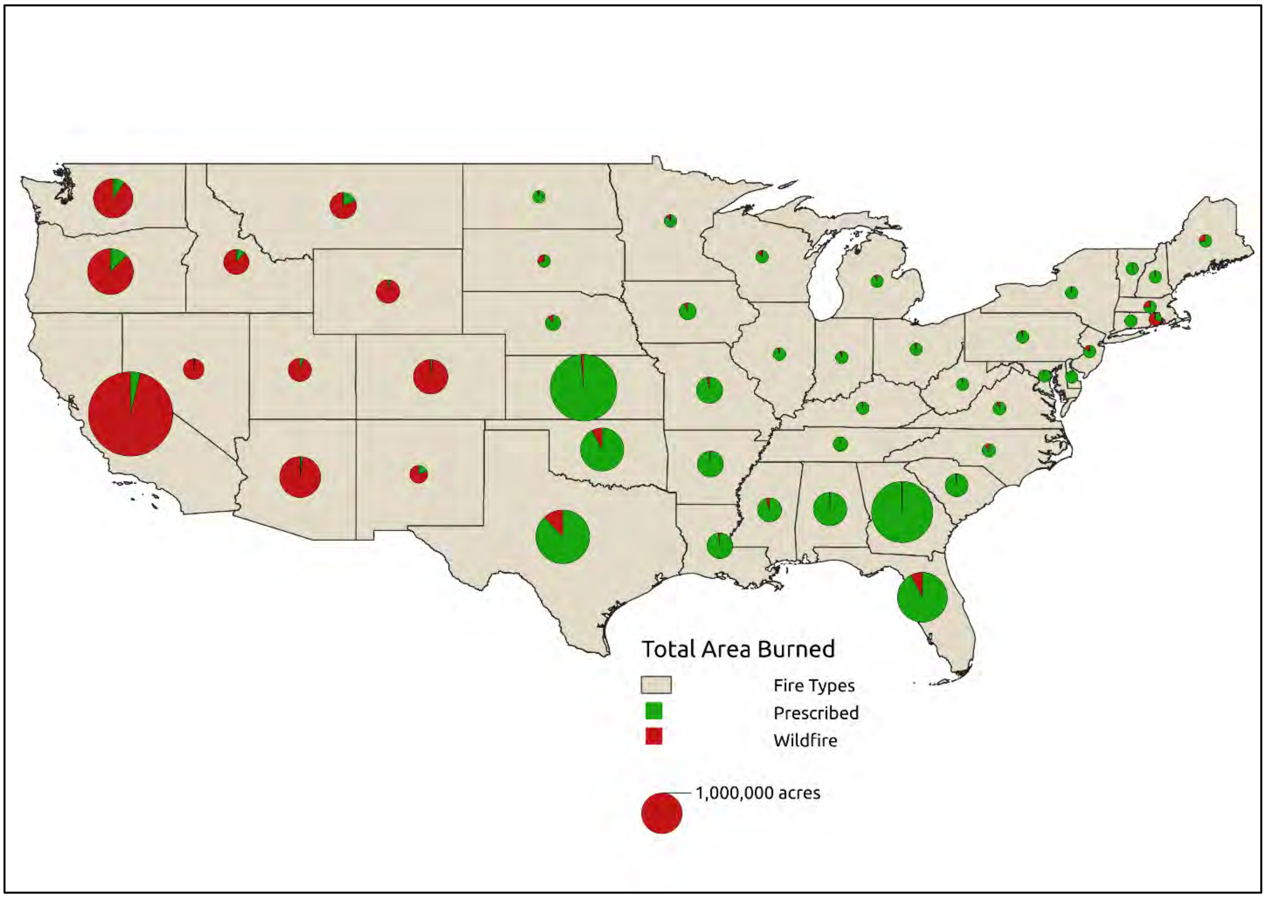
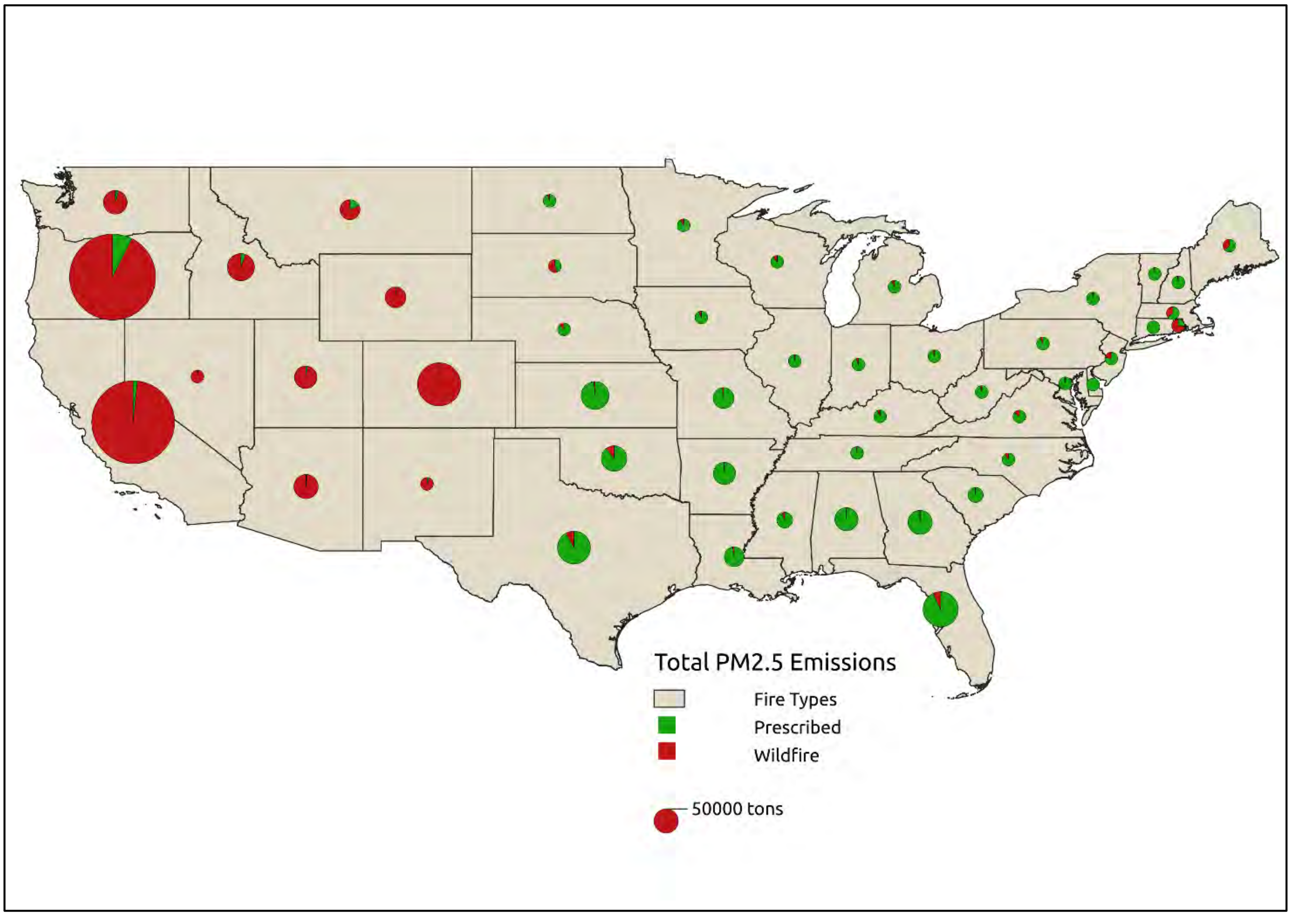


Figure 7-10: Total 2020 NEI PM2.5 wildland fires emissions by state



PM2.5 emissions per square mile are shown in Figure 7-11 and acres burned per square mile are shown in Figure 7-12. The patterns seen correspond to the other graphics and tables shown in this section and are fairly typical of a given NEI for WLFs.

Figure 7-11: 2020NEI county $PM_{2.5}$ wildland fires emissions in tons per square mile

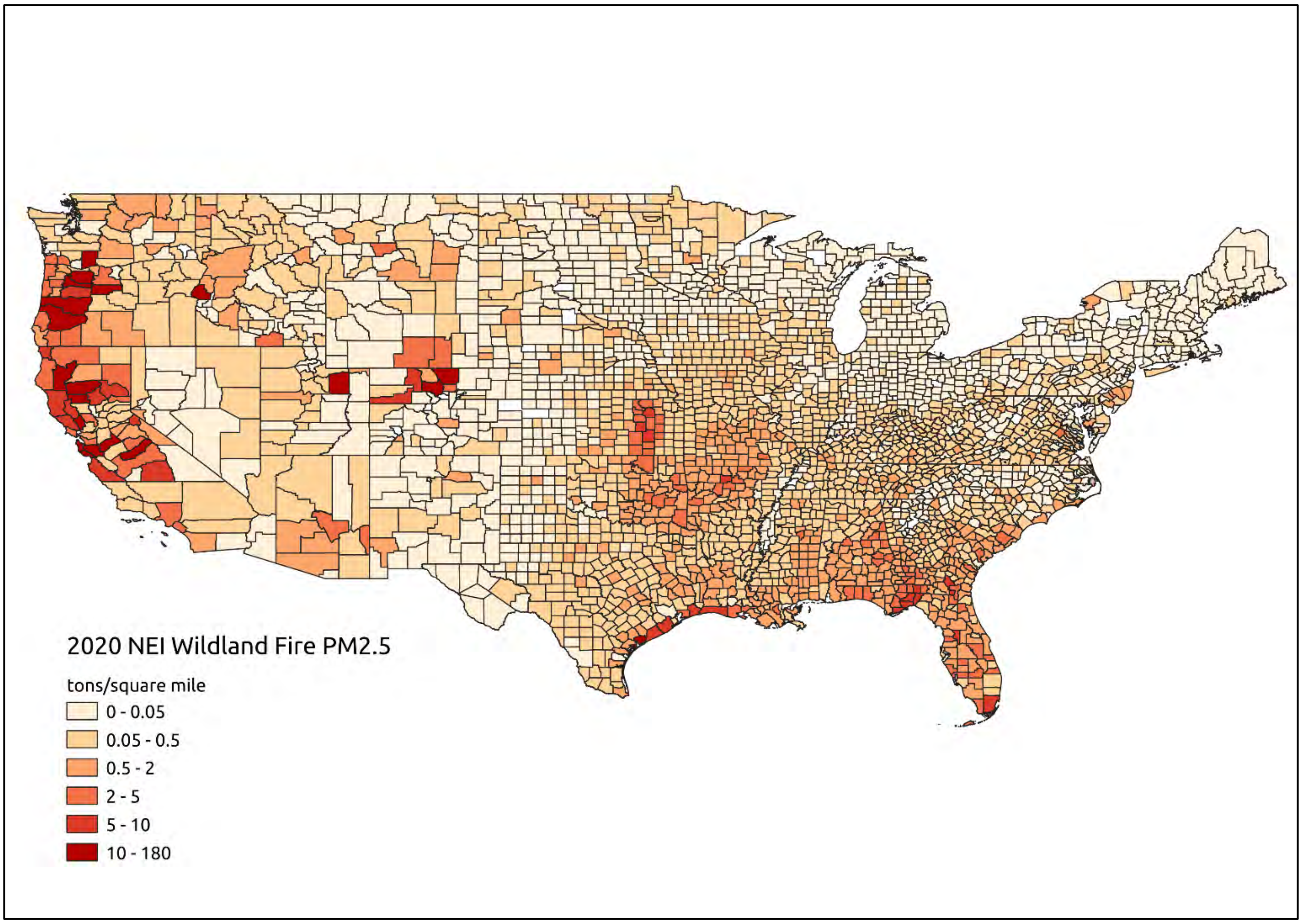
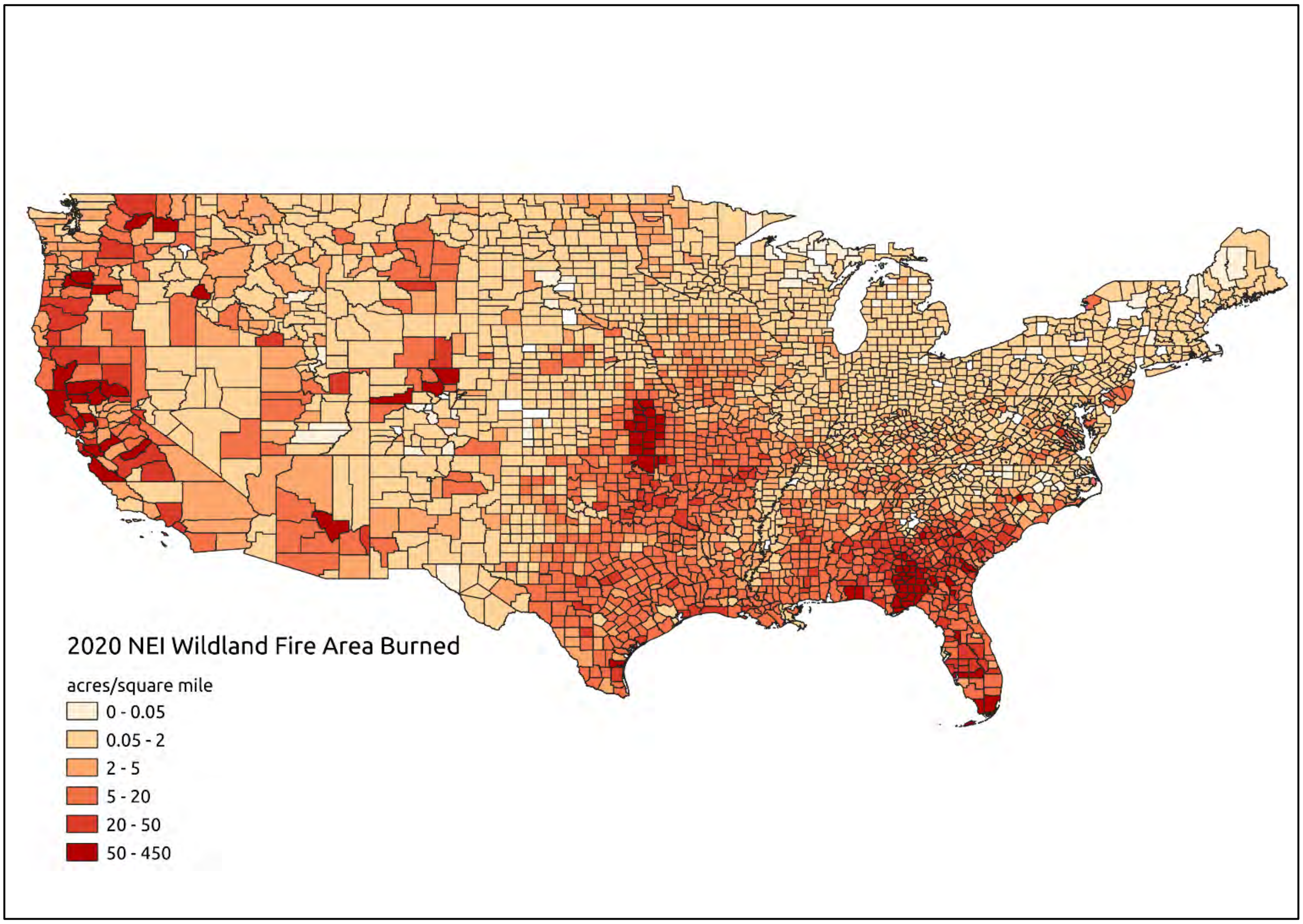


Figure 7-12: 2020NEI wildland fires county area burned in acres per square mile



7.4.2 Agricultural field burning

Figure 7-13 summarizes 2020 NEI PM2.5 emission estimates by state, sorted from largest to smallest, based on the 2020 NEI. Florida, Washington, California, Georgia, and North Dakota are the top emitters. Some of these emissions come from S/L/T submissions, and some from EPA estimates. Tribal emissions are not shown here. A total of about 30,000 tons of PM2.5 are estimated to be emitted by this sector. Shown in Table 7-16 are comparisons of PM2.5 emissions for those states that submitted PM2.5 vs EPA estimates. Only a few states submitted. Of those states that submitted to EIS, only 3 states (GA, ID, IL) and tribes included HAPS in their ag burning emission submittals. Only Idaho indicated to supplement their data with EPA estimates via the Nonpoint Survey. A total of about 33,000 tons of PM2.5 are estimated to be emitted for this sector using EPA methods alone, compared to about 30,000 when these SLT emissions are also factored into the final NEI.

Figure 7-13: Total 2020 NEI Agricultural Burning PM2.5 Emissions by state

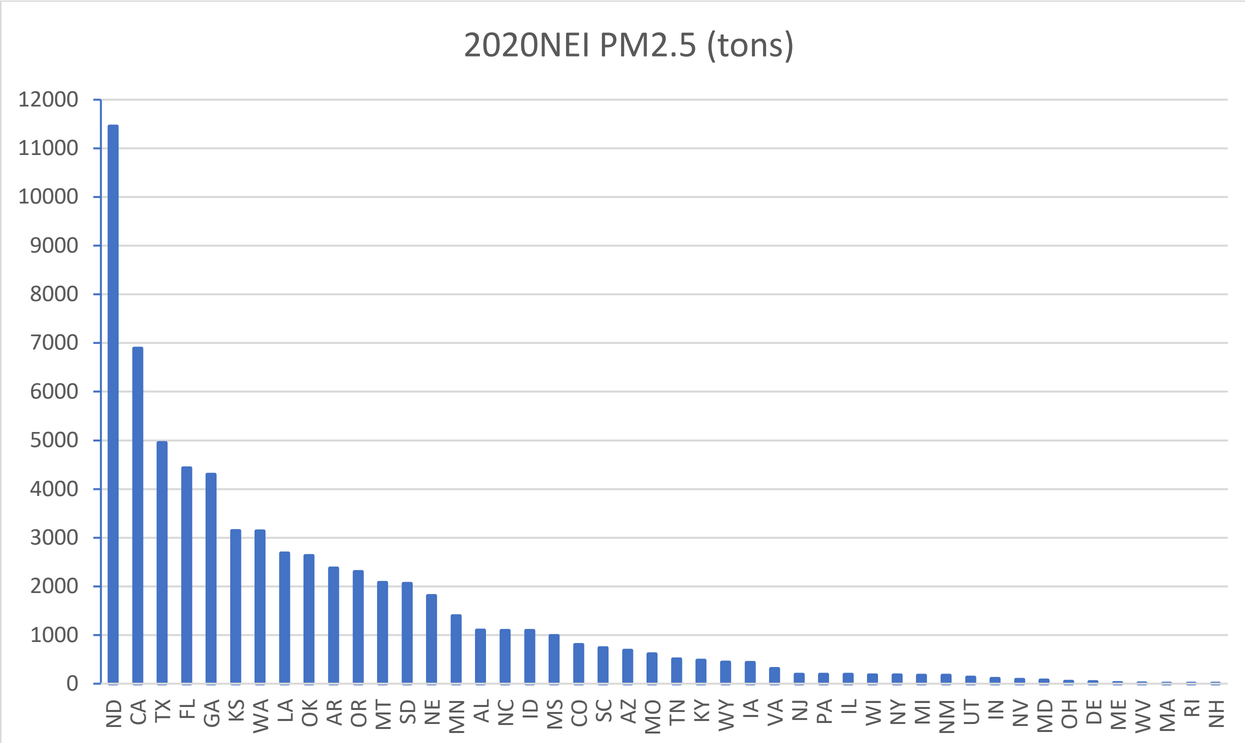


Table 7-16: Comparison of State vs EPA 2020 PM2.5 emissions (tons) for agencies that submitted

State/Tribe	S/L/T-submitted	EPA-generated
California	6891	6172
Georgia	4303	3413
Idaho	1089	3452
New Jersey	192	42
Washington	3135	2338
Tribes Total	647	0

7.5 References

7.5.1 Wildfires and prescribed burning

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7.5.2 Agricultural field burning

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC	Publication No. EPA-454/R-23-001g March 2023