2019 Alaska Fire Emissions Inventory

Department of Environmental Conservation
Air Quality Division
Air Non-Point & Mobile Sources Program

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Table of Contents

Figures

Tables

2019 Alaska Wildfire Emissions Inventory

1 INTRODUCTION

The Alaska Department of Environmental Conservation (DEC) collects, reviews, tracks, and summarizes burn data for annual Alaska Enhanced Smoke Management Plan (ESMP) emissions inventory reports to be distributed to the Alaska Wildland Fire Coordinating Group (AWFCG), the US Environmental Protection Agency (EPA), and the Western Regional Air Partnership (WRAP).

This report fulfills the responsibility for reporting 2019 prescribed fire emissions, as required by the ESMP. It provides information about the DEC Open Burn Applications for prescribed burns approved by DEC for 2019 and it reports statewide wildfire emissions for the same year.

This report does not include any data for other state, federal, or regional agencies which issue burn permits during the state fire season (April 1-September 30). The exception to this is the inclusion of agricultural fires permitted by the Alaska Department of Natural Resources (ADNR/DNR) under their agency's Large Scale Burn Permit program.

Due to the incomplete status of available data through Alaska Interagency Coordination Center databases, DEC may publish an addendum to this report should further technical details emerge that suggest an update is warranted .

1.1 Fire Management in Alaska

The Alaska Interagency Coordination Center (AICC) is the Geographic Area Coordination Center for Alaska. Located on Fort Wainwright, near Fairbanks, the AICC serves as the focal point for initial response, resource coordination, logistics support, and predictive services for all state and federal agencies involved in wildfire management and suppression in Alaska.

AICC operates on an interagency basis; cooperators include Bureau of Land Management (BLM), State of Alaska Department of Natural Resource's Division of Forestry (DNR/DOF), United States Forest Service (USFS), National Park Service (NPS), Bureau of Indian Affairs (BIA), and the US Fish and Wildlife Service (USFWS). AICC collects wildfire data and prepares daily situation reports.

DEC manages permits for prescribed burns and collects and reports air quality data for wild and prescribed fires over 40 acres. The DNR/DOF issues permits for all prescribed burns, including those less than 40 acres.

The AICC and AWFCG coordinate fire management planning, preparedness, suppression, prescribed fire, and related activities. For the purposes of fire suppression, the BLM, USFS, and DNR/DOF each take responsibility for managing fires in regions of the State, regardless of ownership. The State of Alaska is divided into 14 Fire Management Zones (Figure 1). This approach reduces the duplication of efforts and encourages cooperation between state and federal agencies, promoting efficiency and cost effective use of facilities and resources to manage fires.

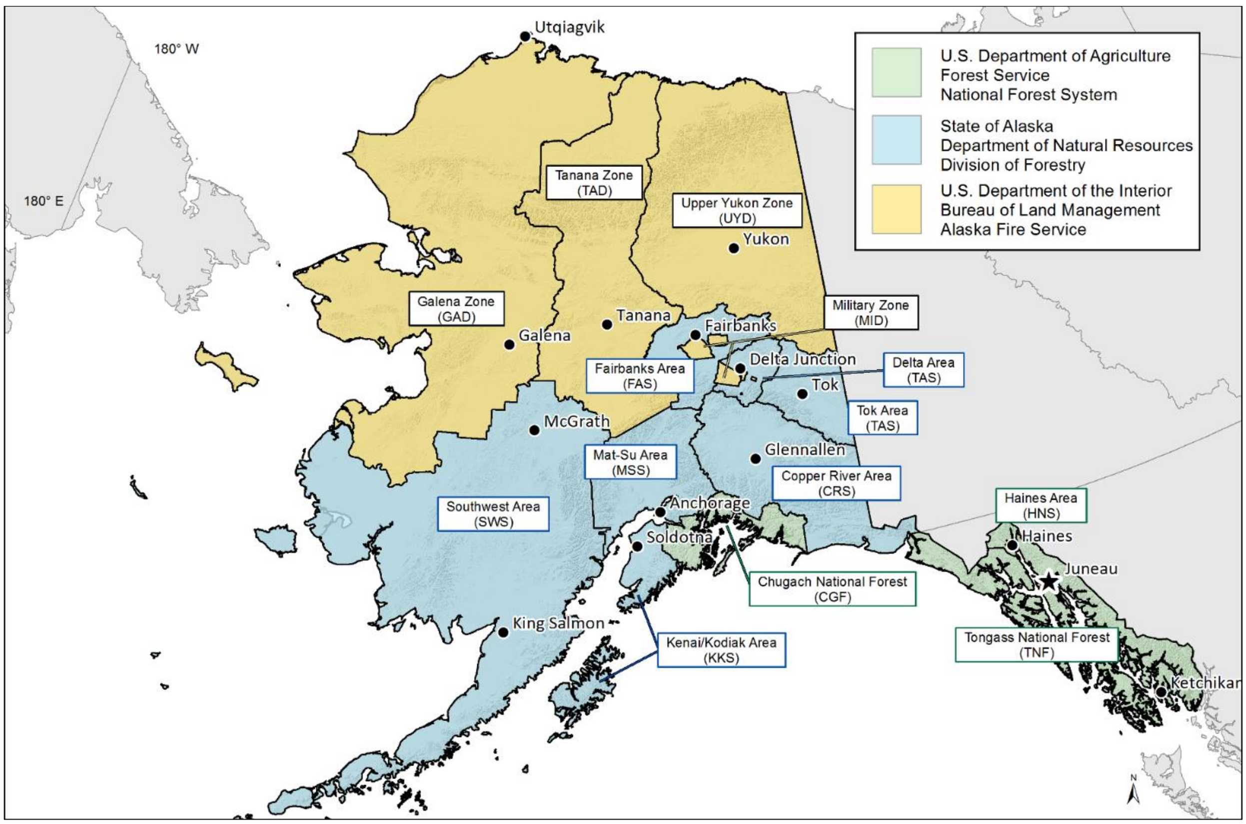


Figure 1 – Fire Management Zone Map

1.2 Fire and Air Quality

DEC's Air Quality Division tracks wildfires and regulates prescribed fires from an air quality perspective and provides emissions data from the fires to the EPA on a triennial basis.

Smoke is made up of a wide range of chemical compounds, including criteria pollutants which are regulated by the EPA to provide protection for public health and the environment. National air quality standards specify allowable concentrations in ambient air. Smoke also impairs visibility. Local impairment can be severe and contribute to unsafe driving conditions, health issues, and regional impairment contributes to haze that obscures vistas.

The pollutants inventoried for this report along with the reasons for including the pollutants are listed in Table 1.

Table 1 – Pollutants Inventoried

Pollutant	Abbreviation	Reason for tracking
Fine particulate matter	$PM_{2.5}$	Criteria pollutant
Coarse particulate matter	PM_{10}	Criteria pollutant
Elemental carbon	EC	Visibility impairment
Organic carbon	OC	Visibility impairment
Sulfur dioxide	SO_2	Criteria pollutant
Oxides of nitrogen	NO_X	Criteria pollutant
Volatile organic compounds	VOC	Hazardous air pollutant
Methane	CH_4	Hazardous air pollutant
Ammonia	NH_3	Visibility impairment
Carbon monoxide	CO	Criteria pollutant

Fine particulate matter ($PM_{2.5}$) is the primary pollutant of concern from wildland fires. $PM_{2.5}$ comprises all airborne particles with an aerodynamic diameter less than 2.5 microns. Because $PM_{2.5}$ is based on size, not chemical composition, it can be made up of a wide range of chemical compounds. Typically, particles in this size range result from combustion sources such as wildland fires, power plants, engines, wood stoves, heaters, and motor vehicles. Due to the small size of the particles, they are inhaled deeply into the lungs, increasing the probability of cardiovascular and respiratory health problems.

1.3 <u>Alaska Enhanced Smoke Management</u>

DEC, in coordination with the AWFCG, developed the ESMP to reduce smoke impacts from prescribed burns in Alaska. The current ESMP and accompanying volume of appendices were adopted by the AWFCG in June 2015. DEC adopted the ESMP as part of a Regional Haze State Implementation Plan (SIP) amendment on December 17, 2015 and submitted it formally to the EPA on March 10, 2016. Minor updates to the Regional Haze SIP regarding the ESMP were approved and became effective May 14, 2018. DEC will be releasing an updated ESMP as part of its updated Regional Haze SIP, which is due to EPA by July 30, 2021. Stipulations applicable to the yearly fire report will be denoted in the 2020 fire inventory for stakeholders and members of the public to review.

The ESMP helps DEC protect air quality and human health under federal and state law, reflects the Clean Air Act requirement to improve visibility in Class I areas, and is an important component of Alaska's Regional Haze SIP. Class I Areas are National Parks, Wilderness Areas, and Wildlife Preserves designated under the 1977 Clean Air Act Amendment. This designation mandates that state and federal agencies should expend resources to protect and improve visibility at these areas for the appreciation of park visitors. Alaska's Class I areas are Denali National Park, Tuxedni National Wildlife Refuge, Simeonof Wilderness Area, and the Bering Sea Wilderness Area.

1.4 ***Open Burn Approvals***

Due to the health and visibility effects of smoke, DEC requires anyone burning vegetation over 40 acres within one year (this includes the summation of multiple burn activities) to obtain an air quality approval, in the form of a prescribed burn permit, before burning activities occur. Open burn approvals outline steps to minimize impacts from smoke such as weather monitoring, emission reduction techniques, and consideration of sensitive features like roads, population centers, schools, and airports where smoke can impact health and visibility. Open burn approvals also require permittees to work with the DEC meteorologist and to submit post burn reports when the prescribed burns are completed. The post-burn reports support DEC's efforts to track and inventory pollutants.

In 2019, DEC granted 10 approvals for prescribed open burns for land clearing purposes and 90 approvals for training exercises which required a black smoke burn approval (mainly for firefighting training). Resource agencies submitted post burn reports for 10 completed prescribed fires. AICC reported zero open burns less than 40 acres that did not require a permit from DEC.

1.5 ***DNR Large Scale Burn Permits***

In 2019, DNR issued 130 large scale burn permits across seven permitting regions (Kenai/Kodiak, Matanuska-Susitna Valley, Fairbanks, Delta, Tok, Copper River, and a general Statewide permit). This is separate from DNR's small-scale permits, of which the agency issued some 10,800 for the same permitting regions. Large scale burn permits, which include agricultural burn permits, are issued for burns over 40 acres, or for burning which will in the aggregate total more than 40 acres.

The available information, at present, sent by DNR lacks information on fuel loads, vegetation, or specific burn types (home land clearing, construction land clearing/pile burning, controlled forest management burns, agricultural burns, etc.). As six of the seven permitting regions coincide with active agricultural tillage areas in the state, there is the distinct possibility that more agricultural burning was conducted under these DNR large-scale burn permits than was reported on yearly agricultural burn reports.

No other information is available at present for other agency-permitted prescribed burning at the local, state, or federal levels which can be included in this yearly fire report.

There were no known adverse effects to Sensitive Areas or to Class I Areas as a result of conducting prescribed burns.

2 INVENTORY METHODOLOGY

To prepare the 2019 wildfire emissions inventory, DEC used the Wildland Fire Emission Template prepared in 2006 by Air Sciences. The template is an Excel spreadsheet prepopulated with formulas and emission factors to calculate wildland fire emissions. The user enters basic information about each fire and assigns fuel loading factors that defines the amount of vegetation per acre. The inputs include:

- Fire name
- Acres
- Start date
- Date fire extinguished
- Vegetation type
- Prescribed or wildfire
- Broadcast or piles
- For prescribed fires, vegetation category determines emission reduction technique effectiveness

As in previous years, AICC provided this data to DEC at the end of the year. Fuel loading factors were determined using either the Basic Method or the LANDFIRE (Landscape Fire and Resource Management Planning Tools) method. These methods are described in sections 2.1 and 2.2.

2.1 Basic Method

For fires with a vegetation type listed in the AICC dataset, DEC assigned a fuel loading factor. DEC assumed that all fires without a vegetation type listed were grass fires. Table 2 shows the fuel factor name and the fuel loading factor assigned to vegetation types.

Table 2 – Fuel Loading Factors

Fuel Factor Name	Wildfire Loading Factor - tons per acre(tpa)	Prescribed Loading Factor - tpa
Western grasses (annual)	0.5	0.5
Intermediate brush	15	15
Short needle (heavy dead)	43.5	25.6
Western grasses (perennial)	0.75	0.75
Alaskan black spruce	57.57	48.76
Hardwood litter (summer)	3.05	3.05
Tundra	19.3	19.05

2.2 LANDFIRE Method

Large fires can start in one vegetation type, and burn through others. Thus, the AICC provides more detailed vegetation data under the LANDFIRE program which includes Alaska specific vegetation types . The calendar year 2019 had 661 wildfires which totaled 2,620,056 acres. DEC uses the LANDFIRE method to more accurately represent either the 25 largest fires recorded or 90% of the total acres burnt, whichever is less.

In 2019, the 19 largest wildfires represented greater than 90% of total acreage of wildfires reported in 2019. As a result, these fires emissions were estimated using the LANDFIRE vegetation data calculation method. Table 3 shows the five largest wildfires from 2019 and their corresponding basic fuel factor. Table 4 lists the three largest fires in 2019 that were submitted in the LANDFIRE dataset without corresponding vegetative data. For the largest 19 fires, the average LANDFIRE fuel factor was 21.945 as opposed to under the basic method. Representation of the largest wildfires with the LANDFIRE method resulted in a reduction of 16% total PM2.5 emissions.

Using the data shown below, only two of the five largest fires in 2019 had vegetative data recorded in the AICC database: Old Grouch Top and Swan Lake. Both occurred in areas of significant forest vegetation, with the vegetative type for both reported as Alaskan Black Spruce. The other three fires had null fields for vegetation types, which resulted in their calculation as grassland fires. Given Alaska's varied topography and vegetation zones, it is likely that these fires, along with Old Grouch Top and Swan Lake, had some amount of acreage which was grassland that burned along with the other types of vegetation. However, the absence of vegetative data skews both the normal emissions calculations as well as LANDFIRE calculations.

Table 3 – Two Largest Fires in 2019 with Known/Reported Vegetation

Fire Name	Acres	Basic Method Fuel Factor	Primary Fuel
Old Grouch Top	308,922.7	57.57	Alaska Black spruce
Swan Lake	167,182.9	57.57	Alaska Black Spruce
Sum:	**476,105.6**		

Table 4 – Largest Fires in 2019 with Unknown/Unreported Vegetation

Fire Name	Acres	Basic Method Fuel Factor	Primary Fuel
Frozen Calf	237,494	0.5	Western Grasses (annual)
Hess Creek	182,908	0.5	Western Grasses (annual)
Bearnose Hill	130,960	0.5	Western Grasses (annual)
Sum:	**551,362**		

Whereas the basic method identifies a singular vegetation type and assigns that fuel factor to represent the entirety of the fire, the LANDFIRE Method breaks the landscape into smaller, more representative fractions, assigning each zone a vegetation type and its corresponding fuel factor. Once the fractional areas, defined as the zones area divided by the total fire area, are found, they are multiplied by the corresponding fuel factor (Appendix Table 2) to find the fuel contribution. This value corresponds with the representative fuel factor for the total fire, which is then multiplied by the original fire acreage to give the total tonnage of vegetation burned. While this method is much more time intensive than the Basic Method, it can be beneficial when dealing with the largest fires because it more accurately represents the fuel loading.

LANDFIRE fuel factors are the average of two basic method fuel factors. For example, the Western North American Boreal spruce-lichen woodland has a fuel factor of 22.13 tons per acre; an average of western grass (0.75 tons per acre) and short needle (43.5 tons per acre). These two averaged fuels are listed as Fuel Factor 1 and Fuel Factor 2 in Appendix Table 2.

The LANDFIRE fuel factors are especially helpful for fires that burn a variety of fuels because the fuel factor more accurately represents the true fuels present on the landscape instead of a blanket designation representing the entire fire.

LANDFIRE fuel factors can differ considerably from the basic method fuel factors as they are generally lower in value. For 2019, one composite fuel factor was developed that covered all of the 19 largest fires. The LANDFIRE 2019 composite value was lower than the basic method values. The 2019 composite fuel factor for the 19 biggest fires used for calculations of emissions from these fires is 21.945. The average fuel factor within that composite reading was 0.348 due to the high number of fires reported that year as grass fires. By comparison, the 2018 composite fuel factor was reported as 36.43, with average fuel factor composite reading being 0.53. This is a difference of 14.485 for two fire years with significant differences in acreage and smoke impacts.

2.3 Temporal Adjustments

The Wildland Fire Emission Template assigns emissions (in tons) to certain months based on a fire's start and end dates to better reflect the period where most emissions occurred. The template averages the calendar start and end dates then assigns the emissions to the month of the averaged date. This may not accurately reflect the time period a fire actually produced the most emissions because fires may not be declared extinguished or 'out' until long after the majority of the active combustion occurred. During 2019, no fires needed to be recalculated in such a way and it is assumed that the averages of the start and out dates were accurate enough for the purposes of this report.

2.4 Prescribed Fires

Two sources provide information on prescribed fires: the AICC dataset and post burn reports submitted to DEC by permittees or organizations that conducted the burns. The AICC dataset and post burn reports recorded 3 prescribed burns totaling 15,204 acres. Two fires were over 40 acres and one was under 40 acres. DEC received three post burn reports applicable to prescribed fires over 40 acres in size. As discussed previously, DNR issues its own permits for large-scale fires over 40 acres. These are not always included in the AICC Database, and could represent a larger fraction of smoke impacts than is presented in this data. The largest prescribed fire was the MID MIPR RX 2019 fire which was 13,646.1 acres (89.7% of the total acreage burned by prescribed fires).

3 EMISSIONS and ACREAGE

3.1 Total Acres and Emissions

During 2019, wild and prescribed fires burned a combined 2,635,260 acres. This is a 596% increase from 2018 (441,781 acres). The 2019 total area burned is 51.16% of 2015 area burned (5,150,673 acres). Figure 2 shows the $PM_{2.5}$ emissions and acreage for both wild and prescribed fires. Wildfires overwhelmingly dominated both acres burned and tons of $PM_{2.5}$ emitted. Total tons of PM2.5 emitted during the 2019 fire year were 189,017 tons, with the majority of those emissions (>99%) coming from wildfires.

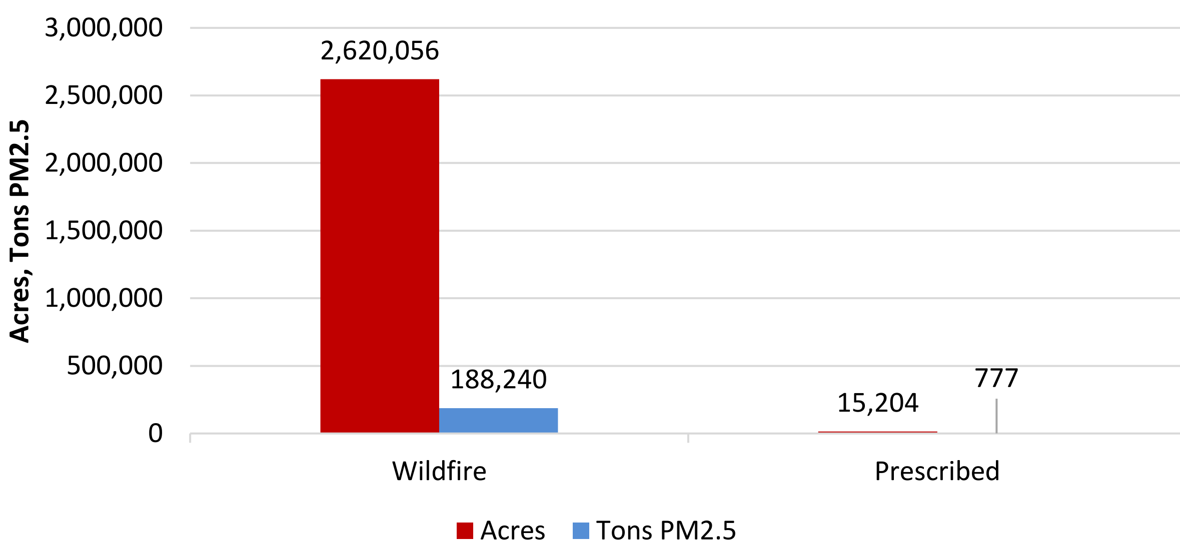


Figure 2 – Wild and Prescribed Area Burned and $PM_{2.5}$ Emissions

Prescribed fires produced proportionally fewer emissions than the wildfires for two main reasons:

- Prescribed fires are intentionally carried out under controlled conditions with the goal of producing fewer emissions.

- All three of this year's prescribed fires were grassland fires, which produce substantially fewer emissions than fires with higher fuel loads (soft or hardwood forests, etc.).

Figures 3 and 4 compare prescribed and wildfire emissions to the area burned over the last decade. Both categories of fire vary widely from year to year. For prescribed fires, the variation depends on need and the agencies' ability to accomplish the fires. Utilizing the right weather conditions plays an important role in agencies' decisions to burn.

The area burned each year by wildfire varies more than the area burned by prescribed fires, historically ranging from under 10,000 to several million acres. In 2019, wildfires burned 2,620,056 acres producing 188,240 tons of $PM_{2.5}$.

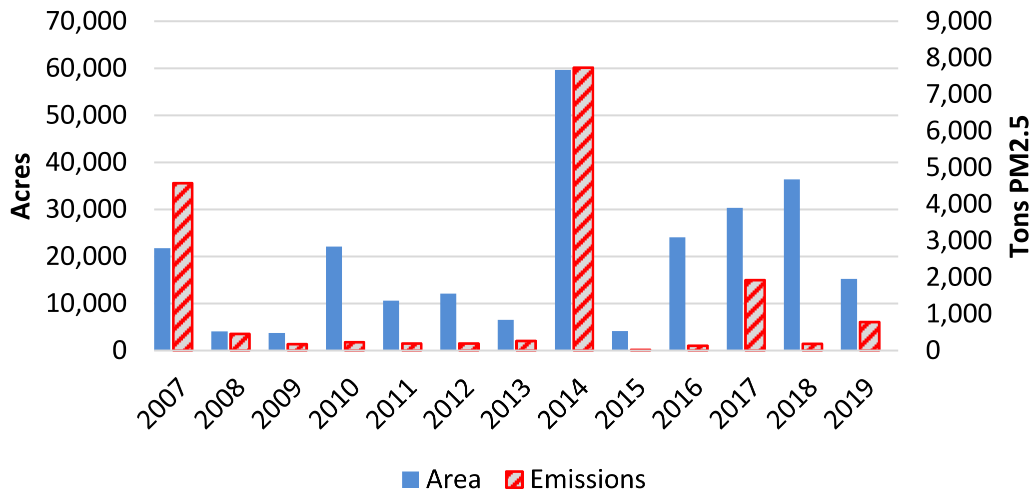


Figure 3 – Prescribed Area and Emissions from 2007 through 2019

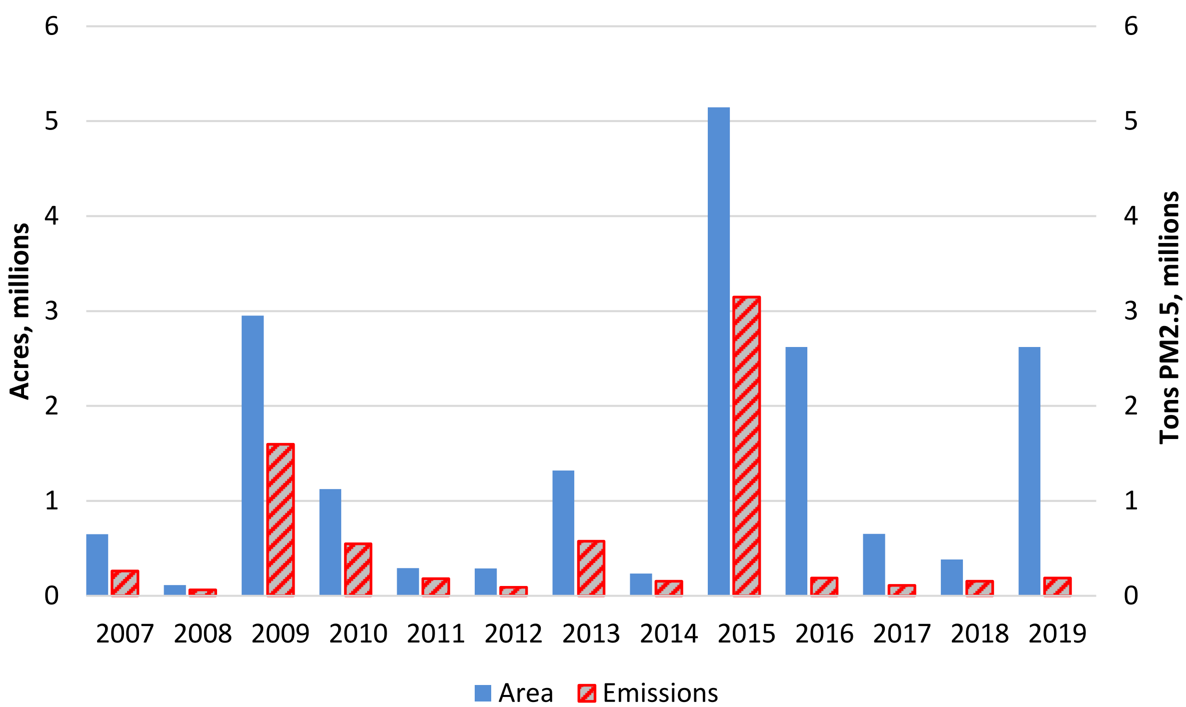


Figure 4 – Wildfire Area and Emissions 2007 through 2019

3.2 Temporal Emissions Distribution

Figure 5, shows the temporal distribution of emissions from both wildfires and prescribed fires. The majority of the prescribed fire emissions occurred in February, with a second spike in emissions in May. The largest fire of the year, the Old Grouch Top, was located in the Southwest Area Fire Area, and burned from June through October. This distributed the emissions from that fire over the summer and fall months.

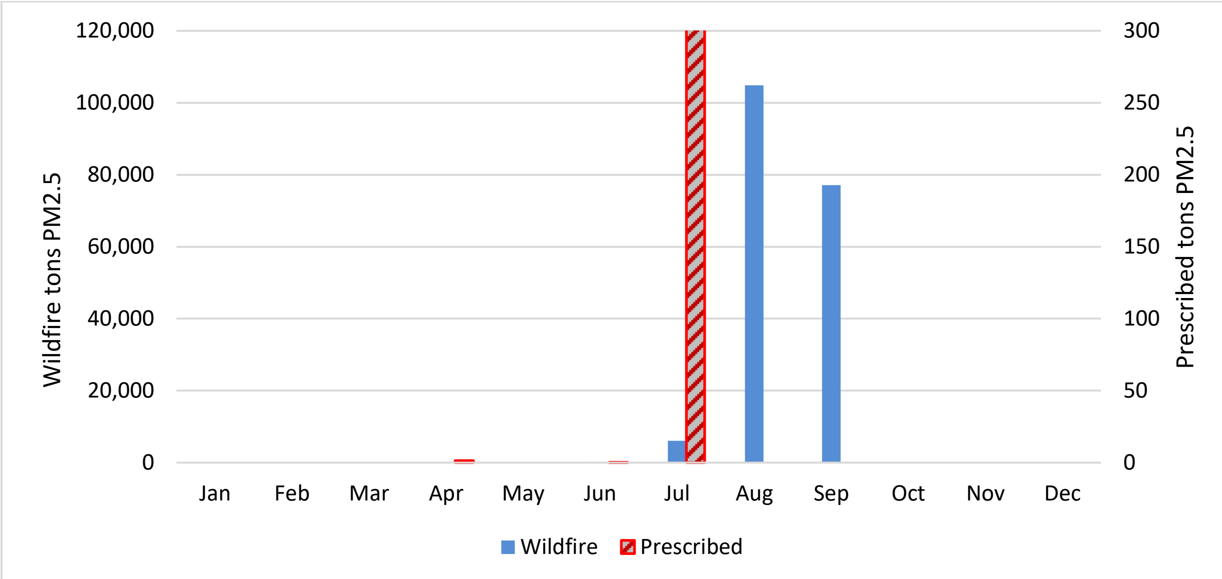


Figure 5 – Wildfire and Prescribed Fire Emissions Temporal Distribution

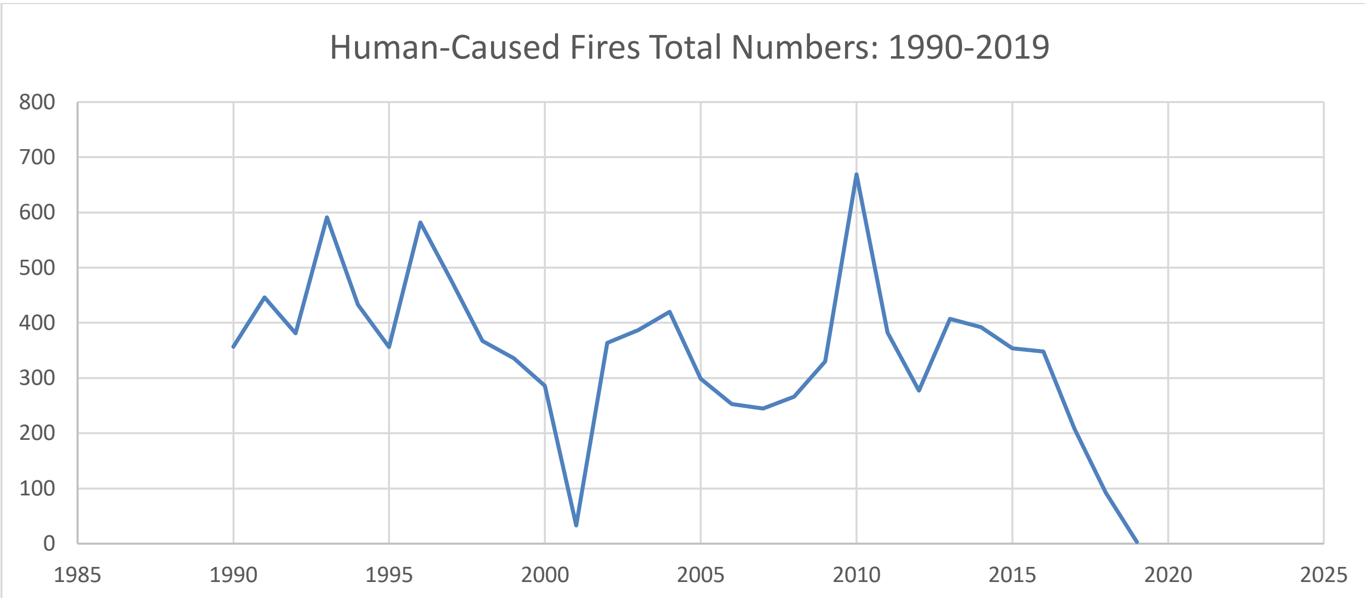
3.3 Emissions by Fire Cause

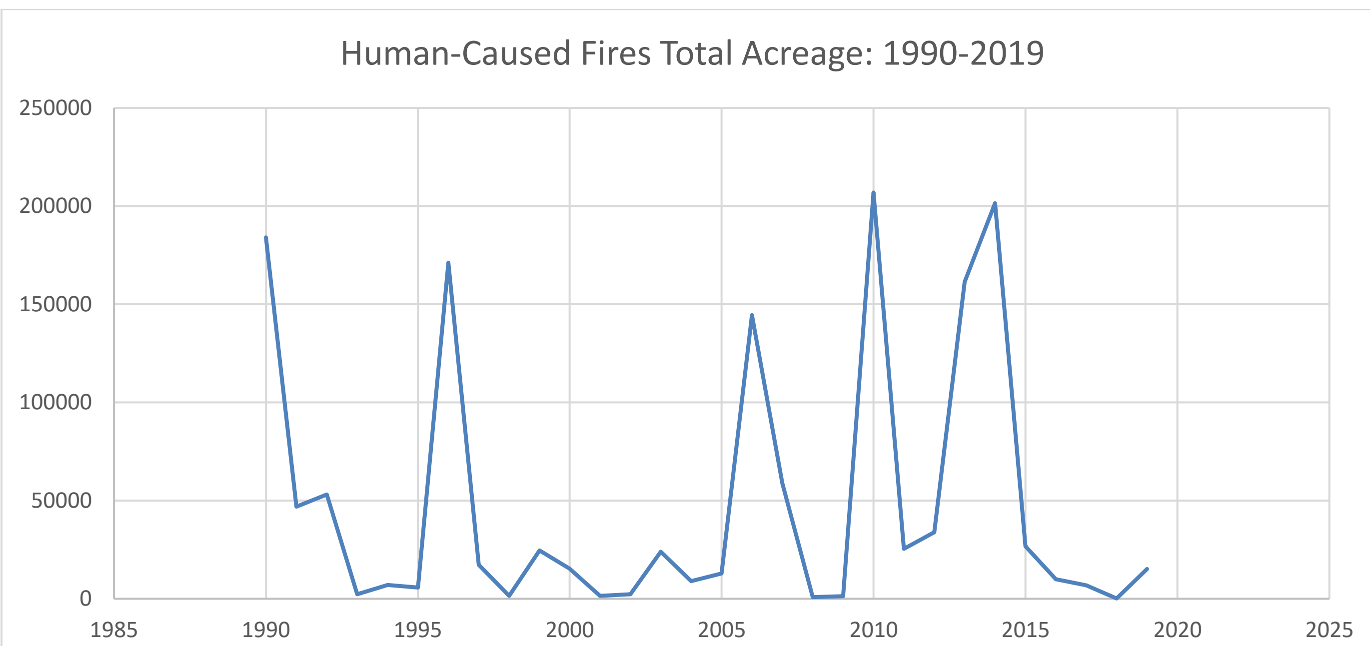
Historically, lightning ignites the majority of fires in Alaska. In 2019, lightning ignited 99.5% of wildfires, as opposed to human activity which started 0.5% of wildfires. Fires ignited by lightning are more likely to start in remote areas, which commonly results in limited suppression response and limited ability to monitor. In 2019, 99% of $PM_{2.5}$ emissions came from fires started by lightning (Figure 6).

Human-caused fires in 2019 burned 15,204 acres and produced 777 tons of PM2.5. By comparison, the largest year for human-caused fires was 2014, with an area of roughly 60,000 acres and 8000 tons of PM2.5 emitted. Human-caused fires remain a small percentage of the yearly fire footprint in the state of Alaska.

Human-caused fires include those fires that become wildfires and necessitate larger-scale responses from fire suppression and land management agencies. As a measure of improvement, DEC keeps track of the number of yearly human-caused wildfires to measure ongoing public outreach and education regarding fire danger. This is one of the primary smoke management techniques DEC has adopted to meet visibility management requirements under federal regulatory requirements.

The number of human caused wildfires shows a continued decline in total fire numbers and acreage; in line with trends since 2017. The overall total number of human-caused wildfires has been on a relative decline over the last decade, with the number of fires spiking to nearly 700 in 2010. Human-caused fire acreage has spiked twice over the last decade, coinciding with the 2010 and 2014 fire seasons. Total acreage in 2019 was roughly 15,000 acres, significantly smaller than previous large fire years.





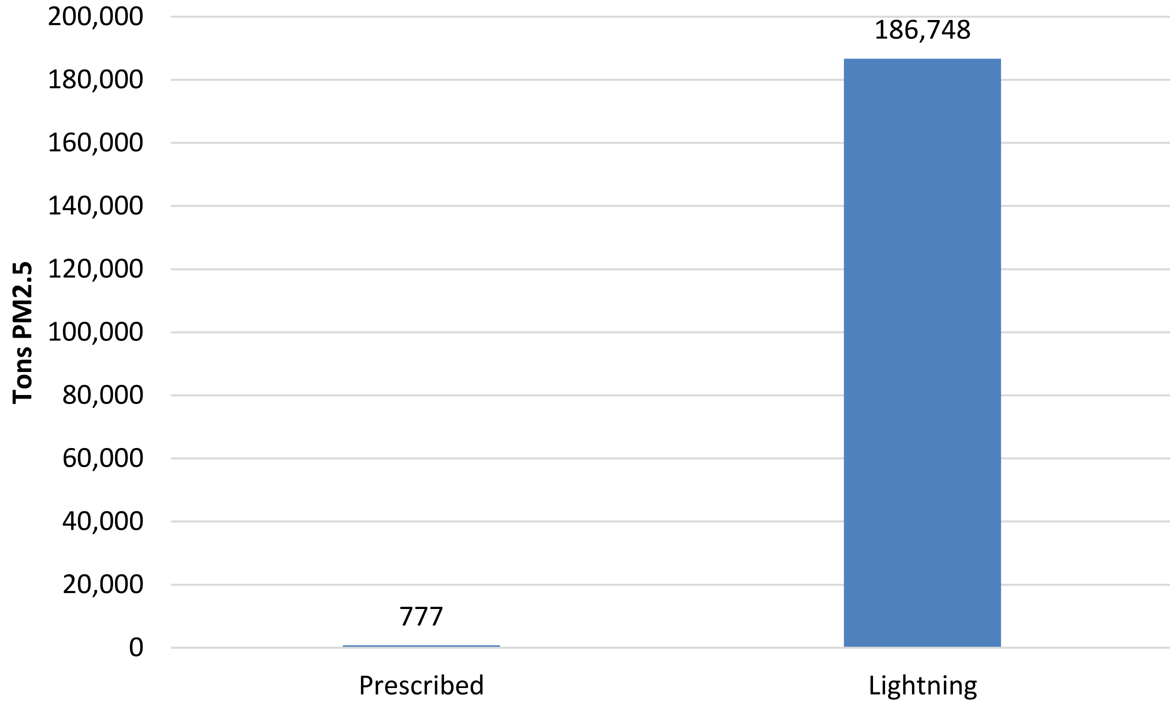


Figure 6 – $PM_{2.5}$ Emissions by Fire Cause

3.4 Emission Reduction Techniques

Emission Reduction Techniques (ERTs) reduce emissions from prescribed fires. Examples include using multiple ignition points, igniting under weather conditions that promote good plume rise, and ensuring that vegetation is dry.

In 2019, the application of ERTs reduced emission of $PM_{2.5}$ by 98% (Figure 7). Without applying ERTs, emissions would have totaled 47,196 tons. With ERTs applied, emissions totaled 777 tons, a reduction of 46,419 tons (98.35%). In addition to reducing emissions, prescribed fires reduce fuel load and create firebreaks, thereby preventing larger uncontrolled fires from occurring.

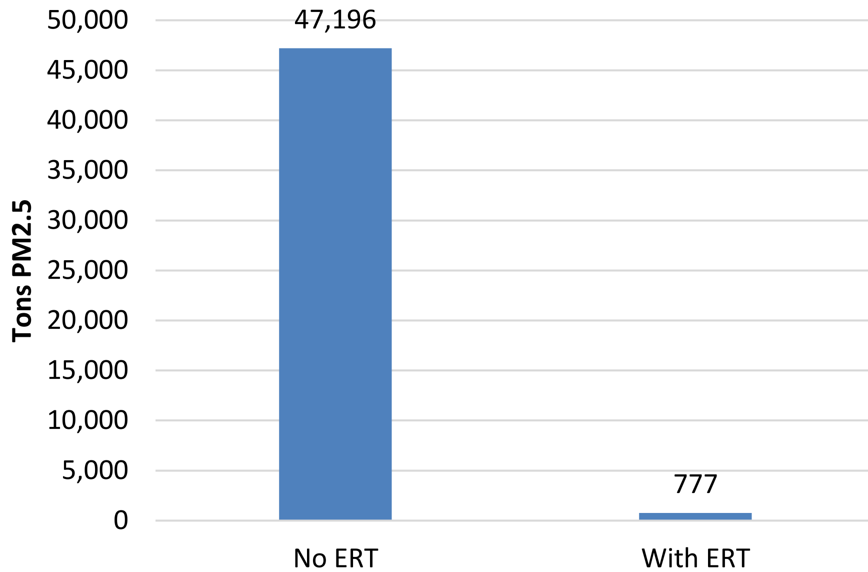


Figure 7 – $PM_{2.5}$ Emission Reductions from Emission Reduction Techniques (ERT)

3.5 All Pollutants

Table 4 and Figure 8 show the quantities of the pollutants inventoried for this report. Figure 8 does not display carbon monoxide because the quantity is so much greater than the other pollutants. Particulate matter, which reduces visibility and contributes to regional haze is of particular importance. $PM_{2.5}$ emitted from flaming comprised 86% of the particulate matter emitted from fires versus smoldering burns. All particulate matter has health effects at high levels but $PM_{2.5}$ is particularly noxious because of its small size and ability to penetrate deep into the lungs, causing respiratory complications and exacerbating bronchoconstriction.

Table 4 – Tons of Pollutants Emitted in 2019

Pollutant	Abbreviation	Tons Emitted
Fine particulate matter	$PM_{2.5}$	189,058
Coarse particulate matter	PM_{10}	189,058
Elemental carbon	EC	14,180
Organic carbon	OC	101,660
Sulfur dioxide	SO_2	40,175
Oxides of nitrogen	NO_X	146,520
Volatile organic compounds	VOC	148,884
Methane	CH_4	181,969
Ammonia	NH_3	11,816
Carbon monoxide	CO	1,755,884

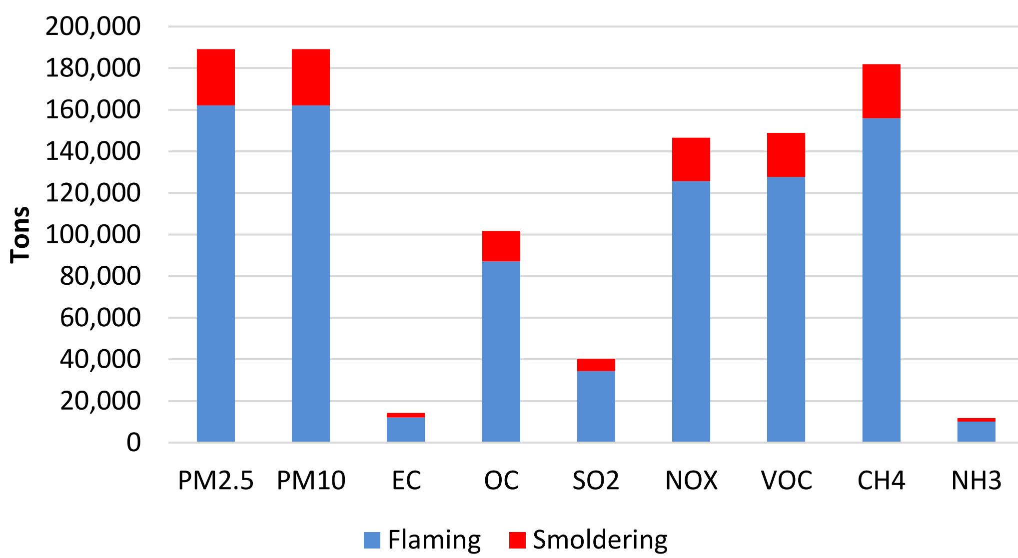


Figure 8 – Tonnage of Pollutants Emitted in 2019

* The tons of CO emitted is not included due to the scale of the graph.

4 AIR QUALITY STANDARDS AND EXCEEDANCES

EPA sets National Ambient Air Quality Standards (NAAQS) for six criteria pollutants to protect human health. As previously stated, $PM_{2.5}$ is the criteria pollutant of primary concern from wildland fires. An exceedance of the $PM_{2.5}$ NAAQS occurs when the 24-hour average concentration, measured in micrograms per cubic meter ($\mu g/m^3$), exceeds 35.4. In Alaska, DEC measures $PM_{2.5}$ in the major population areas and one or two remote locations that can vary from year to year.

Monitors recorded 72 exceedances from 2006 to 2019 caused by wildfire (figure 9). There were 48 exceedances in 2019, some 66% of exceedances recorded since 2006. Of these, 17 occurred in the Fairbanks North Star Borough, 3 occurred in the Matanuska-Susitna Borough, 18 occurred in Anchorage, 2 in Southeast, 5 in Southwest Alaska and the Aleutian Islands, and 3 in Western Alaska. Due to the irregularity of fire locations and the availability of monitoring data, the number of exceedances does not strongly correlate with the intensity of a fire year.

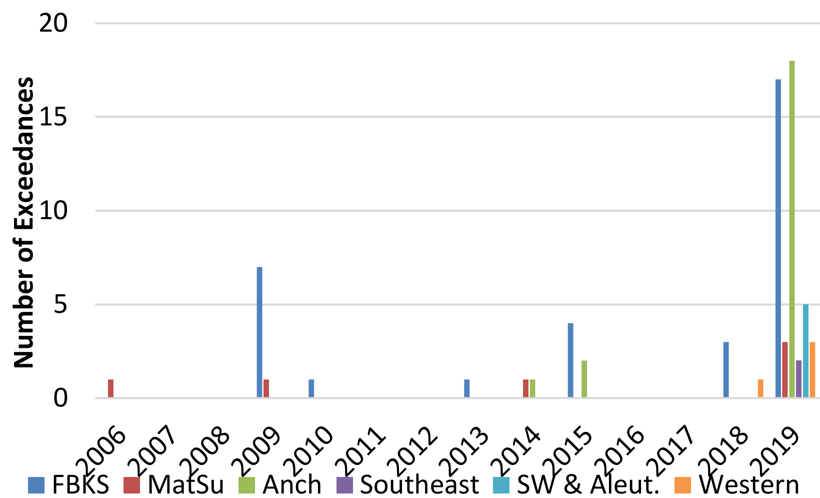


Figure 9 –Exceedances of Air Quality Standards by Area due to Wildfires

To address emissions from natural events DEC prepares exceptional event waiver requests for exceedances recorded as a result of fires. DEC posts exceptional event waiver requests on its website at: http://dec.alaska.gov/air/am/exceptional_events.htm. Exceptional events demonstrations ensure that states are not required to develop a SIP for uncontrollable sources of pollution. When EPA approves an exceptional event demonstration, the data is removed from modeling for programs such as regional haze and from nonattainment or reclassifications determinations.

5 AIR QUALITY ADVISORIES

DEC issues air quality advisories during times of widespread elevated pollution levels, which typically result from wildland fire smoke, windblown dust, volcanic ash, or high levels of wintertime $PM_{2.5}$. Advisories use the Air Quality Index (AQI) to normalize air quality readings across multiple pollutants and issue corresponding cautionary statements (Table 5).

Table 5 – Air Quality Index Levels for $PM_{2.5}$

24-Hour $PM_{2.5}$ Level (µg/m^3)	AQI Score	AQI Category	AQI Cautionary Statement
0.0 to 12.0	0-50	Good	None
12.1 to 35.4	51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
35.5 to 55.4	101-150	Unhealthy for Sensitive Groups	People with respiratory or heart disease, the elderly, and children should limit prolonged exertion.
55.5 to 150.4	151-200	Unhealthy	People with respiratory or heart disease, the elderly, and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
150.5 to 250.4	201-300	Very Unhealthy	People with respiratory or heart disease, the elderly, and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
> 250.5	301-500	Hazardous	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly, and children should remain indoors.

The number of air quality advisories is not necessarily dependent on the acreage burned in a year. Factors such as fire location, duration, intensity, wind direction, and wind speed all play a role in fire behavior and issued air quality advisories (Figure 10). Large fire years are usually accompanied by an increased number of advisories.

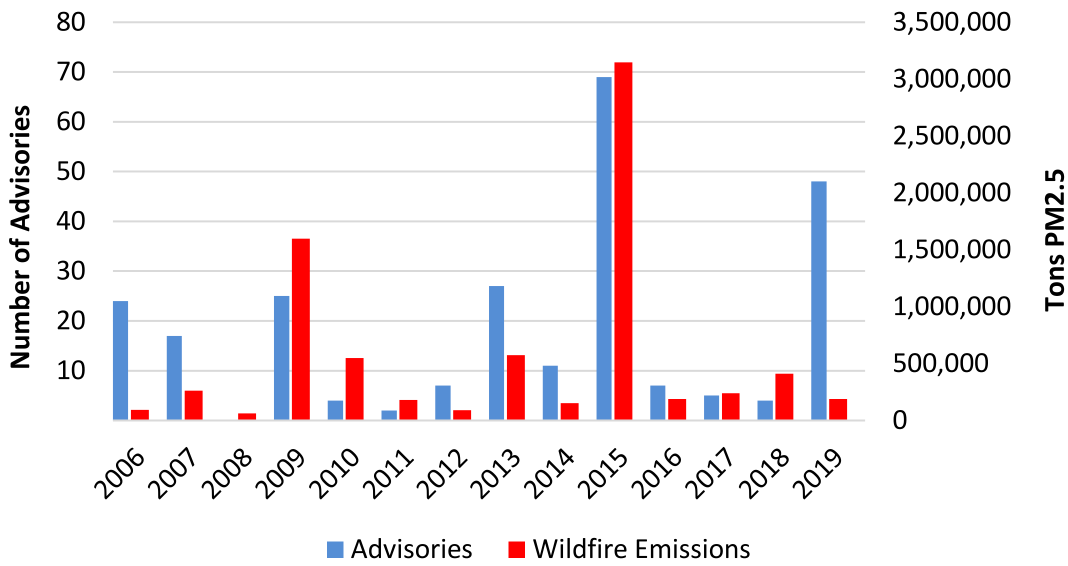


Figure 10 – Air Quality Advisories Issued due to Wildfire Emissions

Figure 11 shows the number of advisories issued by month on an annual basis for wildfires. DEC issued 48 air quality advisories in 2019 covering a total of 119 days. The number of advisories per month were as follows: 3 advisories for April (not included in below graphic); 4 advisories in May, 15 in June, 17 in July, and 10 issued in August. (Figure 11). Because of the widespread fire activity in 2019, many of these advisories were issued in overlapping jurisdictions and periods of time.

In April, three advisories were issued for Southcentral Alaska in the Matanuska-Susitna Borough. In May, four advisories were issued; two were issued for Central and Eastern Interior Alaska and two in Southcentral Alaska. During June, fifteen advisories were issued six in Southcentral Alaska, seven in the Central and Eastern Interior, and two issued in the Western Interior. In July, 17 advisories were issued; four in Southcentral, two in Southeastern Alaska, two in Southwestern and the Aleutians, eight in Central and the Eastern Interior, and one in the Western Interior. Lastly in August, nine advisories were issued; six in Southcentral, and three in Southwestern Alaska and the Aleutians.

Multiple air quality advisories may be issued on the same day for different areas of the State, and advisories span multiple days. All the advisories that DEC or local communities call may be found at:

http://dec.alaska.gov/Applications/Air/airtoolsweb/Advisories

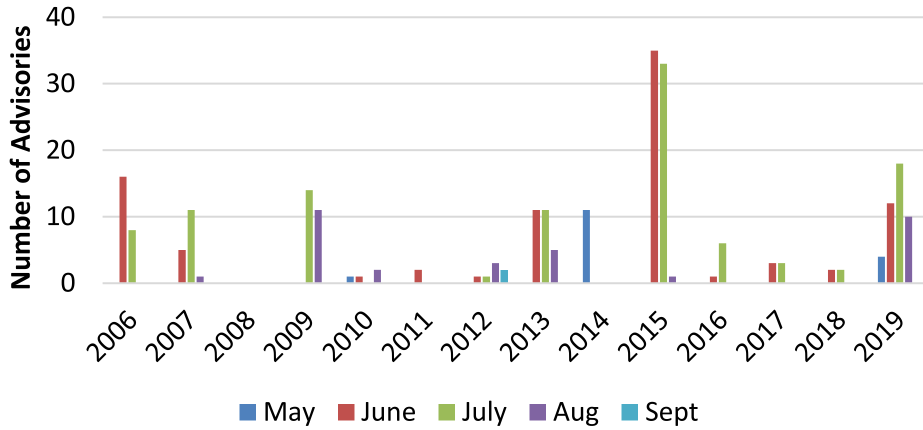


Figure 11 – Number of Air Quality Advisories Issued by Month

Appendix 1 – Vegetation Types and Fuel Factors

Table 1 provides the basic fuel factor name and factor values listed in tons per acre (tpa).

Table 1: Basic Fuel Factor Name and Fuel Factors

Fuel Factor Name	Fuel Factor – tpa
Western grasses (annual)	0.50
Western grasses (perennial)	0.75
Intermediate brush	15.00
Tundra	19.30
Short needle (normal dead)	27.54
Short needle (heavy dead)	43.50
Intermediate slash	33.95
Alaskan black spruce	57.57

Table 2 shows the calculations used to determine the 2019 LANDFIRE fuel factor for the 19 largest fires. As described in Section 2.2, LANDFIRE fuel factors are an average of two Basic Method fuel factors.

$$\frac{\text{Fuel Factor Name 1 value} \times \text{Fuel Factor Name 2 value}}{2} = \text{LANDFIRE Fuel Factor - tpa}$$

Table 2: LANDFIRE Vegetation Types and Fuel Factors

Vegetation Type Name	Fuel Factor Name 1	Fuel Factor Name 2	Fuel Factor -tpa
Barren	None	None	0.00
Boreal Sparsely Vegetated	None	None	0.00
Open Water	None	None	0.00
Snow-Ice	None	None	0.00
Agriculture-Cultivated Crops and Irrigated Agriculture	Western grasses (perennial)	Western grasses (perennial)	0.75
Alaska Arctic Mesic Herbaceous Meadow	Western grasses (perennial)	Western grasses (perennial)	0.75
Alaska Sub-boreal and Maritime Alpine Mesic Herbaceous Meadow	Western grasses (perennial)	Western grasses (perennial)	0.75
Arctic Herbaceous Wetlands	Western grasses (perennial)	Western grasses (perennial)	0.75
Arctic Sedge Meadows	Western grasses (perennial)	Western grasses (perennial)	0.75

Vegetation Type Name	Fuel Factor Name 1	Fuel Factor Name 2	Fuel Factor -tpa
Boreal Aquatic Beds	Western grasses (perennial)	Western grasses (perennial)	0.75
Boreal Herbaceous Wetlands	Western grasses (perennial)	Western grasses (perennial)	0.75
Developed-Low Intensity	Western grasses (perennial)	Western grasses (perennial)	0.75
Developed-Open Space	Western grasses (perennial)	Western grasses (perennial)	0.75
Western North American Boreal Alpine Mesic Herbaceous Meadow	Western grasses (perennial)	Western grasses (perennial)	0.75
Western North American Boreal Dry Grassland	Western grasses (perennial)	Western grasses (perennial)	0.75
Western North American Sub-boreal Mesic Bluejoint Meadow	Western grasses (perennial)	Western grasses (perennial)	0.75
Alaska Arctic Dwarf-Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Alaska Arctic Scrub Birch-Ericaceous Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Alaska Sub-boreal Avalanche Slope Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Alaska Sub-boreal Mesic Subalpine Alder Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Alaskan Pacific Maritime Alpine Dwarf-Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Alaskan Pacific Maritime Subalpine Alder-Salmonberry Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Boreal Dwarf Shrub Wetland	Intermediate brush	Western grasses (perennial)	7.88
Boreal Floodplains	Intermediate brush	Western grasses (perennial)	7.88
Boreal Herbaceous Floodplains	Intermediate brush	Western grasses (perennial)	7.88
Boreal Peatlands	Western grasses (perennial)	Intermediate brush	7.88
Boreal Shrub Floodplains	Intermediate brush	Western grasses (perennial)	7.88
Boreal Shrub Swamp	Intermediate brush	Western grasses (perennial)	7.88
Pacific Maritime Herbaceous Wetlands	Western grasses (perennial)	Intermediate brush	7.88
Pacific Maritime Shrub Floodplains	Western grasses (perennial)	Intermediate brush	7.88

Vegetation Type Name	Fuel Factor Name 1	Fuel Factor Name 2	Fuel Factor -tpa
Western North American Boreal Alpine Dryas Dwarf-Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Western North American Boreal Alpine Dwarf-Shrub Summit	Intermediate brush	Western grasses (perennial)	7.88
Western North American Boreal Alpine Dwarf-Shrub-Lichen Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Western North American Boreal Alpine Ericaceous Dwarf-Shrubland	Intermediate brush	Western grasses (perennial)	7.88
Boreal Riparian Stringer Forest and Shrubland	Intermediate brush	Intermediate brush	15.00
Arctic Peatlands	Tundra	Intermediate brush	17.15
Alaska Arctic Acidic Dwarf-Shrub Lichen Tundra	Tundra	Tundra	19.30
Arctic Floodplains	Tundra	Tundra	19.30
Arctic Shrub-Tussock Tundra	Tundra	Tundra	19.30
Boreal Shrub-Tussock Tundra	Tundra	Tundra	19.30
Boreal Tussock Tundra	Tundra	Tundra	19.30
Western North American Boreal Spruce-Lichen Woodland	Short needle (heavy dead)	Western grasses (perennial)	22.13
Boreal Coniferous Woody Wetland	Alaskan black spruce	Western grasses (perennial)	29.16
Western North American Boreal Mesic Scrub Birch-Willow Shrubland	Short needle (heavy dead)	Intermediate brush	29.25
Western North American Boreal Subalpine Balsam Poplar-Aspen Woodland	Short needle (heavy dead)	Intermediate brush	29.25
Boreal Forested Floodplains	Alaskan black spruce	Intermediate brush	36.29
Boreal Forest-Tussock Tundra	Alaskan black spruce	Tundra	38.44
Recently Burned-Tree Cover	Short needle (heavy dead)	Short needle (heavy dead)	43.50
Western North American Boreal Dry Aspen-Steppe Bluff	Short needle (heavy dead)	Short needle (heavy dead)	43.50
Western North American Boreal Mesic Birch-Aspen Forest	Short needle (heavy dead)	Short needle (heavy dead)	43.50
Alaska Boreal Hardwood Forest	Alaskan black spruce	Alaskan black spruce	57.57

Vegetation Type Name	Fuel Factor Name 1	Fuel Factor Name 2	Fuel Factor -tpa
Alaska Boreal White Spruce Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Boreal White Spruce-Hardwood Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Sub-boreal Hardwood Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Sub-boreal Mountain Hemlock-White Spruce Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Sub-boreal White Spruce Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Sub-boreal White Spruce-Hardwood Forest	Alaskan black spruce	Alaskan black spruce	57.57
Alaska Sub-boreal White-Lutz Spruce Forest and Woodland	Alaskan black spruce	Alaskan black spruce	57.57
Alaskan Pacific Maritime Mountain Hemlock Forest	Alaskan black spruce	Alaskan black spruce	57.57
Boreal Black Spruce-Tussock Woodland	Alaskan black spruce	Alaskan black spruce	57.57
Boreal Coniferous-Deciduous Woody Wetland	Alaskan black spruce	Alaskan black spruce	57.57
Western North American Sub-boreal Mesic Bluejoint Meadow	Alaskan black spruce	Alaskan black spruce	57.57
Western North American Boreal Mesic Black Spruce Forest	Alaskan black spruce	Alaskan black spruce	57.57
Western North American Boreal Treeline White Spruce Woodland	Alaskan black spruce	Alaskan black spruce	57.57
Western North American Boreal White Spruce Forest	Alaskan black spruce	Alaskan black spruce	57.57
Western North American Boreal White Spruce-Hardwood Forest	Alaskan black spruce	Alaskan black spruce	57.57

Table 3: 2019 LANDFIRE Factor Contributions - 19 Largest Fires

Factor Contribution	Fuel Factor	% Veg Type	Vegetation Type Name
5.100702	57.57	8.86%	Western North American Boreal White Spruce Forest
0.466317	57.57	0.81%	Western North American Boreal Treeline White Spruce Woodland
0.272199	22.13	1.23%	Western North American Boreal Spruce-Lichen Woodland
2.412183	57.57	4.19%	Alaska Boreal White Spruce Forest
10.59288	57.57	18.40%	Western North American Boreal Mesic Black Spruce Forest
4.089	43.50	9.40%	Western North American Boreal Mesic Birch-Aspen Forest
0.0087	43.50	0.02%	Western North American Boreal Dry Aspen-Steppe Bluff
0.008775	29.25	0.03%	Western North American Boreal Subalpine Balsam Poplar-Aspen Woodland
0.001576	7.88	0.02%	Alaska Sub-boreal Avalanche Slope Shrubland
0.091408	7.88	1.16%	Alaska Sub-boreal Mesic Subalpine Alder Shrubland
2.418975	29.25	8.27%	Western North American Boreal Mesic Scrub Birch-Willow Shrubland
0.322392	57.57	0.56%	Western North American Sub-boreal Mesic Bluejoint Meadow
0.00375	0.75	0.50%	Western North American Boreal Dry Grassland
0.011032	7.88	0.14%	Western North American Boreal Alpine Dwarf-Shrub Summit
0.00	0.75	0.00%	Western North American Boreal Alpine Mesic Herbaceous Meadow
0.026004	7.88	0.33%	Western North American Boreal Alpine Dryas Dwarf-Shrubland
0.062252	7.88	0.79%	Western North American Boreal Alpine Ericaceous Dwarf-Shrubland
0.010244	7.88	0.13%	Western North American Boreal Alpine Dwarf-Shrub-Lichen Shrubland
0.017336	7.88	0.22%	Alaska Arctic Mesic Alder Shrubland
0.011032	7.88	0.14%	Alaska Arctic Mesic-Wet Willow Shrubland
0.00	43.50	0.00%	Aleutian Kenai Birch-Cottonwood-Poplar Forest
0.005757	57.57	0.01%	Alaskan Pacific Maritime Sitka Spruce Forest
	0.75	0.01%	Alaska Sub-boreal and Maritime Alpine Mesic Herbaceous Meadow
0.000075	57.57	0.01%	Alaskan Pacific Maritime Western Hemlock Forest
0.270579	57.57	0.47%	Alaskan Pacific Maritime Mountain Hemlock Forest
0.00	0.00	0.00%	Alaskan Pacific Maritime Subalpine Mountain Hemlock Woodland
0.00	0.00	0.00%	Alaskan Pacific Maritime Subalpine Alder-Salmonberry Shrubland

0.00	0.00	0.00%	Alaskan Pacific Maritime Alpine Sparse Shrub and Fell-field
0.604485	57.57	1.05%	Alaska Sub-boreal White-Lutz Spruce Forest and Woodland
0.034542	57.57	0.06%	Alaska Sub-boreal Mountain Hemlock-White Spruce Forest
0.731139	57.57	1.27%	Alaska Sub-boreal White Spruce Forest
0.0591	7.88	0.75%	Alaska Arctic Scrub Birch-Ericaceous Shrubland
0.000788	7.88	0.01%	Alaska Arctic Mesic Sedge-Willow Tundra
0.00	0.00	0.00%	Alaska Arctic Acidic Sparse Tundra
0.00193	19.30	0.01%	Alaska Arctic Lichen Tundra
0.00	0.00	0.00%	Alaska Arctic Acidic Dryas Dwarf-Shrubland
0.008668	7.88	0.11%	Alaska Arctic Dwarf-Shrubland
0.02895	19.30	0.15%	Alaska Arctic Acidic Dwarf-Shrub Lichen Tundra
0.00	0.00	0.00%	Alaska Arctic Mesic Herbaceous Meadow
0.00	0.00	0.00%	Aleutian Mesic Alder-Salmonberry Shrubland
0.00	0.00	0.00%	Aleutian Mixed Dwarf-Shrub-Herbaceous Shrubland
0.00	0.00	0.10%	Barren
0.00	0.00	0.16%	Snow-Ice
0.00	0.00	0.90%	Open Water
0.000225	0.75	0.03%	Boreal Aquatic Beds
0.010425	0.75	1.39%	Boreal Herbaceous Wetlands
0.000788	7.88	0.01%	Pacific Maritime Herbaceous Wetlands
0.0003	0.75	0.04%	Arctic Sedge Meadows
0.069084	57.57	0.12%	Alaska Sub-boreal Hardwood Forest
4.802652	29.16	16.47%	Boreal Coniferous Woody Wetland
0.794466	57.57	1.38%	Boreal Coniferous-Deciduous Woody Wetland
0.00	0.00	0.00%	Agriculture-Pasture and Hay
0.07486	7.88	0.95%	Boreal Dwarf Shrub Wetland
0.00	0.00	0.00%	Pacific Maritime Dwarf Shrub Wetland
0.954427	36.29	2.63%	Boreal Forested Floodplains
2.826687	57.57	4.91%	Boreal Black Spruce-Tussock Woodland
0.000225	0.75	0.03%	Developed-Open Space
0.000075	0.75	0.01%	Developed-Low Intensity
0.00	0.00	0.00%	Developed-Medium Intensity
0.05831	17.15	0.34%	Aleutian Shrub Peatlands
0.010296	17.15	0.06%	Arctic Shrub Peatlands
0.174148	7.88	2.21%	Boreal Peatlands
0.024	15.00	0.16%	Boreal Riparian Stringer Forest and Shrubland
0.026004	7.88	0.33%	Boreal Shrub Swamp
0.431775	57.57	0.75%	Alaska Boreal Hardwood Forest
0.639027	57.57	1.11%	Alaska Boreal White Spruce-Hardwood Forest
100%	**21.945**	**Final Fuel Factor (composite)**	