Montana/Idaho Wildfire Carbon Emissions Inventory

Wildfire carbon emissions were calculated for Idaho and Montana for 2013 through 2017. The results are shown in the Table 1 and Figure 1. To allow further context a graph is provided of acres burned over the last 13 years compared to the number of wildfire data flags for the same year (Figure 2). The method used to calculate emissions is provided at the end of this memo.

Table 1 – Montana and Idaho Wildfire Acres Burned and Estimated Emissions. [1]

Parameter	Year	Montana	Idaho
Area Burned (acres)	2013	89,923	752,455
	2014	24,762	232,597
	2015	337,572	793,410
	2016	52,431	231,686
	2017	922,038	512,023
CO_2 Emissions (tons)	2013	2,443,791	10,830,746
	2014	260,911	2,648,319
	2015	8,327,930	13,925,262
	2016	1,033,597	4,907,299
	2017	15,129,539	6,590,812
CO Emissions (tons)	2013	230,116	1,021,286
	2014	17,060	251,012
	2015	825,666	1,369,736
	2016	86,156	403,165
	2017	1,252,740	517,325
$PM_{2.5}$ Emissions (tons)	2013	37,216	165,237
	2014	2,666	40,261
	2015	134,042	222,276
	2016	14,752	68,726
	2017	214,064	86,914
CH_4 Emissions (tons)	2013	11,128	49,651
	2014	754	12,206
	2015	40,291	66,991
	2016	4,660	21,743
	2017	67,669	27,632
Hg Emissions (tons)	2013	0.21	0.93
	2014	0.02	0.23
	2015	0.72	1.21
	2016	0.09	0.41
	2017	1.26	0.55

[1] Data from Missoula Fire Lab Emissions Inventory (MFLEI) - https://www.fs.usda.gov/rds/archive/Product/RDS-2017-0039/%20

Figure 1: Total acres burned per year in Idaho and Montana.

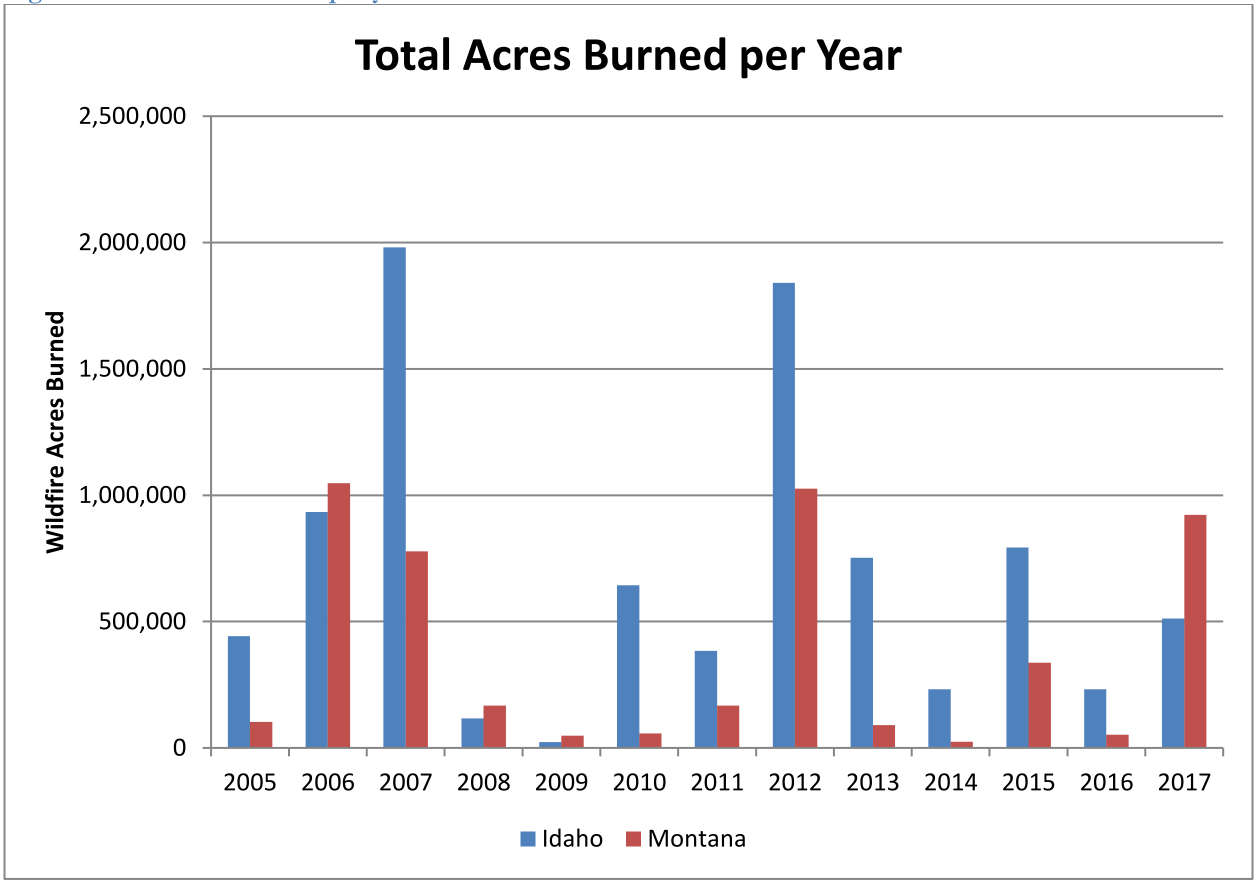
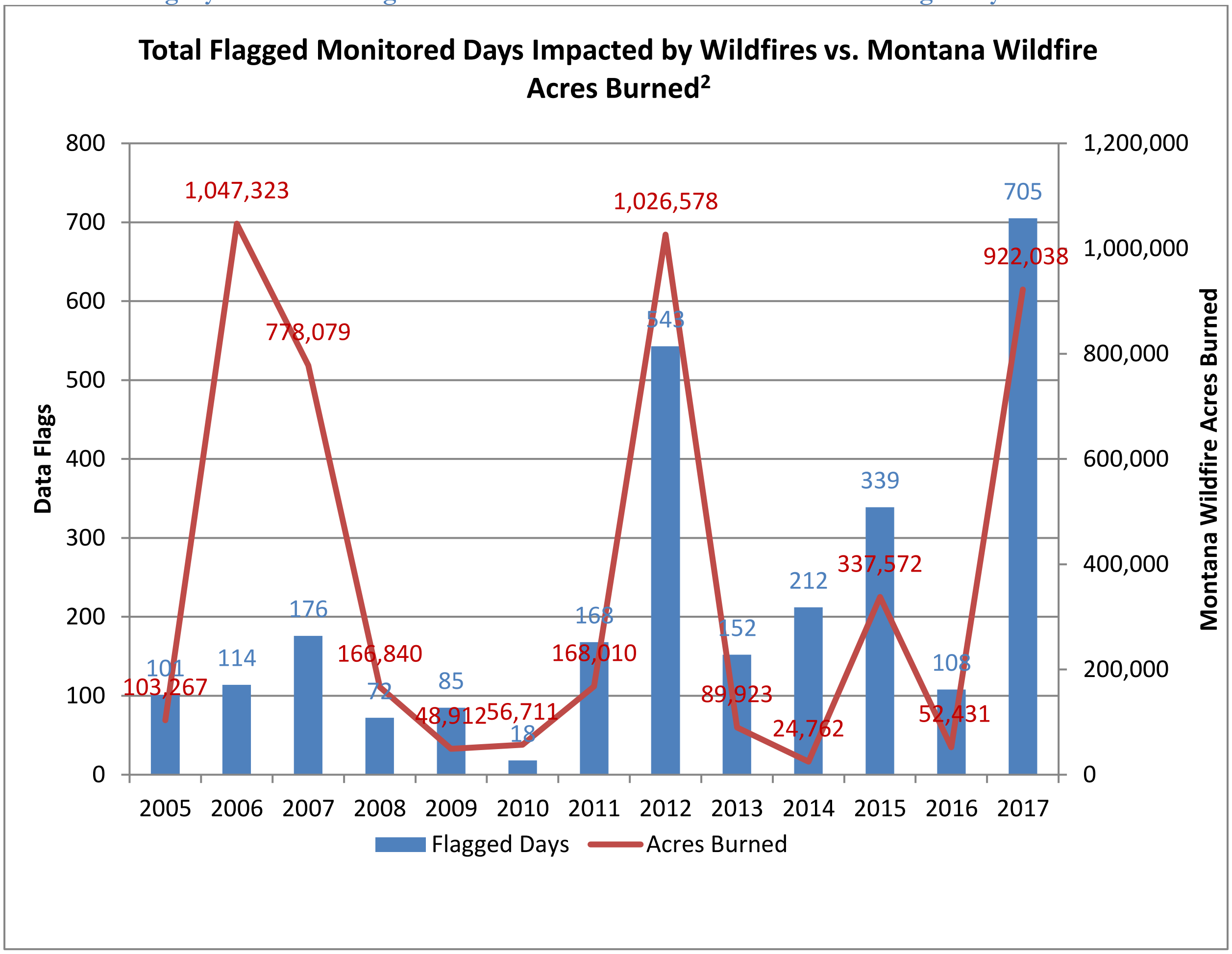


Figure 2: Number of monitored days that were flagged by Montana DEQ staff as having been impacted by wildfires during a year shown along with the number of wildfire acres burned during that year. [2]



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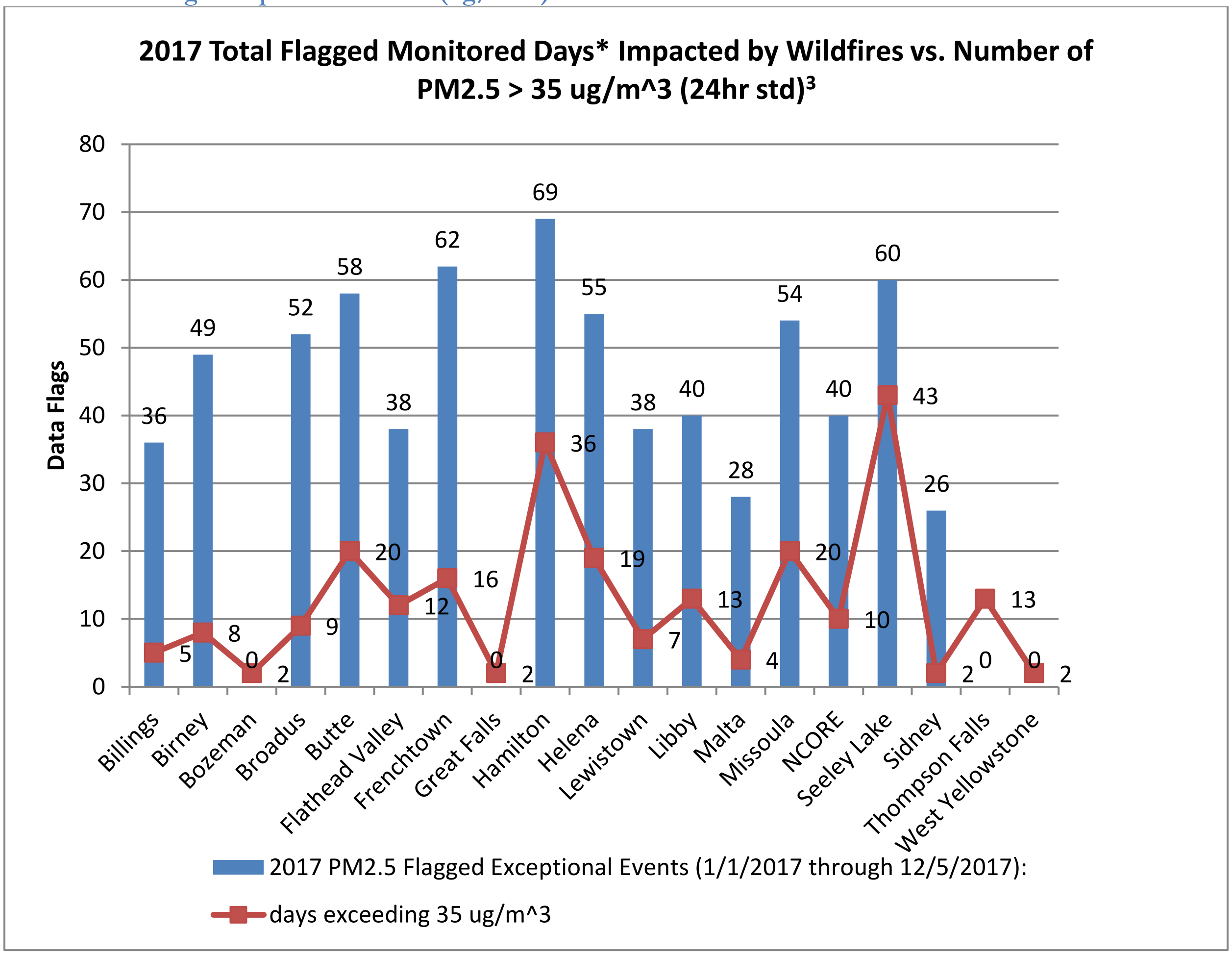
[2] A flagged monitored day could include data from any and/or all monitors which have been noted to be impacted by smoke from wildfires on any given day.

Figure 3: Number of monitored days that were flagged by Montana DEQ staff as having been impacted by wildfires during a year shown along with the number of times that the 24-hour average ambient fine particulate matter ($PM_{2.5}$) concentration exceeded the corresponding National Ambient Air Quality Standard (NAAQS) level of 35 micrograms per cubic meter (ug/m^3). [3]



[3] A flagged monitored day could include data from any and/or all monitors which have been noted to be impacted by smoke from wildfires on any given day.

Year to Date Wildfire Emission Inventory

2013 through 2017 carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$), and mercury (Hg) emission estimates for wildfires in Montana and Idaho have been estimated by Shawn Urbanski, United States Forest Service. This describes the methodology used to derive the emission estimates.

METHODOLOGY

Fire emission of pollutant X (E_X) may be estimated as the product of area burned (A; m^2), fuel load (F; kg-dry vegetation m^{-2}), combustion completeness (C; unitless), and specific emission factor for X (EF_X; [g-compound X] [kg-dry vegetation burned^{-1}]) (Urbanski et al., 2011 and references therein):

$$E_X = A \times F \times C \times 0.001 \times EF_X \qquad (1)$$

Equation (1) was used to estimate annual fire emissions of CO_2, CO, CH_4, $PM_{2.5}$, and Hg from wildfires in Montana and Idaho. The methods and data sources used to estimate E_X are described in the following sections.

AREA BURNED, A

Burned area polygons were compiled using four burned area/fire activity datasets: Monitoring Trends in Burn Severity (MTBS) fire boundaries (https://www.mtbs.gove/direct-download; last access August 18, 2017), the Moderate Resolution Imaging Spectroradiometer (MODIS) active-fire based Direct Broadcast Monthly Burned Area Product, the incident fire perimeters from the Geospatial Multi-Agency Coordination Wildland Fire Support archive (GEOMAC - http://www.geomac.gov/index.shtml) and a spatial wildfire occurrence database (FOD).

FUEL LOAD, F

The fuel load for the area burned was estimated from an overlay of the fire perimeters with vegetation and fuel loading maps. Forest vegetation type and fuel loading was assigned using an expanded version of the Fuels Type Group (FTG) fuel classification system [Keane 2013], which used recently available Forest Inventory and Analysis (FIA - https://www.fia.fs.fed.us/library/database-documentation/index.php) fuels data. The forest surface fuel loading was augmented with fuel loading estimates of understory fuels [Wilson et al., 2013] and canopy fuels, the later which was derived from FIA plot Treelist tables. Rangeland fuels were estimated using the Rangeland Vegetation Simulator (RVS) [Reeves, 2016]. Woody and herbaceous fuel loading was quantified using the inputs from LANDFIRE (https://www.landfire.gov), in addition to using the normalized difference vegetation index (NDVI) from MODIS for herbaceous material.

FUEL CONSUMPTION, C

Fuel consumption for forest surface, understory, shrub and herbaceous fuels was estimated from simulations using the fire effects models CONSUME [Prichard et al., 2006] and First Order Fire Effects Model (FOFEM; http://www.firelab.org/science-applications/fire-fuel/111-fofem) [Lutes, 2016a].

EMISSION FACTORS, EF_X

Emission factors for CO_2, CO, $PM_{2.5}$, and CH_4 used modified combustion efficiency (MCE) values, fire types and emissions factors for western forests [Urbanski 2017]. Emission factor for Hg was based on Wiedinmyer and Friedli (2007) Environ. Sci. Technol., 2007, 41 (23), pp 8092-8098.

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