Montana Department of
ENVIRONMENTAL QUALITY

MEMO

TO: Jim Keane, Chair
Environmental Quality Council

FROM: Eric Merchant, Air Policy and Planning Section Supervisor
Air Resources Management Bureau

DATE: November 19, 2013

SUBJECT: Wildfire Smoke and Air Quality Discussion Materials

Attached for your consideration are materials in support of the discussion involving wildfire smoke and air quality. Questions regarding these materials may be directed to me at 444-1457 or by e-mail at emerchant@mt.gov.

MT DEQ Wildfire Smoke Program

- **Monitoring Current Wildfire Smoke**
- **Forecasting Future Wildfire Smoke**
- **Communicating Information to the Public**

Monitoring - Network of Ambient Samplers

- 13 State Local Air Monitoring Stations (SLAMS) for PM-2.5
- Communities with monitors are those already susceptible to air pollution
- Visibility Ranges by Health Effects Categories

Forecasting - Wildfire Smoke Update

- Daily report / current conditions / communities at risk
- Produced up to seven days per week / 2x per day (morning / afternoon)
- Smoke forecast using MET, Inciweb, satellite imagery, etc. next 12 hours

Communicating – Public and Media Outreach

- Today's Air web site – Dots on the map with associated Health Effects Categories
- Phone calls to DEQ staff from public & stakeholders
- Media contacts including television, radio, and newspaper
- DEQ outreach and coordination with stakeholders, FLMs, county health departments, etc
- Outdoor Sporting Events handout – cooperation with OPI, DPPHS, State Medical Physician
- Always emphasizing coordination with personal physicians / county health officers

Contact

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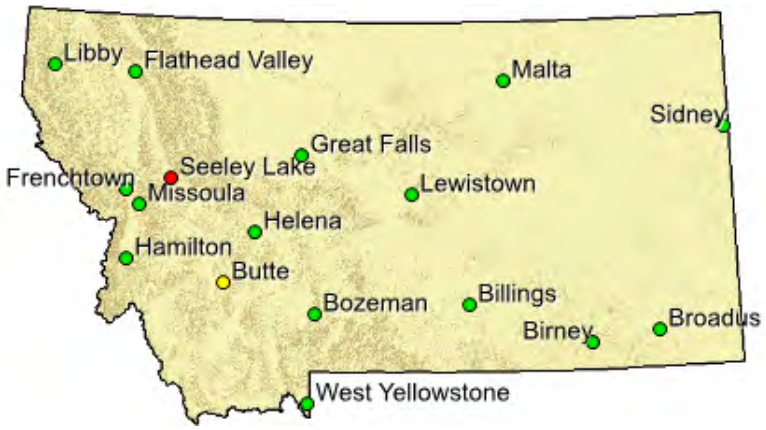
Today's Air



HEALTH EFFECTS CATEGORIES

Air Quality Index (AQI) for BAM-2.5 24-Hour [1]			
Health Effects Categories		**Health Effects**	**Cautionary Statements**
	Hazardous	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in the general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly, and children should remain indoors.
	Very Unhealthy	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant risk of respiratory effects in the general population.	People with respiratory or heart disease, the elderly, and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
	Unhealthy	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in the general population.	People with respiratory or heart disease, the elderly, and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
	Unhealthy for Sensitive Groups	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
	Moderate	Possibility of aggravation of heart or lung disease among persons with cardiopulmonary disease and the elderly.	None

[1] Guideline For Reporting Of Daily Air Quality – Air Quality Index (AQI), EPA-454/R-99-010, July 1999, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 27711.

VISIBILITY RANGES

Health Effects Categories	Visibility Ranges (miles)[3]
Hazardous	< 1.3
Very Unhealthy	2.1 - 1.3
Unhealthy	5.0 - 2.2
Unhealthy for Sensitive Groups	8.7 - 5.1
Moderate	13.3 - 8.8
Good	> 13.4 +

The procedure for making personal observation to determine the forest fire smoke index value for local areas without National Weather Station (NWS) or Department of Environmental Quality (DEQ) monitors is:

1. Face away from the sun.

2. Determine the limit of your visible range by looking for targets at known distances (miles).

3. Visible range is that point at which even high contrast objects totally disappear.

4. Use the values above to determine the local forest fire smoke category.

Air Quality Resources For Wildfire Smoke

Today's Air Website: http://todaysair.mt.gov/

The public may go directly to this website, or may find a link from the DEQ home page. DEQ provides real-time PM2.5 monitoring for thirteen locations across the state. Cumulative PM2.5 exposures are reported as one hour, eight hour, and 24 hour averages.

Wildfire Smoke Update: http://svc.mt.gov/deq/smokereport/mostRecentUpdate.aspx

From the Today's Air web page, the link to the Wildfire Smoke Update home page is at the top-center. From here, one must click on the "Most Recent Smoke Update" link. This web page is updated every day during fire season by the state air quality meteorologist. The page includes a descriptive narrative of current smoke conditions around the state, wildfire activity, and a weather and smoke forecast.

Explanation of health effects categories: http://www.deq.mt.gov/FireUpdates/SmokeCategories.mcpx

Links to this page are provided on the Today's Air home page, the Wildfire Smoke Updates home page, and at the bottom of each Wildfire Smoke Update.

Visibility ranges to determine health effects categories:

http://www.deq.mt.gov/FireUpdates/VisibilityRanges.mcpx

Links to this page are provided on the Wildfire Smoke Updates home page, and at the end of the narrative description in each Wildfire Smoke Update. Using the visibility guidelines is suggested for anyone that does not live near one of the thirteen air monitors. One can determine the range of visibility wherever they are and then associate that visibility range with a health effect category to

better understand the air quality conditions and the general precautions they can use to protect themselves.

Recommendations for outdoor sporting events:

This PDF can be found on the Wildfire Smoke Updates home page. It was produced by Montana DPHHS, in conjunction with DEQ, and provides recommendations for outdoor physical activity under given visibility ranges and air quality health effects categories.

County Air Quality Programs: http://www.deq.mt.gov/AirQuality/coprograms.mcpx

This link can be found on the Today's Air home page. Some counties have their own air quality program, which may provide more specific and localized health-based information in times of poor air quality.

Decision making recommendations during wildfire season for

Outdoor Sporting Events

based on visibility and air quality

Health Effect Category*	Visibility†	Recommendation
Good	13.4 miles and up	Hold outdoor sporting events as usual. Athletes with asthma should keep rescue inhalers at hand. Athletes with other smoke related sensitivities should take precautions as symptoms dictate.
Moderate/ Unhealthy for Sensitive Groups	5.1 to 13.3 miles	Hold outdoor sporting events as usual. Athletes with asthma should have rescue inhalers readily available and pretreat before exercise as directed by their healthcare provider. All athletes with respiratory illness should limit outdoor activity, monitor symptoms and reduce/cease activity if symptoms arise.
Unhealthy	2.2 to 5.0 miles	Consider postponing/delaying outdoor sporting events, especially high exertion activities like soccer and track and field. If possible, move athletic practices indoors. If event/practice is held, athletes with asthma or other respiratory illnesses are advised not to participate. All athletes should limit their outdoor activity for prolonged periods of time.
Very Unhealthy	1.3 to 2.1 miles	Consider postponing/delaying all outdoor sporting events. Move all athletic practices indoors. All athletes with asthma and other respiratory illnesses are advised to stay indoors. All others should avoid prolonged exertion outdoors.
Hazardous	1.3 miles or less	Cancel all outdoor sporting events or relocate to an indoor location. Move all athletic practices indoors.
At all times, athletes experiencing respiratory symptoms should consult their personal healthcare provider		

*For more information on the health effect categories visit the "Today's Air" website run by the Department of Environmental Quality at http://todaysair.mt.gov Air monitoring stations exist in Billings, Bozeman, Butte, Great Falls, Hamilton, Helena, Kalispell, Libby, Missoula, and West Yellowstone. The Today's Air website has hourly updates on the health effect category at these sites based on measured particulate matter levels. All other locations must determine the health effect category at their location based on visibility.

† To determine visibility:
1. Face away from the sun
2. Determine the limit of your visible range by looking for targets at known distances
3. Visible range is that point at which even high contrast objects totally disappear

Use the values above to determine the local forest fire smoke category

MONTANA Department of Public Health & Human Services

For more information contact the State Medical Officer
Steven Helgerson, MD, MPH at shelgerson@mt.gov

http://todaysair.mt.gov

Montana Department of Environmental Quality

OPI

YEAR TO DATE WILDFIRE EMISSION INVENTORY

Year to date (November, 11 2013) pollutant emissions for wildfires in Montana (Table 1) and Idaho (Table 2) have been estimated at the request of Stephen Coe, Senior Planning Engineer, Air Resources Management Bureau, Montana Dept. of Environmental Quality. This document provides the wildfires estimates and describes the methodology used to derive the emission estimates.

Table 1. Montana 2013 Wildfire Emission Estimates (through Nov. 11, 2013)

	Forest	Rangeland	Total	Total
		Area Burned		
		(km^2)		(acre)
	287	6	293	72439
		Fuel Consumed		
		(Gg)		(short ton)
	953.05	1.51	954.56	1052219
		Emissions		
		(Gg)		(short ton)
Pollutant				
Carbon Dioxide (CO2)	1.52E+03	2.54E+00	1.53E+03	1683693
Carbon Monoxide (CO)	1.29E+02	9.49E-02	1.29E+02	141930
Methane (CH4)	6.98E+00	2.92E-03	6.98E+00	7693
Acetylene (C2H2)	2.79E-01	3.62E-04	2.80E-01	308
Ethylene (C2H4)	1.63E+00	1.24E-03	1.63E+00	1798
Propylene (C3H6)	9.15E-01	1.19E-03	9.16E-01	1010
Formaldehyde (HCHO)	2.48E+00	1.10E-03	2.48E+00	2733
Methanol (CH3OH)	2.99E+00	1.78E-03	2.99E+00	3301
Formic Acid (HCOOH)	2.48E-01	3.16E-04	2.48E-01	273
Acetic Acid (CH3COOH)	3.55E+00	5.35E-03	3.55E+00	3914
Phenol (C6H5OH)	9.72E-01	7.83E-04	9.73E-01	1072
Furan (C4H4O)	5.72E-01	2.56E-04	5.72E-01	631
Glycolaldehyde (C2H4O2)	9.82E-01	1.22E-03	9.83E-01	1083
Hydrogen Cyanide (HCN)	7.91E-01	6.18E-04	7.92E-01	873
Ammonia (NH3)	1.81E+00	7.83E-04	1.81E+00	1997
Nitrogen Oxides (NOx as NO)	1.84E+00	5.88E-03	1.85E+00	2034
PM2.5 (fine particulate matter)	2.46E+01	1.08E-02	2.46E+01	27116
Propane (C3H8)	2.51E-01	1.51E-04	2.51E-01	276
n-Butane (C4H10)	7.94E-02	2.41E-05	7.94E-02	88
Isoprene (C5H8)	7.09E-02	5.88E-05	7.10E-02	78
Benzene (C6H6)	5.28E-01	3.01E-04	5.28E-01	582
Toluene (C6H5CH3)	2.33E-01	1.21E-04	2.33E-01	256

Table 2. **Idaho 2013 Wildfire Emission Estimates** (through Nov. 11, 2013)

	Forest	Rangeland	Total	Total
		Area Burned		
		(km^2)		(acre)
	1405	1600	3006	742436
		Fuel Consumed		
		(Gg)		(short ton)
	4448	316	3006	3313341
		Emissions		
		(Gg)		(short ton)
Pollutant				
Carbon Dioxide (CO2)	7.12E+03	5.32E+02	7.65E+03	8432219
Carbon Monoxide (CO)	6.01E+02	1.99E+01	6.20E+02	683895
Methane (CH4)	3.26E+01	6.12E-01	3.32E+01	36569
Acetylene (C2H2)	1.30E+00	7.57E-02	1.38E+00	1520
Ethylene (C2H4)	7.61E+00	2.59E-01	7.87E+00	8670
Propylene (C3H6)	4.27E+00	2.49E-01	4.52E+00	4982
Formaldehyde (HCHO)	1.16E+01	2.30E-01	1.18E+01	13003
Methanol (CH3OH)	1.40E+01	3.72E-01	1.43E+01	15808
Formic Acid (HCOOH)	1.16E+00	6.63E-02	1.22E+00	1348
Acetic Acid (CH3COOH)	1.65E+01	1.12E+00	1.77E+01	19476
Phenol (C6H5OH)	4.54E+00	1.64E-01	4.70E+00	5183
Furan (C4H4O)	2.67E+00	5.37E-02	2.72E+00	3001
Glycolaldehyde (C2H4O2)	4.58E+00	2.56E-01	4.84E+00	5332
Hydrogen Cyanide (HCN)	3.69E+00	1.29E-01	3.82E+00	4213
Ammonia (NH3)	8.45E+00	1.64E-01	8.62E+00	9498
Nitrogen Oxides (NOx as NO)	8.59E+00	1.23E+00	9.82E+00	10821
PM2.5 (fine particulate matter)	1.15E+02	2.26E+00	1.17E+02	129006
Propane (C3H8)	1.17E+00	3.16E-02	1.20E+00	1324
n-Butane (C4H10)	3.71E-01	5.05E-03	3.76E-01	414
Isoprene (C5H8)	3.31E-01	1.23E-02	3.43E-01	378
Benzene (C6H6)	2.46E+00	6.31E-02	2.53E+00	2786
Toluene (C6H5CH3)	1.09E+00	2.52E-02	1.11E+00	1224

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):

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

We used Equation (1) to estimate 2013 year to date fire emissions of 22 pollutants 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

Shape files of incident fire perimeters were used to estimate area burned. Incident perimeters were downloaded through the GEOMAC Wildland Fire Support website (http://www.geomac.gov/index.shtml). Fire perimeters were downloaded on November 7, 2013. This analysis assigned emissions geospatially and as a result the burned area used here differs from that reported in the national fire statistics. The difference is largely due to the ~43,000 acre Gold Pan Complex which burned mostly Idaho but was assigned Montana ownership in the ISC-209 and the National Interagency Fire Center (NIFC) fire static reports.

FUEL LOAD, F

The fuel load for the area burned was estimated from an overlay of the fire perimeters with a USFS Remote Sensing Application Center (RSAC) / Forest Inventory Analysis Program (FIA) map of forest type group (REF) and a rangeland biomass developed by Matt Reeves of the USFS, Rocky Mountain Research Station, Missoula, MT (Reeves, 2013). The RSAC/FIA forest type map (hereafter FTG map) has a resolution of 250 m. Classification accuracy for the FTG map forest/non-forest product is approximately 90 percent. The overall classification accuracy for the forest type group was 65 percent for the western conterminous U.S. (Ruefenacht et al., 2008). Fuel loading for each forest type group was taken from a fuel loading model developed from ~13,000 FIA fuel loading plots (Keane et al., 2013). Rangeland fuel loading is estimated with a Normalized Differenced Vegetation Index (NDVI) based biomass product developed using a large set of field data from the USDA Soil Survey Geographic (SSURGO) database, NDVI from the MODIS sensor on the Terra satellite, and landscape attributes (Reeves, 2013). The NDVI based rangeland biomass product accounts for the inter-annual variability in fine fuel loading which can exceed the decadal mean loading by more than 100%. The FTG fuel loading model provided loadings for litter, duff, and down deadwood by size class (1-hr, 10-hr, 100-hr, 1000-hr). Due to the high uncertainty in estimating canopy fuel consumption without the benefit of post-fire remote sensing and/or ground based observations, we did not consider canopy fuels in our emission inventory estimates.

FUEL CONSUMPTION, C

Fuel consumption was estimated using the First Order Fire Effects Model (FOFEM; http://www.firelab.org/science-applications/fire-fuel/111-fofem). All simulations employed the following fuel moistures: 10-hour = 10%; 1000-hour = 15%; duff = 40%. The FOFEM simulations used FTG and FCCS fuel models as input to estimate the fuel load consumed (kg-dry vegetation m^{-2}), which is F × C in Eq. (1), for each fuel model class.

EMISSION FACTORS, EF_X

Emission factors for 22 pollutants based on EF published in the peer review literature and recent field measurements of EF for wildfires in the interior mountain west. The EF_X used in this emission inventory are provided in Table 3. For non-forest vegetation we used the 'savanna' EF_X reported by

Akagi et al. (2011). Most of the forest EF_X are from recent field measurements of wildfire emissions in Montana and Idaho (Urbanski et al., 2013), or were estimated using the combustion efficiency measured by Urbanski et al. (2013) and EF_X – combustion efficiency relationships reported by Burling et al. (2011). A few of the forest EF_X are from peer reviewed literature, as indicted in Table 3.

Table 3. Emission Factors

Pollutant	Forest EF[1] ($g\ kg^{-1}$)	Non-Forest EF[2] ($g\ kg^{-1}$)
MCE	0.883	0.945
Carbon Dioxide (CO2)	1600	1686
Carbon Monoxide (CO)	135	63
Methane (CH4)	7.32	1.94
Acetylene (C2H2)	0.29[3]	0.24
Ethylene (C2H4)	1.71	0.82
Propylene (C3H6)	0.96	0.79
Formaldehyde (HCHO)	2.6	0.73
Methanol (CH3OH)	3.14	1.18
Formic Acid (HCOOH)	0.26	0.21
Acetic Acid (CH3COOH)	3.72	3.55
Phenol (C6H5OH)	1.02	0.52
Furan (C4H4O)	0.6	0.17
Glycolaldehyde (C2H4O2)	1.03	0.81
Hydrogen Cyanide (HCN)	0.83	0.41
Ammonia (NH3)	1.9	0.52
Nitrogen Oxides (NOx as NO)	1.93	3.9
PM2.5 (fine particulate matter)	25.8	7.17
Propane (C3H8)	0.26[3]	0.1
n-Butane (C4H10)	0.083[3]	0.016
Isoprene (C5H8)	0.074[4]	0.039
Benzene (C6H6)	0.55[4]	0.2
Toluene (C6H5CH3)	0.24[4]	0.08

[1]All Forest EF_X are from Urbanski et al. (2012) unless otherwise noted

[2]All Non-Forest EF are from Akagi et al. (2011)

[3]EF from "Temperate Forest" column of Table 1 in Akagi et al. (2011)

[4]EF from Simpson et al. (2011)

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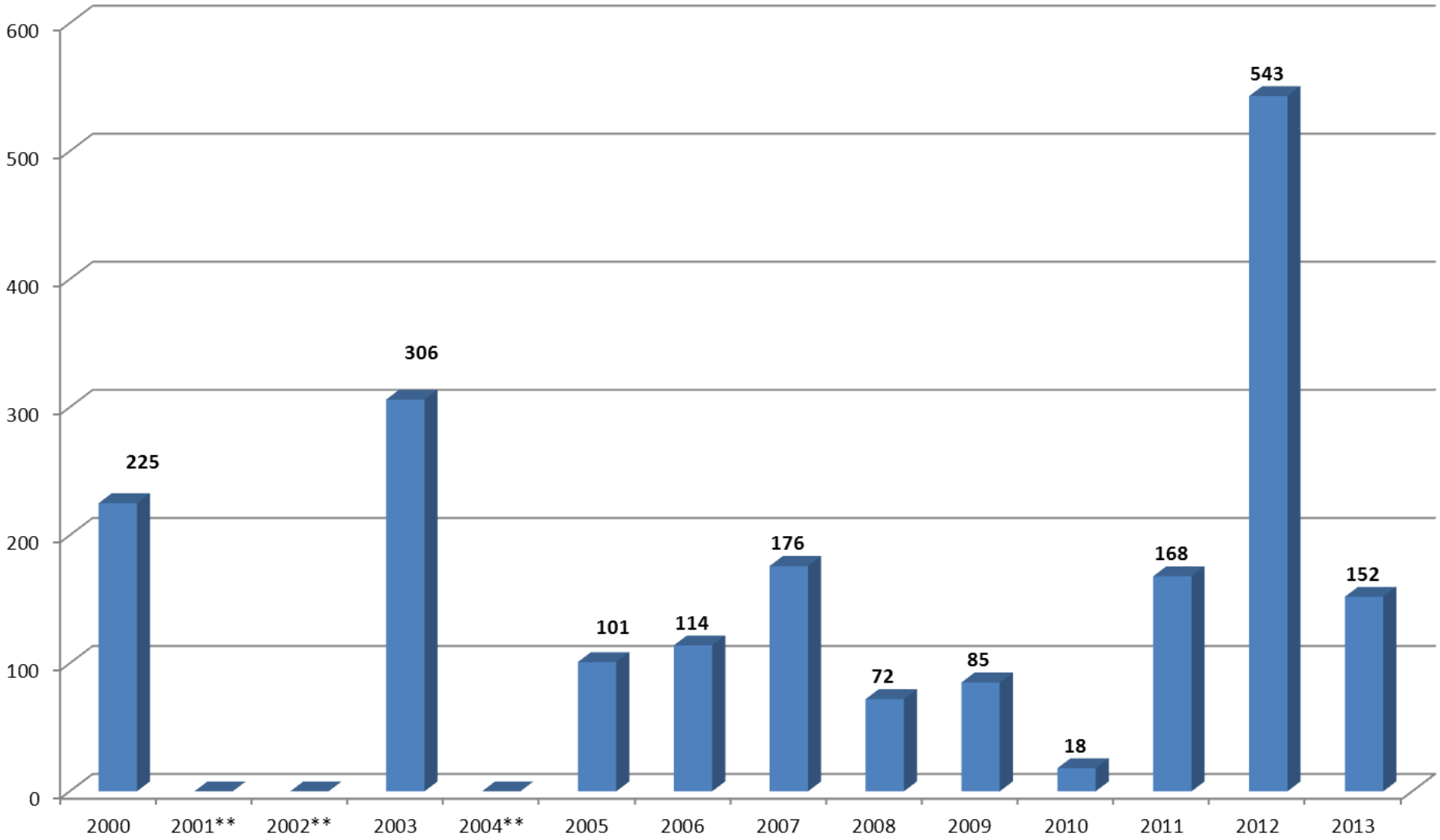
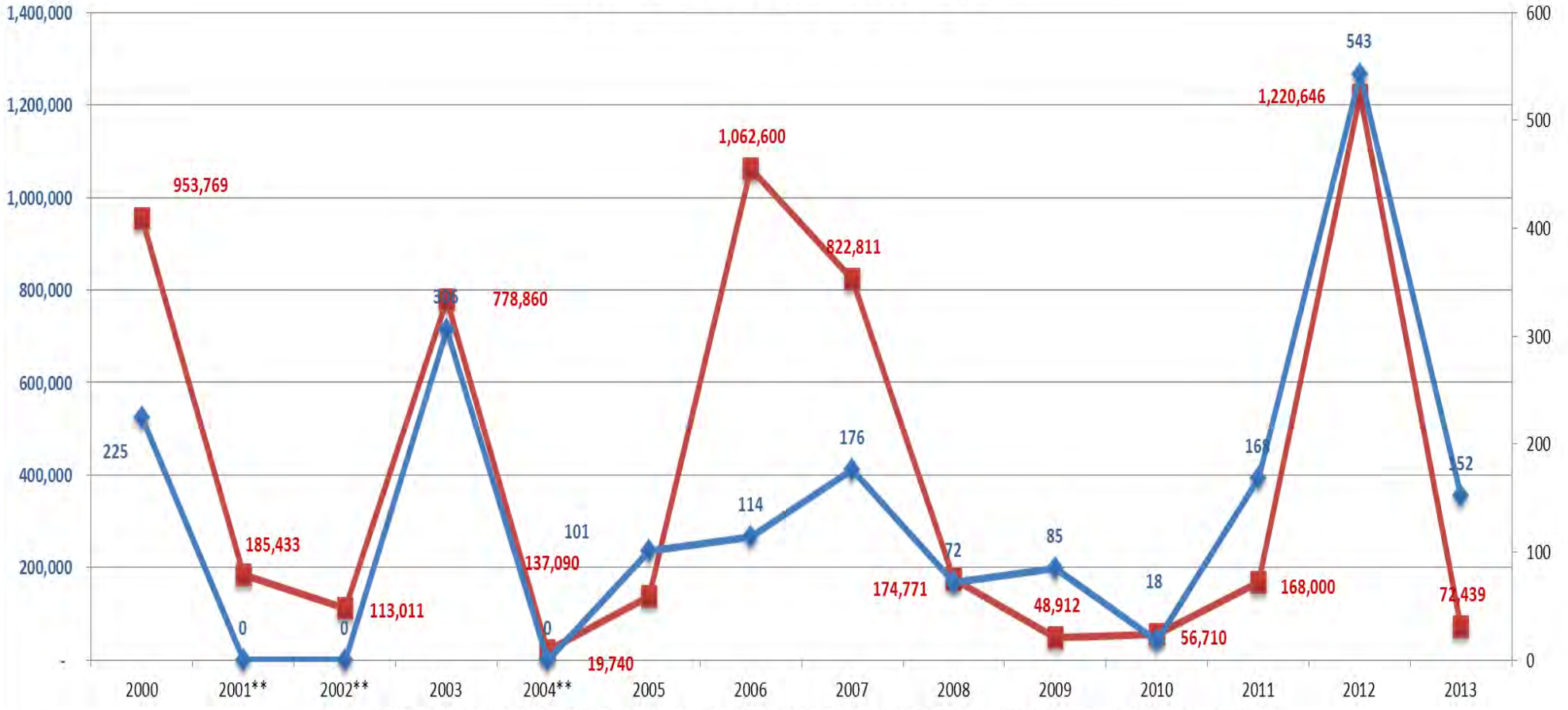
Total Flagged Monitored Days* Impacted by Wildfires



*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.

** 2001, 2002, and 2004 had no data flagged for fires.

Total Flagged Monitored Days* Impacted by Wildfires vs. Montana Wildfire Acres burned



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