

# METHODOLOGY

## METHODS USED TO DEVELOP NRDC'S 2011 U.S. WILDFIRE AND SMOKE MAP AND ASSOCIATED DATA TABLE

Wildfires and smoke in some parts of the United States are projected to increase with future climate change and associated longer, drier summer fire seasons, increasing temperatures, and lower soil moisture.<sup>1</sup> Wildfires and smoke particulate matter can cause serious health problems and worsen chronic respiratory and lung disease, including asthma.<sup>2</sup>

There are three main data components to the Wildfire and Smoke map:

1. Wildfire area extent
2. Smoke condition areas
3. PM<sub>2.5</sub> air monitoring stations

Dense and medium smoke areas were determined using the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS) satellite archive of U.S. smoke. Medium-density smoke is that found in concentrations of approximately 10.5 to 21.5 µg/m<sup>3</sup> (micrograms per cubic meter); high-density smoke is >21.5 µg/m<sup>3</sup>. Regions with more days' duration of persistent smoke are more vulnerable to health hazards posed by wildfire smoke, especially in areas where other sources of air pollution already pose respiratory health risks. The presence of fine particulate matter (PM<sub>2.5</sub>) monitoring stations offers a way to watch the status of air pollution and air quality in a location, and potentially to provide early warning of worsening air quality conditions if wildfire smoke begins to affect local air quality, since PM<sub>2.5</sub> is a key health-harming component of fire smoke.

### 1. WILDFIRE DATA

**Data Source:** Data for wildfire perimeters from 2011 were collected from the Rocky Mountain Geographic Science Center's archive of GeoMAC wildfire data. Wildfire perimeter data are created from incident intelligent sources, GPS data, and infrared and satellite imagery.

**Data Preparation:** Data were assembled in a Structured Query Language (SQL) database. Each record represents a single wildfire. Wildfire polygons were converted to areas affected by wildfires. If multiple perimeters were collected for one wildfire, the final entry was used to obtain the most accurate wildfire perimeter.

### 2. SMOKE DATA

**Data Source:** Data for medium and dense smoke regions was extracted from NOAA's HMS daily archived Geographic Information System (GIS) data from 2008-2011. The HMS smoke data represented the entire vertical air column and

did not distinguish between smoke components at different altitudes, e.g., between smoke higher in the atmosphere versus smoke at ground level. It is reasonable to assume that the denser smoke components remain at lower altitudes, and thus affect atmospheric conditions of the air people are breathing.<sup>3</sup> These data were created by NOAA HMS analysts who manually draw thin, medium, and dense smoke perimeters using Geostationary Operational Environmental Satellite (GOES) data. Smoke areas in this product are manually defined by analysts primarily using several hours of GOES (Geostationary Operational Environmental Satellite) visible channel animations. Plume outlines/edges are most easily determined when there is a sharp contrast between the smoke/no smoke areas. This is usually the case for relatively fresh smoke from active fires but is also dependent on other factors such as vertical wind profiles, atmospheric stability and presence of clouds. Gridded data representing smoke at 500 meters by 500 meters (500m x 500m) horizontal resolution were provided for each day of 2011 for the United States.

#### Smoke data source

Link to smoke data (current as of 7/19/13): [ftp://satepsanone.nesdis.noaa.gov/volcano/FIRE/HMS\\_smoke/](ftp://satepsanone.nesdis.noaa.gov/volcano/FIRE/HMS_smoke/)

#### Useful link describing the HMS smoke

<http://www.ssd.noaa.gov/PS/FIRE/about.html>

**Data Preparation:** Data were assembled in an SQL database. Each smoke table represents an individual day, and records within the table are categorized by thin, medium, and dense smoke. Medium and dense smoke records were extracted from the table and compiled into a single 500m x 500m raster. Individual rasters were tallied by year, resulting in a 500m x 500m raster of the total number of medium/dense smoke days in the United States. Only the 2011 smoke data offered 75% or greater daily data completeness to proceed with a daily smoke condition analysis across the entire year; subsequently 2011 was selected as the year from which to present the corresponding fire perimeter and particulate matter monitoring station data. For smoke years 2008-2011 we calculated the percentage of days for which we had data. Results below:

- 2008: 65.8% complete
- 2009: 0% complete
- 2010: 58.1% complete
- 2011: 99.5% complete

The 500m x 500m grid cells containing smoke data for each day of 2011 were averaged across all the grid cells within each county of each state. Subsequently the values across all the counties of the states were compiled across the whole year, state by state.

### 3. FINE PARTICULATE MATTER MONITORING STATIONS

**Data Source:** Data for PM<sub>2.5</sub> were collected from the EPA's Air Quality System archive from monitoring stations nationwide for 2011.

**Map:** The EPA has a network of monitoring stations where concentrations of fine particles 2.5 micrometers or less in aerodynamic diameter (PM<sub>2.5</sub>) are measured daily (in micrograms per cubic meter). Points indicate the locations where PM<sub>2.5</sub> is monitored by the EPA on at least 50% of days within each quarter of 2011, for which all four quarters of the year were available and the overall average annual completeness was 85% or higher at the station. Only monitors operating on an every-day schedule were mapped.

### STATE POPULATION AND AREA AFFECTED BY FIRE AND SMOKE CONDITIONS, COMPILED FOR THE TABLE ASSOCIATED WITH THE MAP

For Table 1 in the Issue Brief text, states were ranked in descending order based on the population within each state that lived in areas with 7 or more days of medium/high-density smoke conditions in 2011, tallied from the corresponding table columns in Table A1. The Table 1 column "Population in Areas with Smoke Conditions for a Week+ (7-47 days)" arithmetically combines the estimated populations that experienced a High-Range (12-47) number of smoke condition days and a Medium-Range (7-11) number of smoke condition days in 2011, in each state. Those entries are sorted in descending order for the 32 states with one week-or-more of medium/high density smoke conditions (7-47 days); and then sorted in alphabetical order for the remaining 19 states and the District of Columbia.

Table A1 in the Appendix includes:

"Wildfire Area (square miles)" was taken from the 2011 fire perimeter data tally.

In each state, the populations living in areas directly affected by wildfires in 2011 were tallied and totaled for "Population Living in Areas with Fire," applying the fire perimeter data from the 2011 map along with 2010 state-level U.S. census population data. A similar method was applied to estimate the population affected by fire in each county, using 2011 fire perimeter data with 2010 county-level U.S. census population data.

The "Range of Smoke Days" was compiled by listing the minimum and maximum values of medium/high smoke day conditions in 2011, from across the individual smoke data grid cells within the states' counties. The range of values suggests the variety of smoke conditions that occurred within different portions of each state in 2011.

County populations experiencing low, medium, and high

numbers of smoke days were calculated by averaging the grid cell values for numbers of medium- or high-density smoke days in 2011, and assigning the county's population to a corresponding set of smoke conditions, based on four "smoke days" categories (which were based on 2011 quartiles). Quartiles for med/high smoke days in 2011 are as follows:

- 0-2 days: "None" category for "Population Experiencing Smoke Days"
- 3-6 days: "Low" category for "Population Experiencing Smoke Days"
- 7-11 days: "Medium" category for "Population Experiencing Smoke Days"
- 12-47 days: "High" category for "Population Experiencing Smoke Days"

So for example, if within State Z, County A has population=10 and its average number of medium/high-density smoke days in 2011 was 15 days, field "popSMKhigh" is assigned a population of 10. Similarly if County B has population=20 and average number of smoke days=5, field "popSMKlow" is assigned a population of 20. This proceeds for all the counties in State Z until all the counties' smoke conditions, and populations affected, are summed. Population tallies for states were calculated by summing the populations for each category (popSMKlow, popSMKmed, popSMKhigh) for each state.

At the county level, the "Average Number of Medium/High Smoke Days in 2011" is calculated by county.

The "Number of PM<sub>2.5</sub> Monitors" in each state was tallied from the 2011 EPA's Air Quality System information, with the limitations noted above.

The various data categories compiled as supporting data for each state included:

Variable	Description
areaTOTAL	total area in square miles
areaFIRE	wildfire area (square miles), from area of 2011 fire perimeters
popFIRE	population living in areas with fire, applying 2010 population data
rangeSMKday	[State Only] range of smoke days, from minimum & maximum 2011 values in each county for medium/high smoke days
popSMKnone	population (2010) affected by an average of 0-2 medium/high smoke days in 2011
popSMKlow	population (2010) affected by an average of 3-6 medium/high smoke days in 2011
popSMKmed	population (2010) affected by an average of 7-11 medium/high smoke days in 2011
popSMKhigh	population (2010) affected by an average of 12-47 medium/high smoke days in 2011
stnPM25	number of PM <sub>2.5</sub> monitors in state
areaRatio	[National Only] area affected by 12-47 medium/high smoke days vs. the area directly affected by fire

## References

- 1 Dillon, G.K., et al. 2011. Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006. *Ecosphere* 2(12), Article 130, p. 3; Morgan, P., et al. 2008. Multi-season climate synchronized forest fires throughout the 20th century, northern Rockies, USA. *Ecology* 89(3), p. 725; Littell, J.S., et al. 2009. Climate and wildfire area burned in the western U.S. ecoprovinces. *Ecological Applications* 19(4), p. 1019.
- 2 Johnston FH. 2009. Bushfires and human health in a changing environment. *Australian Family Physician* 30(9):720-724.
- 3 Based on consultation with NOAA experts who manage the Hazard Mapping System (HMS) smoke data set.