Wildland Fire Emissions in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009

National Wildfire Coordinating Group (NWCG) Smoke Committee (SmoC)

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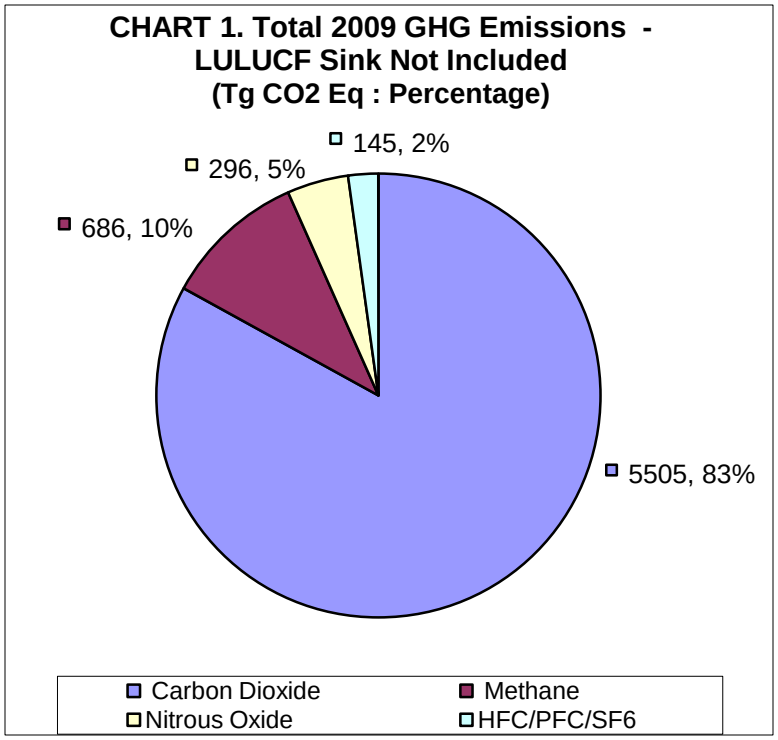
PURPOSE

The purpose of this paper is to provide an overview of how emissions from wildland fires were calculated and reported in the Environmental Protection Agency's (EPA) *Inventory of U.S. Greenhouse Gas Emissions And Sinks: 1990 – 2009*. All information presented below is from the inventory report published April 2011 and available at http://epa.gov/climatechange/emissions/usinventoryreport.html. Detailed explanations of the data and methodologies used for forest fire emissions calculations are contained in Chapter 7 and Annex 3 of the EPA inventory. To be consistent with the GHG report terminology, when the term "forest fires" is used in this paper, it represents wildfire and prescribed fire summed together.

BACKGROUND

Each year, the Environmental Protection Agency (EPA) publishes its Inventory of U.S. Greenhouse Gas Emissions and Sinks. Annually, the emission and sink estimates are calculated and revised for all years in the inventory using methodologies consistent with guidelines approved by the Intergovernmental Panel on Climate Change (IPCC). The current draft report covers anthropogenic emission estimates by source from 1990 through 2009. In the context of the report, anthropogenic emissions are those resulting from direct human activities or from natural processes that have been affected by human activities. In its working group special report on Land Use, Land Use Change, Forestry (LULUCF), the IPCC (2000) discusses natural versus human-induced stock changes and managed versus unmanaged forests. While they recommend that unmanaged forests be excluded from accounting frameworks, they recognize the great difficulty in doing so. For the purposes of this emission inventory, the EPA chose to designate the entire land area of the U.S. lower 48 states as "managed", thus all disturbances such as fire and pests are included in this anthropogenic emission inventory.

The inventory focuses on anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and three potent fluorine-containing greenhouse gases --- hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). Using the IPCC established global warming potentials for each gas and setting carbon dioxide as the reference GHG, the emissions are reported as teragrams (1 Tg = 1 million metric tons) of carbon dioxide equivalent (Tg CO_2 Eq). In 2009, total U.S.anthropogenic GHGs were estimated at 6633 Tg CO_2 Eq; 83% are CO_2, 10% are CH_4, 5% are N_2O, and the remaining 2% are HFC/PFC/SF_6 (see Chart 1).



Contact: Pete Lahm, SmoC Chair, US Forest Service // 202-205-1084 // plahm@fs.fed.us, pete.lahm@gmail.com

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METHODOLOGY OF CALCULATING FOREST FIRE EMISSIONS

Carbon dioxide, methane, and nitrous oxide emissions from forest fires were calculated and reported as part of the "Land Use, Land-Use Change, Forestry" (LULUCF) source . The LULUCF inventory sector covers greenhouse gas emissions and removals from activities and disturbances on forest lands, croplands, grasslands, wetlands, settlements, and other lands. The LULUCF estimate is based on the net annual changes in carbon stocks, which accounts for the amount carbon sequestered minus any carbon losses or emissions resulting from disturbances (e.g., forest fires, pests, etc).

It is very important to remember that emissions of CO_2 from forest fires are already accounted for in the LULUCF estimates. However, because of the interest in quantifying the magnitude of CO_2 emissions from forest fires emissions, EPA highlights that information in Chapter 7 and Annex 3 of the report. The 2009 calculations separated wildfire and prescribed fire for CO_2 emissions only; emissions for CH_4 and N_2O were calculated for forest fires as a whole. Also, wildfire calculations were completed separately for the lower 48 and Alaska; prescribed fire calculations were done only for the lower 48.

The primary data sources for the wildfire and prescribed fire estimates were the USDA Forest Service Forest Inventory Analysis (FIA), the National Interagency Fire Center (NIFC) wildland fire statistics, and the National Association of State Foresters (NASF). Personal communications with USDA Research Foresters at the Northern Research Station's Forest Carbon Dynamics program were referenced also. The complete list of references used in the fire emissions are listed in Chapter 11 of the inventory report (pages 11-41 through 11-46).

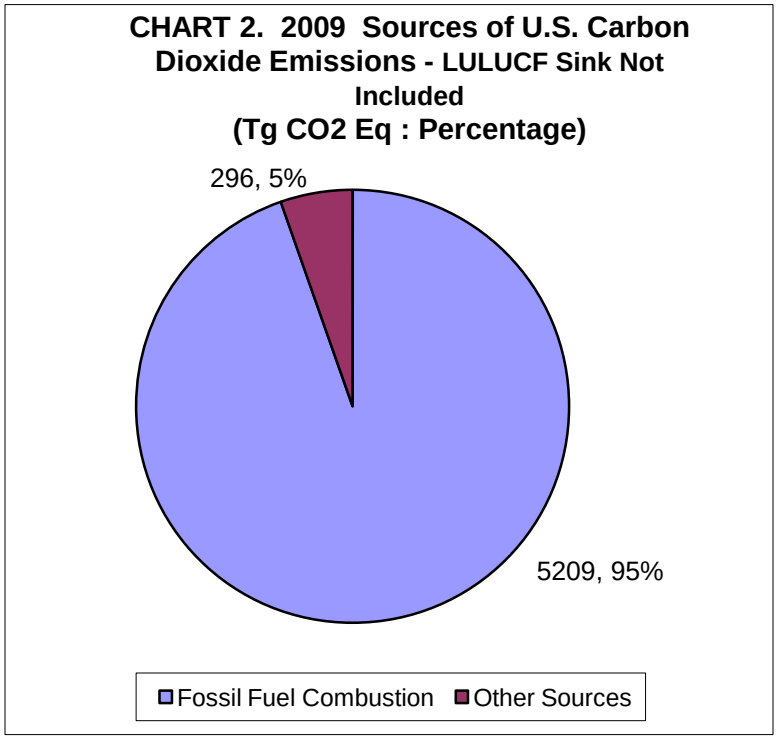
Areas reported as burned by forest fires include non-forest land such as shrublands and grasslands. In order to get emission estimates specifically from forest fires, a rudimentary estimate of the percent of forest land burned was calculated (forest land is defined as $\geq$ 10% stocked with trees). This estimate was developed by multiplying the reported area burned by a ratio of total forest land area to the total area considered to be under protection from fire. The FIA and NASF data served as the primary sources for calculating the ratio. Reported area burned from the NIFC database was then multiplied by the ratio to develop an estimate of forest burned for the lower 48 states. In Alaska, the reported area burned by wildfire was obtained from the Alaska Department of Natural Resources.

To get the estimate of carbon dioxide emissions from forest fires, the average carbon density for above ground biomass was estimated from FIA data. This carbon density was determined to be 91 megagrams per hectare (Mg/ha) for the lower 48 states and 179 Mg/ha for Alaska. For prescribed fire, the carbon density was 30 Mg/ha (based on data from the USDA Forest Service Research). Note that these densities would equate to 40 tons per acre, 80 tons per acre, and 13 tons per acre, respectively.

These carbon densities were then multiplied by a combustion factor value (0.45) to get the emission factor for wildfire and prescribed fire. For wildfire, 41.0 megagrams of carbon per hectare (Mg C/ha) are emitted in the lower 48 and 80.6 Mg C/ha in Alaska (18 tons/acre and 36 tons/acre, respectively). For prescribed fire, the calculated emissions are 13.5 Mg C/ha (6 tons/acre). These factors were then multiplied by the calculated forest area burned to get the CO_2 emissions per year for wildfire and prescribed fire. Table A-228 in Annex 3 (page A-284) of the report displays the results of acreage reported, area burned, carbon emitted, and carbon dioxide emitted.

SUMMARY OF FOREST FIRE CARBON DIOXIDE EMISSIONS

Total CO_2 emissions in 2009 (not including the LULUCF sink) were estimated to be 5505 Tg CO_2 Eq. (rounded to nearest whole number). As illustrated in Chart 2, fossil fuel combustion accounted for 95% (5209 Tg CO_2 Eq) of the 2009 CO_2 emissions. The five major consuming sectors of fossil fuel combustion are electricity generation, transportation, industrial, commercial, and residential. Globally, approximately 30,313 Tg CO_2 Eq were added to the atmosphere through the combustion of fossil fuels in 2009, of which the U.S. accounted for about 18 percent.



For the LULUCF sector, removal of atmospheric CO_2 through sequestration is greater than CO_2 emissions through events such as forest harvests, land conversions, fires, or other uses. The overall LULUCF result is a net sequestration (i.e., a sink), of 1015 Tg CO_2 Eq. As noted in the EPA GHG inventory, this sink represents an offset of approximately 18% of total U.S. CO_2 emissions.

For 2009, an estimated 127 Tg of CO_2 were emitted from forest fires in the U.S. This total is broken down as follows: 99 Tg from wildfire and 28 Tg from prescribed fire in the lower 48 states (emissions from Alaska were less than 0.05 Tg and not included in the totals). Remember, these fire emissions are captured already in the LULUCF totals. Fire is a natural ecosystem process and post-fire effects can include enhanced CO_2 uptake, soil respiration, and above-ground and below-ground biomass growth. Therefore, even though fire releases CO_2 into the atmosphere, our forests continue to be a net sink of CO_2.

Contact: Pete Lahm, SmoC Chair, US Forest Service // 202-205-1084 // plahm@fs.fed.us, pete.lahm@gmail.com
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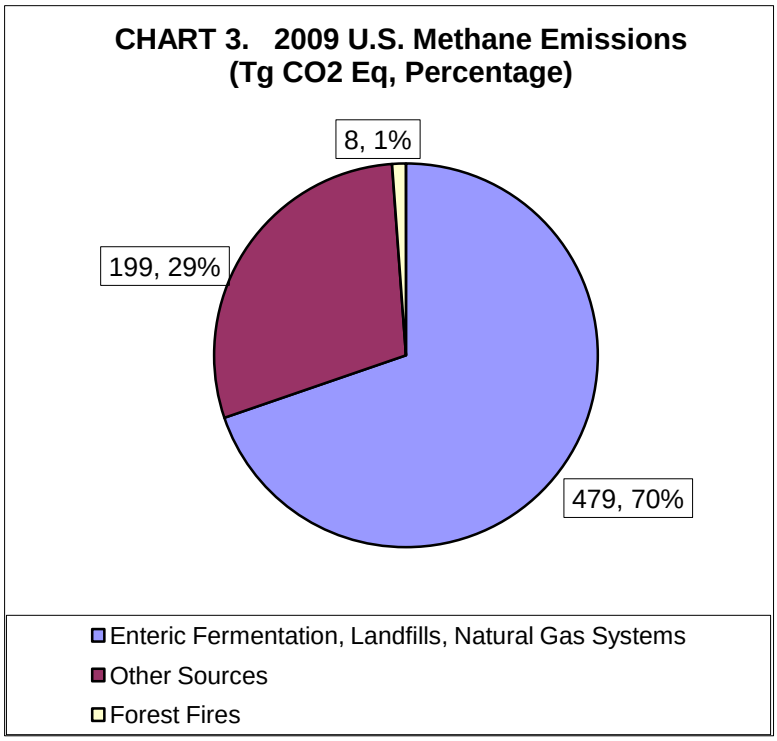
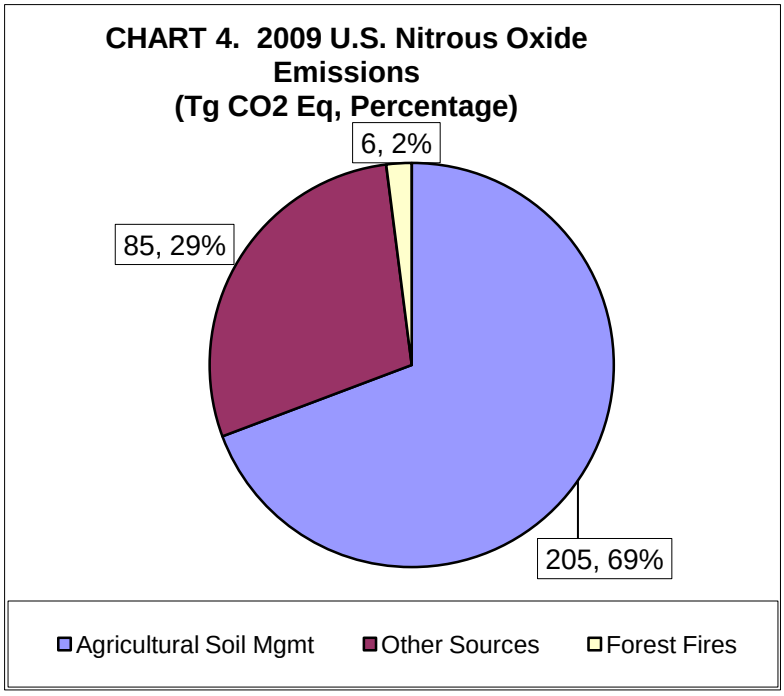
SUMMARY OF FOREST FIRE METHANE EMISSIONS

Total CH_4 emissions in 2009 were estimated at 686 Tg CO_2 Eq (includes the LULUCF source). As illustrated in Chart 3, the largest portion of this GHG (64%) is produced by enteric fermentation (ruminant animal digestion), landfills, and natural gas systems. Methane from forest fires amount to about 1% (8 Tg CO_2 Eq) of the total. Other sources include coal mining, manure management, wastewater treatment, and others. Forest fire methane emissions were calculated by multiplying the total estimated carbon emitted from burned forests by gas-specific emission ratios and conversion factors (IPCC 2003 and 2006 default factors).



SUMMARY OF FOREST FIRE NITROUS OXIDE EMISSIONS

For N_2O, forest fires amount to about 2% of the total nitrous oxide emissions (6 Tg CO_2 Eq). Agricultural soil management accounts for the largest portion (see Chart 4). N_2O emissions from forest fires were calculated in the same manner as methane, but were multiplied also by a nitrogen-carbon ratio of 0.01 as recommended by the IPCC (2003). Other sources of N_2O include nitric acid production, manure management, mobile combustion, and others.



AGRICULTURAL AND GRASSLAND BURNING

As in forest fires, management activities related to agriculture and grasslands were included in the LULUCF source category for carbon dioxide emissions. No specific information could be found in the report showing specific estimates for CO_2 emissions from fires on either of these types of land. For, methane and nitrous oxide emissions, only "field burning of

Contact: Pete Lahm, SmoC Chair, US Forest Service // 202-205-1084 // plahm@fs.fed.us, pete.lahm@gmail.com

agricultural residues" were estimated (0.2 and 0.1 Tg CO_2 Eq., respectively) (refer to page A-19 of Annex 1).

ISSUES and QUESTIONS

1. **Accuracy of Wildland Fire Acres Burned and Resulting Emissions.** As noted in EPA's GHG Inventory Report (Annex 3, A-283), there is interest in the size of the CO_2 emissions from disturbances such as forest fires. However, Table A-228 shows that EPA accounts for only 50-percent of the wildfire acres. Specifically, the National Interagency Fire Center (NIFC) reported 5,921,786 acres; EPA included only 2,970,197 acres in its calculations (EPA did not account for the 2,951,597 acres of wildfire in Alaska). In terms of prescribed fire, EPA used the NIFC data (2,531,115 acres). The lack of consistent reporting of prescribed burn acres across the U.S. has been a widely recognized problem. Given these problems, the data reported through NIFC is too low by $^{\pm}$6 million acres. These shortfalls in EPA's estimates of burn acres result in under reporting of GHG emissions by wildland fires. Rough calculations show that including the Alaska wildfires acreage and the additional 6 million acres of prescribed fire would triple the reported CO_2 emissions from forest fires.

2. **Lack of Emissions from Rangeland/Shrubland Prescribed Burning.** Per the EPA GHG Inventory Report (Chapter 7, p. 7-7), "grasslands on federal lands are included in the managed land base, but C stock changes are not estimated on these lands. Federal grassland areas have been assumed to have negligible changes in C due to limited land use and management change, but planned improvements are underway to further investigate this issue and include these areas in future C inventories." An estimated 10 million acres of grasslands/shrublands are burned annually in the U.S. Not including these in the calculations results in an under reporting of GHGs.

3. **Terminology.** Should EPA be consistent with other agencies (Federal, State, and Tribal) in the use of wildland fire terminology? EPA uses the term "forest fires" to include wildfire and prescribed fire. For several years, federal land management agencies and state regulatory agencies have used the "unplanned (wildfire) and planned (prescribed fire) ignitions" as the two components of wildland fire. To avoid confusion, terminology should be consistent with the current definitions.

4. **Are the Estimates of Burned Biomass Per Hectare Too High?** Converting the megagrams-per-hectare estimates to tons per acre of biomass burned (or carbon emitted) shows EPA's estimates of biomass burning to average 18 tons/acre biomass burned by wildfire in the lower 48 states. An average of 36 tons/acre of biomass is burned by wildfire in Alaska. Prescribed fire in the lower 48 averages 6 tons per acre of biomass burned.

REFERENCES

Intergovernmental Panel on Climate Change (IPCC, 2000) Special Report on Land Use, Land-Use Change And Forestry. Section 2.3.3.1. Natural versus Human-Induced
http://www.grida.no/publications/other/ipcc%5Fsr/?src=/climate/ipcc/land_use/index.htm

Acknowledgements: Primary author Anthony Matthews (US Forest Service).

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