

**Air Quality Considerations for Prescribed Burning Options,  
Boswell Creek HFI Pilot Project  
Sam Houston National Forest**

**Modified from June 18, 2003  
Angelina NF Report by Bruce A. Bayle, USDA Forest Service, Atlanta, GA**

**Management Situation**

The Sam Houston National Forest (SHNF) contains 163,037 acres of federal land, distributed among three Texas counties: Montgomery (47,801), San Jacinto (60,369), and Walker (54,597). Over the last three years, the USDA Forest Service (FS) has completed prescribed burning (for all purposes) on these lands at a rate that averages 15,532 acres per year. The amounts for each fiscal year (2001, 2002 & 2003) were 18,843, 18,246, and 9,508 acres, respectively. The 1996 Land and Resource Management Plan for the National Forests in Texas (Plan) indicates an increasing prescribed fire program on the National Forests, an approximate eight percent increase is planned from the first to the second period of the Plan. Air quality information and discussions provided in the Plan are included here by reference. In response to the Plan, and a national initiative aimed at reducing the buildup of woodland fuels in the National Forests, the FS is planning to prescribe burn approximately 21,000 acres on the Sam Houston NF during FY2004.

The above prescribed fire acreage is what is planned, whereas the actual acreage burned may vary due to weather and other considerations limiting the amount of burning that can be accomplished in a given year. Some small parts of the SHNF are so confined by nearby smoke sensitive sites that planning prescribed fires for those sites are impractical.

The Boswell Creek Healthy Forest Initiative Pilot Project lies within Walker County, Texas. The project, designed in part to reduce hazardous fuel accumulations, proposes to prescribe burn about 7,420 acres of upland pine national forest land in the Boswell Creek Watershed on a 2-to 5-year cycle. In addition, fire would be allowed to burn into about 1,230 acres of hardwood-dominated forests; these areas, although not protected from fire, would only burn minimally due to their fuel characteristics and generally moister conditions. A potential total of about 8,650 acres would have prescribed fire applied. In any given year about 2,500 to 4,000 acres would be burned as part of the SHNF regular prescribed burning program.

**Issues**

There are two sets of air quality issues related to prescribed fire. One set relates to the portion of smoke that is emitted with sufficient heat to raise it into the atmosphere for dispersal above the zone of human exposure. A second set relates to the portion of smoke that is emitted with insufficient heat, that portion which must be dispersed within the zone of human exposure.

Prescribed fire smoke with adequate dispersal, via lift into the atmosphere, can cause health and regional haze concerns. The role of woodland fire smoke in regional haze is not clear due to the difficulty of determining which carbon emissions are the results of woodland fires, as compared with other sources of carbon emissions. Carbon is emitted from the combustion of all fossil and vegetative fuels. Fine particulates from woodland smoke contribute very little to the regional airborne fine particulate budget on an annual basis. Woodland fire smoke is just one of many source categories for fine particulate matter (PM<sub>2.5</sub>). Because all PM<sub>2.5</sub>, and its chemical precursors, may travel hundreds of miles while they remain suspended in the air, the central States have formed a regional organization, Central States Regional Air Planning Association (CENRAP), to consider/implement regulations that will reduce regional haze. Texas is a participant in CENRAP ([www.cenrap.org](http://www.cenrap.org)). The FS is a participant in CENRAP as well. By approximately 2008 CENRAP States will have a formal plan to reduce PM<sub>2.5</sub> emissions to reduce regional haze. However, because the prescribed fire program on the SHNF is not a regionally significant source of fine PM emissions, on an

annualized basis, and because there are no irreversible effects or irretrievable resource commitments, there is little risk in proceeding without more definitive information on the regional haze issue.

The primary purpose of the National Ambient Air Quality Standards (NAAQS) is to protect public health. The NAAQS establish pollution thresholds for six pollutants that adversely impact human health: (1) sulfur dioxide, (2) nitrogen dioxide, (3) ozone, (4) particulate matter, (5) lead, and (6) carbon monoxide. Of those six, FS prescribed fire managers are primarily concerned with two of those pollutants: (1) particulate matter and (2) ozone. Prescribed fire production of these two pollutants is discussed below. State and federal air quality monitoring is performed to determine compliance with the NAAQS. State and federal guidelines for locating air quality monitors strongly favor locations where populations may be exposed to significant accumulations of air pollutants. The Texas Commission of Environmental Quality (TCEQ) operates no air quality monitors directly on the SHNF. The closest PM2.5 and ozone monitors are located in Montgomery and Harris Counties. For purposes of this analysis, air quality data for ozone and PM2.5 from nearby air quality monitors is used to gauge the potential impact of SHNF prescribed fire operations on regional air quality. Smoke that must be dispersed within the human environment due to insufficient lift can encounter nuisance, safety and occasional health issues.

### **Affected Environment**

The fate of forest fire emissions (smoke) is twofold. Most (usually more than 60%) of the emissions are "lifted" by convection to a fluctuating boundary in the troposphere known as the mixing height. From the mixing height, these emissions are dissipated by horizontal and downward dispersion above nearby counties. The "un-lifted" balance of the emissions (less than 40%) remains in intermittent contact with the ground.

Ground Level Smoke: This part of the smoke plume does not have enough heat to rise into the atmosphere. While smoke aloft is already dispersed before it returns to the human environment, ground level smoke must dissipate within that environment. It is dissipated by dispersion and deposition of smoke particles on vegetation, land surfaces, and other objects.

Ground level smoke is a common phenomenon in the vicinity of the SHNF. Its impacts generally are limited to an area extending a few miles downwind of the originating fire. Local FS personnel most frequently limit the level of impact by applying the mitigating measures described in a following section.

Smoke Aloft: Until recent decades, the impact of the lifted portion of smoke was ignored -- it just seemed to go away. As community and industrial development increasingly dotted the landscape with perennial air pollution sources, the smoke sent aloft could no longer be ignored.

Current Air Quality: The Plan for the NFs in Texas (1996) discusses air quality standards and air quality for the Forest. That discussion is included here by reference. Since that writing, however, relevant air quality data has become available for ozone and PM2.5 up to calendar year 2002. This new data is included in the following discussion.

### **Ozone**

Prescribed fires emit moderate amounts of volatile organic compounds (VOC), small amounts of nitrogen oxides (NOx), and a very small amount of direct ozone production. These are precursors to formation of ground level ozone. Fire related emissions become important only when other persistent and larger pollution sources already present a substantial base load of ozone precursors or when there is a threat of atmospheric confinement. In some circumstances, additional intermittent emissions might aggravate an already bad situation.

Historically, one county within of the SHNF, Montgomery County, has not attained the NAAQS ozone standard. The closest ozone non-attainment area to the SHNF is the Houston metropolitan area which is rated as severe by the EPA. Texas has 43 ozone monitors spread throughout the State, with an emphasis on urban areas. Due to the paucity of rural ozone monitors in east Texas, it is appropriate to review the locations

of Louisiana ozone monitors located in the west/central portion of the State. Louisiana has a total of 21 ozone monitors. Summary data from four monitors representative of the conditions found in the SHNF are presented below. Of the four ozone monitoring sites, Harrison County and Beauregard Parish are more representative of the rural character of the SHNF in San Jacinto and Walker Counties than the more urban counties of Montgomery (Houston metropolitan area) or Gregg (City of Longview).

**NAAQS-Ozone Standard.** Ozone monitors run continuously throughout the growing season (April through October). They provide up to 5036 hourly values which result in 5028 “8-hour running averages” per year. Attainment of the standard occurs when the mean of the yearly fourth-highest “8-hour running average” values, over three consecutive years, does not exceed 0.08 parts per million.

County	1 <sup>st</sup> Through 4 <sup>th</sup> Highest of all 8-Hour Ozone Concentrations, Units – parts per million							
	2000				2001			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Gregg, TX	0.103	0.103	0.099	<b>0.099</b>	0.095	0.084	0.083	<b>0.082</b>
Harrison, TX	No data				0.065	0.064	0.063	0.061
Montgomery, TX	0.106	0.104	0.103	<b>0.100</b>	0.091	0.076	0.069	0.058
Beauregard Parish, LA	0.093	0.086	0.086	<b>0.081</b>	0.084	0.077	0.076	0.073

County	1 <sup>st</sup> Through 4 <sup>th</sup> Highest of all 8-Hour Ozone Concentrations, Units – parts per million				3-Year Aver. of 4 <sup>th</sup> Highest Annual Values
	2002				
	1st	2nd	3rd	4th	
Gregg, TX	0.091	0.090	0.085	<b>0.084</b>	0.088
Harrison, TX	0.090	0.088	0.088	<b>0.088</b>	0.075
Montgomery, TX	0.108	0.100	0.089	<b>0.082</b>	0.080
Beauregard Parish, LA	0.077	0.076	0.070	0.070	0.075

**Table 1.** Summary of ozone monitoring data reported by the States of Texas and Louisiana (2000 – 2002). The summary data (all but last column) are from the EPA national air data monitoring site - [www.epa.gov/air/data/index.html](http://www.epa.gov/air/data/index.html). “3-Year Averages” calculated by the author. The following information is helpful in understanding the data presented above. Ozone monitors run continuously, recording a mean concentration for each hour. The data presented above are 8-hour running averages (calculated from the base data), there are still 24 values for each day. Only the highest value per day is used for evaluating attainment of the standard. This table presents the 1<sup>st</sup> through 4<sup>th</sup> highest, of roughly 230 daily, values generated per year. The 4<sup>th</sup> highest value for each year and the 3-year average of those values are critical for evaluating attainment of NAAQS.

The highlighted “4<sup>th</sup> highest” annual values above show those county ozone monitors which exceed the NAAQS of 0.080 parts per million. State non-attainment determinations are made on the basis of three years of monitoring data. Therefore, a preliminary review of the data shows that Gregg and Montgomery Counties will likely be in a non-attainment status, this is currently true for Montgomery County since it is part of the Houston metropolitan non-attainment area for ozone. At several monitors 2002 registered cleaner air than did 2000. The process for designating non-attainment areas under the new “8-hour” ozone standard will begin this calendar year.

Based on the above monitoring data for largely rural counties (Harrison County, TX and Beauregard Parish, LA) it is assumed that ozone pollution within Walker and San Jacinto Counties on the SHNF are acceptable in terms of the NAAQS. Additionally, prescribed burning is a minor contributor to ozone air pollution problems,

both in terms of ozone precursor pollution (nitrogen oxides and volatile organic compounds) and minor amounts of direct ozone generation.

**Fine Particulate Matter (PM2.5)**

A review of the current situation for PM2.5 is warranted because it is by far the most significant air pollutant emitted from prescribed burning. NAAQS for PM is a more complex standard than ozone. Currently two PM standards are in effect, one for PM10 and another for PM2.5. PM10 refers to particles less than or equal to 10 microns in diameter. Recent health studies demonstrate that PM2.5 poses a much greater health risk than PM10 pollution. Both the old PM10 standard and the tougher/newer PM2.5 (particles with a diameter less than or equal to 2.5 microns) are in effect.

**NAAQS-PM2.5 Standard.** PM2.5 monitors filter air for complete 24-hour periods. They're most often set up to operate on a 3-day cycle, providing approximately 122 samples per year for analysis. Attaining this standard requires that 98% of the 24-hour samples shall show a PM2.5 concentration not exceeding 65 micrograms per cubic meter (ug/m<sup>3</sup>). The standard further requires that the annual mean of these 24-hour sample values shall not exceed 15 ug/m<sup>3</sup> over a running 3-year averaging period.

Texas has 29 PM2.5 monitoring locations throughout the state, Louisiana has 16. Summary data from monitors closest to the SHNF that represent the range of conditions found on the forest:

County	Summary of 24-Hour PM2.5 Samples Reported Yearly, Units – micrograms/cubic meter					
	2000			2001		
	98 <sup>th</sup> Percentile	Annual Mean	Number of Samples	98 <sup>th</sup> Percentile	Annual Mean	Number of Samples
Gregg, TX	29	13.4	114	28	12.2	119
Harrison, TX	No Data			30	13.5	83
Montgomery, TX	24	13.7	45	24	11.7	88
Rapides Parish, LA	30	13.4	114	29	12.2	119

County	Summary of 24-Hour PM2.5 Samples Reported Yearly, Units – micrograms/cubic meter			Three-Year Average	
	2002			98 <sup>th</sup> Percentile	Annual Mean
	98 <sup>th</sup> Percentile	Annual Mean	Number of Samples		
Gregg, TX	39	12.4	120	32	12.7
Harrison, TX	36	11.5	120	33	12.5
Montgomery, TX	25	11.0	203	24	12.1
Rapides Parish, LA	25	10.6	120	28	12.1

**Table 2.** Summary of PM2.5 monitoring reported by the States of Texas and Louisiana. Data obtained from EPA web site – [www.epa.gov/air/data/index/html](http://www.epa.gov/air/data/index/html). The 3-year averages of annual means and 98<sup>th</sup> percentiles were calculated by the author. Note - While most PM2.5 monitors run for continuous 24-hr periods, generally every 3<sup>rd</sup> day, providing up to 122 values per year; some monitors operate daily, giving up to 365 values per year.

The annual threshold for PM2.5 is 15.0 micro-grams/cubic meter. None of the above four PM2.5 monitoring sites representative of the SHNF, including the site in Montgomery County, approach the annual standard with the attendant risk of a non-attainment status. The above data show 2002 registered cleaner air than did 1999.

The process for designating non-attainment areas under the new PM2.5 particulate standard will begin early in 2004, calendar year 2003 may push some of the above counties towards a non-attainment status, but that appears unlikely.

### Effects

The risk of smoke impact on the human environment differs between the two portions of smoke plume. Turbulent surface winds move ground smoke erratically and it stays in intermittent contact with the human environment. In comparison to smoke aloft, human exposure to ground level smoke is limited to a smaller area, relatively brief (a few hours), and more intense.

The potential for ground level smoke to create a nuisance is always present. Where there's enough smoke to cause a nuisance, remedies are straightforward. What constitutes a nuisance is not often defined but generally includes a property use that significantly impairs the use of another property due to some health, safety, or economic consideration. What constitutes "enough" smoke, in terms of a specific concentration or duration, is seldom mentioned. The primary, and most serious, "nuisance" aspect of prescribed fire smoke is smoke on public highways, especially in lower lying areas where smoke can accumulate during night-time inversions.

The impact of smoke aloft is usually not realized until dispersal mechanisms bring dissipated portions of lifted smoke back to ground level. Because the smoke has already dispersed over a broad and deep volume of air, the concentration at ground level is usually minimal. Because the dispersal area is broad, the duration of exposure within that area may, however, last for the better part of a day. Decades ago, the impact of such dispersed emissions went unnoticed because they were merely an intermittent contribution of minor amount to relatively clean air.

As shown in the previous section, the creation of additional pollution sources in the rural landscape and the tightening of air quality standards present a situation where the air masses we burn into can seldom be described as "clean". While smoke from prescribed fire is still an intermittent contribution of minor proportions, on an annual basis, it nonetheless must be considered by State air regulatory agencies in reviewing the status of the NAAQS pollutants.

If any of the other counties near the SHNF eventually are included in an ozone non-attainment area, prescribed fire should be considered only as a very small source. Consider the following:

- In much of the rural South, ozone formation tends to be nitrogen oxide limited, prescribed fire is not usually a major nitrogen oxide producer/source when compared to other sources (vehicles and stationary power generation facilities).
- Weather and climate conditions in this area tend to preclude prescribed fire from becoming a significant contributor to ozone non-attainment. Most ozone events occur during the summer, as warm high pressure air masses stagnate over an area, limiting atmospheric ventilation. The majority of the SHNF's prescribed fire program is conducted during the dormant season, although growing season burns will become more numerous over the coming years to more closely mimic historic/natural fire occurrences.

If some counties near the SHNF eventually fall into PM2.5 non-attainment, prescribed fire would be considered as a small source of emissions on an annual basis. If that were to occur, the SHNF would be requested by the Texas Commission of Environmental Quality to participate in the resolution of the non-attainment rating. PM2.5 statistics show a problem that is not limited just to "bad air quality days". The 98<sup>th</sup> percentile values do not approach the daily (24-hour) standard of 65 ug/m<sup>3</sup>, nor 3-year average of mean annual PM2.5 values do not approach exceeding the annual standard of 15 ug/m<sup>3</sup>. Emissions of PM2.5 pollutants or their precursors, even on "clean" days, add to the problem.

## **Mitigation**

In order to avoid nuisance situations that may be created by ground level smoke, the FS employs smoke management guidelines that conform to the guidance of the Texas Forest Service. These guidelines, initiated in advance of each fire, include:

- 1) During project planning, smoke sensitive targets are identified that may be affected by the project. Such targets include: health care facilities, airports, high volume & high speed roads, homes of persons known to have chronic respiratory illness, schools and poultry farms.
- 2) Weather and burning conditions are prescribed to direct smoke away from sensitive targets. Obvious weather considerations include wind direction and speed. Others are fuel conditions and ignition methods that maximize the amount of smoke lifted, plus weather that promotes smoke dispersal (e.g. mixing height, transport wind speed and improbability of air mass stagnation). For some projects, even the most diligent planning will provide no option that can avoid all smoke sensitive targets. In those cases, modify the project or contact the resident/owner to see if the impact can be mitigated.
- 3) During the afternoon of the day before the project is to be done, a weather forecast is obtained to make sure the prescribed weather and burning conditions will be met. Also the Texas Forest Service, local fire department(s), and local/potentially affected residents are contacted in reference to the planned prescribed fire operations.
- 4) On the morning of the project, the most recent weather forecast is reviewed. If conditions are acceptable, then begin any planned mitigation measures, light the fire, and begin monitoring the fire and smoke for unanticipated situations. Be prepared to stop ignition and/or begin suppression if unanticipated situations cannot be controlled or mitigated. Also be prepared to patrol smoke sensitive roadways through the night if the fire is still producing significant smoke at dusk.
- 5) Record any significant smoke management problems in the review section of the project plan.

## **Monitoring**

Information contained in this narrative conforms to the following sections of the National Forests in Texas Plan that address monitoring:

- “Forest-wide Standards and Guidelines”, National Forests in Texas Plan, for air quality (FW-001 through FW-004).
- Three monitoring questions listed within the “monitoring summary table” (Appendix G) that addresses “objective 5-d” - “Implement procedures and precautions that promote air quality consistent with federal and state laws.”