Air Quality

INTRODUCTION

Federal land management agencies have the unique responsibility to protect the air, land and water under their respective authorities from degradation associated with air pollution emitted outside the borders of Agency lands (Clean Air Act 1990), as well as from the impacts of air pollutants produced within those borders. These mandates are established through a series of legislative and regulatory requirements (Clean Air Act 1990; Organic Act 1977, Wilderness Act 1997). With the burden of these responsibilities, it is important for federal land managers to understand the rules and regulations governing air pollutant emissions and how those air pollutants are impacting Forest resources.

First, the Clean Air Act (CAA) sets the standards for air quality in the United States. The CAA has numerous sections, and among these, three are particularly important to National Forest System (NFS) management: National Ambient Air Quality Standards (NAAQS), the Prevention of Significant Deterioration (PSD) program and the Regional Haze Rule (Visibility Protection CAA Sec. 169a).

The NAAQS set the air quality standards for six criteria pollutants that entire country must comply with. Primary NAAQS standards are set based on human health criteria. It is up to the state air quality regulatory agencies to come up with State Implementation Plans (SIPs) to ensure that these standards are met in their respective states. If the standards are not met for any criteria pollutant, the area is designated as non-attainment for the pollutant. It is the responsibility of the Monongahela National Forest (MNF) to ensure that management activities do not significantly contribute to a violation of the NAAQS.

The Clean Air Act Amendments (CAAA) of 1977 established the prevention of significant deterioration (PSD) program. These amendments designated specific Wildernesses and National Parks as Class I areas. The MNF has two Class I areas; Dolly Sods and Otter Creek Wildernesses. Federally mandated Class I areas are provided with an additional measure of protection under Title I, Part C of the CAAA, which states that one purpose of the Act is "to preserve, protect, and enhance the air quality in national parks, national wildernesses". Further more, the PSD regulations charge the federal land manager with the "affirmative responsibility to protect the air quality related values (including visibility) of any such lands," and to consider "whether a proposed source or modification would have an adverse impact on such values" (40 CFR 51.166 (p)(2)). In light of this responsibility, it is important for federal land managers to be familiar with the status of air quality in and near the Class I areas, as well as how current levels of air pollution are impacting Air Quality Related Values (AQRVs). This information assists federal land managers when making impact determinations about new sources of air pollution.

It is important to note that while the Clean Air Act Amendments of 1977 gave the Forest Service the "affirmative responsibility" to protect Air Quality Related Values (AQRVs) in the Class I areas it manages, that role was limited by Congress to one of *consultation*. This means that the MNF has no direct regulatory authority over sources of air pollution. This authority was given to the United States Environmental Protection Agency (EPA) under the CAA. EPA was given the opportunity to delegate this authority to a respective state agency, which is the case in West Virginia. The MNF consults with state air permitting agencies on PSD and Regional Haze matters through the processes described below.

The permitting agency is required to send a copy of all PSD permit applications and Class I analyses, to the FLM of any Class I area(s) that may be impacted (40 CFR 52.21(p)). The FLM assesses the permit and modeling analyses and, based on this evaluation, determines whether or not the new source of air pollution will adversely impact AQRVs in the Class I area(s) of concern. PSD impact determinations are made on a case-by-case basis, taking into account the geographic extent, intensity, duration, frequency and time of any modeled impacts. The FLM provides the state with this determination as well as any additional concerns or comments. However, the state regulatory agency legally retains the authority to issue a PSD permit. Given that certain requirements are met, the permitting authority can issue a PSD permit regardless of an "adverse impact determination" made by the FLM(s).

While the PSD program was designed to protect Class I areas from new or modified sources of air pollution, the Regional Haze Rule was promulgated to achieve the national "Visibility Protection" goals for Class I areas set forth in section 169 (a) of the CAA. This section of the CAA sets as a national goal: "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." The Regional Haze rule requires states to develop long-term strategies for reducing manmade visibility impairing pollutants in 156 federally mandated Class I areas. States must show reasonable progress toward achieving natural visibility conditions in the Class I areas by the year 2064. Because the problem of haze pollution is regional in nature, these reduction strategies are being assessed over large geographic areas through the Regional Planning Organizations (RPOs). Additionally, as part of these reduction strategies, certain existing facilities that emit visibility impairing pollutants at levels that have been demonstrated to cause or contribute to visibility impairment in any Class I area(s) will be subject to applying the Best Available Retrofit Technology (BART). The Forest Service (as well as other FLM agencies) plays a key role in the Regional Haze process, and as such, is currently consulting with states, the EPA and other stakeholders through the RPO process. Forest Service involvement in this process can help to reduce visibility impairment in Dolly Sods and Otter Creek Class I areas.

The authority and responsibility to protect resources within NFS lands is not limited to Class I wildernesses, but requires federal land managers to take the necessary steps to protect all federal lands from air quality impacts; regardless of whether those impacts are coming from within agency borders or without. The CAA of 1990 contains numerous sections dealing with these responsibilities, and Section 101(c) states the primary purpose of the Act:

> "A primary goal of this Act is to encourage or otherwise promote reasonable Federal, State, and local governmental actions, consistent with the provisions of this Act, for pollution prevention" (Clean Air Act 1990).

Beyond the CAA, additional legislation recognizes the importance of air quality and the impact it can have on forest resources. The National Forest Management Act states that Land and Resource Management Plans are, in part, specifically based on:

> "…recognition that the National Forests are ecosystems, and their management for goods and services requires an awareness and consideration of the interrelationships among plants, animals, soil, water, air, and other environmental factors within such ecosystems" (National Forest Management Act 1976).

It is within this regulatory framework that the MNF must strive to protect resources on NFS lands from the detrimental effects of any pollution source. Additionally, it is imperative that while federal land managers work to alleviate harmful effects of air pollution from new and existing sources external to Forest boundaries, they must also continue to be good stewards when conducting management activities that contribute to regional air pollution.

Issues and Indicators

Issue Statement

Forest Plan management strategies may affect air quality in and around the Forest.

Background

Although a majority of this area's pollution comes from sources outside the National Forest, activities from within the Forest boundaries can also affect air quality in the region. Activities such as timber harvesting, oil and gas well drilling and operations, road construction or maintenance, and prescribed fire all produce emissions. Additionally, effects of these activities may exacerbate existing air quality related issues (see *Soil Resource* section). However, not all of these activities are expected to change significantly for all alternatives within this planning period. Natural gas exploration and development are expected to remain at current levels, or decrease from existing levels, depending on the alternative. Also, the number of days where road construction or maintenance occurs is not expected to increase over existing levels, and is not a major component of air pollution problems in West Virginia. The remaining two activities, timber harvesting and prescribed fire, are expected to change within the planning period. Particulate matter (PM) and nitrogen oxide (NOx) emissions from these activities will contribute to the total pollution load and are the major pollutants of concern in terms of contributions to NAAQS. Therefore, potential emissions of these pollutants will serve as indicators for air quality effects.

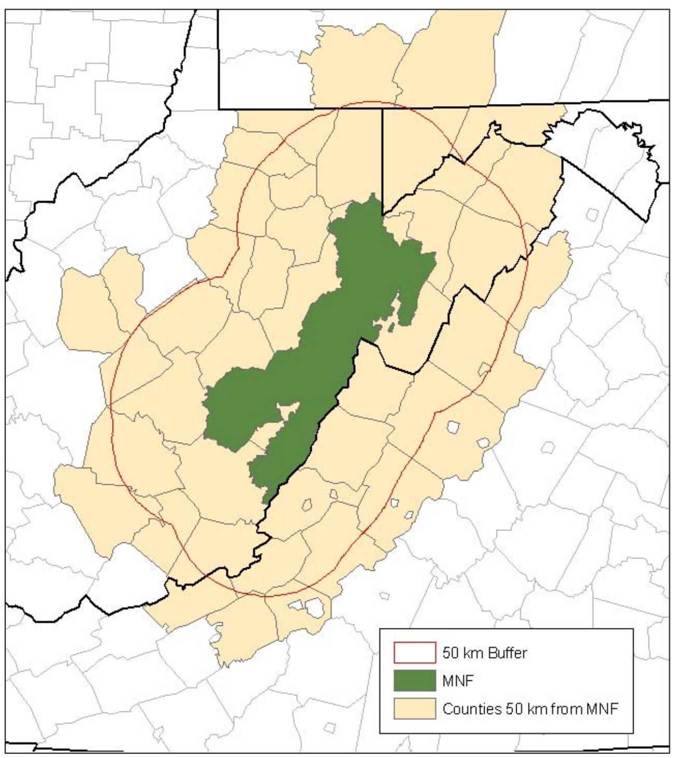
Indicators

Potential emissions of PM and NOx from predicted timber harvest and prescribed fire activities are evaluated and compared to total PM and NOx emissions in counties near the Forest.

Scope of the Analysis

Analyses for direct and indirect effects of air pollution are limited to pollution *emitted* from within lands administered by the MNF as a result of management activities. However, because air pollution disperses beyond political boundaries, levels of pollution emitted from MNF management activities must be evaluated taking into consideration regional pollution loads and current air quality monitoring data. Pollution coming from Forest management activities can impact air quality within Forest boundaries and without. Likewise, pollution from sources outside the Forest boundary affects Forest resources as well as regional air quality. For this reason, air pollution must be evaluated in both a regional and cumulative context; and it is imperative that an area larger than just NFS lands is used in an air quality evaluation. An analysis area with a radius of 50 kilometers from the Forest boundary will be used to describe the effects of emissions from the Forest on regional air quality in this document. This distance was determined to be adequate to describe the area potentially affected by the mobile and area sources of pollution from Forest management activities. Figure AQ-1 shows the analysis area.

Figure AQ-1. Air Quality Analysis Area



CURRENT CONDITIONS

Current air pollution impacts occurring on the MNF are the cumulative result of numerous sources. Pollution from sources such as automobiles, off-road construction equipment, wildland fires, factories, oil refineries and power plants all contribute to the regional pollution load. The

MNF is situated near the industrial heart of the United States. It is within a day's drive of a large percentage of the United States' population, and is downwind of a high concentration of coal-fired electric generating facilities; the leading source of sulfur dioxide (SO_2) and nitrogen oxide (NOx) emissions. This network of coal-fired power plants includes the generally defined "Ohio River Valley". In West Virginia alone, there are 18 existing major coal-fired power plants (US EPA, eGRID data 2003); with several companies seeking to build additional facilities (MNF air specialist, professional knowledge).

When looking at the impacts of air quality on Forest resources, it is important to keep in mind that only a handful of pollutants contribute to a variety of air quality related issues. These pollutants are a concern because of their impacts to both human health and ecosystems, and are described in detail below. Air pollutants are generally classified as either primary or secondary pollutants. Those emitted directly to the atmosphere as products of combustion are classified as primary pollutants, and those formed when primary pollutants undergo atmospheric chemical reactions are secondary pollutants.

Sulfur Dioxide

About 69 percent of SO_2 released to the air (11.2 million tons in 2000), comes from electric utilities, especially those that burn coal (US EPA, Progress Report 2003). Other sources of SO_2 are industrial facilities that derive their products from raw materials—like metallic ore, coal, and crude oil—or that burn coal or oil to produce heat. Examples are petroleum refineries, cement manufacturing, and metal processing facilities. Also, locomotives, heavy marine equipment, and some non-road diesel equipment currently burn high sulfur fuel and release SO_2 in large quantities. Within 300 kilometers of the MNF, there are 311 coal-fired electric generating units (EGUs). Seven of these EGUs are among the top ten highest SO_2 emitting EGUs in the nation[1] (US EPA, eGRID data 2003). Once SO_2 is emitted into the atmosphere, it undergoes chemical transformations to form secondary pollutants such as sulfates and sulfites. In the eastern United States, these secondary sulfur pollutants are the major contributors to visibility impairment and acidic deposition.

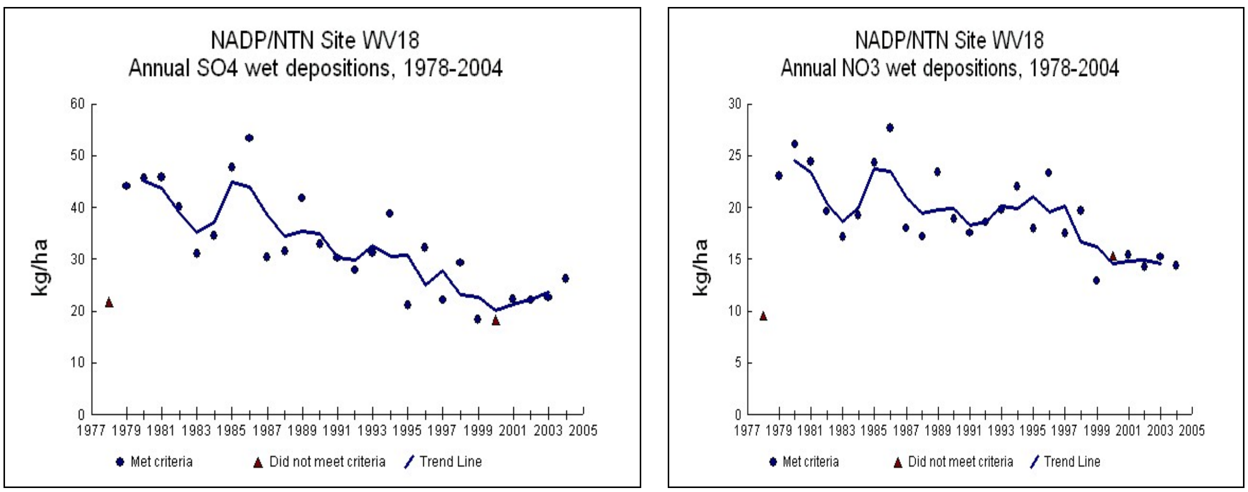
<u>Sulfur Dioxide and Acid Deposition</u>

Acid deposition occurs when acidic sulfur and nitrogen compounds in the atmosphere are deposited on the earth's surface through rain, clouds, snow, fog, or as dry particles. These acidic inputs can contribute to degradation of stream water quality and decrease the amount of available base cations in the soil substrate. An ecosystem's susceptibility to soil nutrient losses and decreases in stream water acid neutralizing capacity (ANC) are influenced by many factors; most notably the bedrock geology/lithology types and the level of acidic inputs. Areas that receive high levels of acidic deposition and have bedrock geology with a naturally low buffering capacity may exhibit nutrient depletion and stream acidification. Stream chemistry data show that streams on the Forest have decreasing ANC values, and there currently is concern that soil nutrient depletion is occurring in sensitive areas (see *Soil Resource* section.) While nitrogen-containing compounds can also result in acidifying effects in ecosystems, sulfates are the dominant contributor in the Eastern US.

[1] Some of these facilities may have made reductions since the time the US EPA eGRID data was compiled.

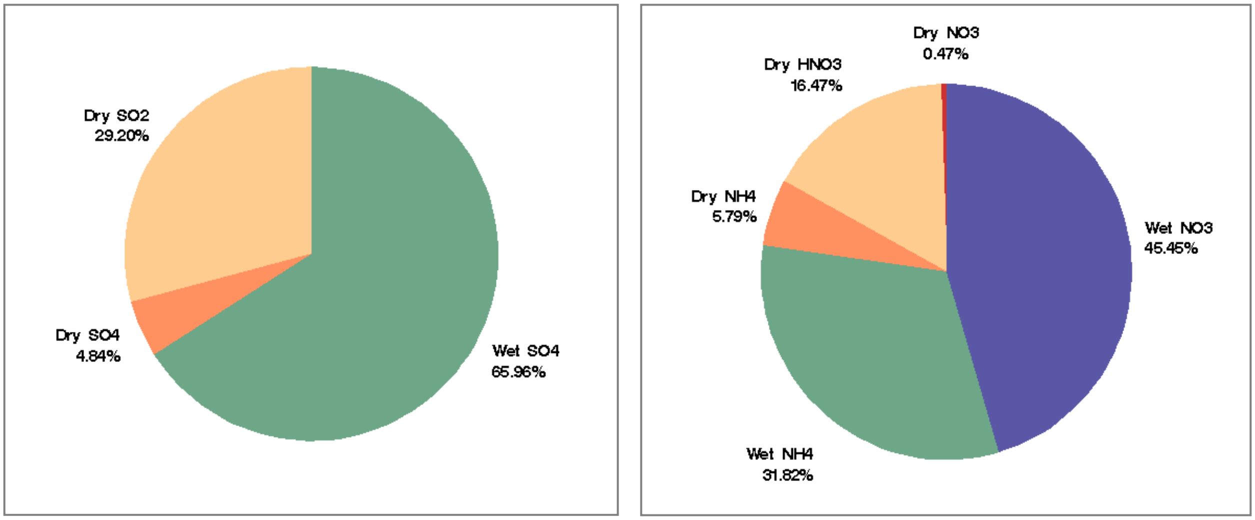
The largest network for monitoring the wet component of acidic deposition is the National Atmospheric Deposition Program (NADP). The NADP monitoring program is a nationwide network that was initiated in 1978 to assess long-term spatial and temporal trends in precipitation chemistry. There are three NADP monitoring sites in West Virginia located in Tucker, Gilmer, and Fayette Counties. The Tucker County site, the closest monitoring site to the MNF, began monitoring precipitation chemistry in 1978 and has the longest data record of the three sites. (Trends in sulfate and nitrate deposition from the Tucker County site are shown in figure AQ-2 below.) The Gilmer and Fayette County sites began monitoring in 1999 and 1983 respectively. Annual wet deposition values from NADP monitoring network show that the MNF, particularly the northern end of the Forest, receives some of the highest sulfate deposition inputs in the country (Estimated Sulfate ion Deposition Rates During 2003; Source, NADP 2003). These observed trends make sense, given the location of the Forest relative to the large upwind network of coal-fired power plants and industries.

Figure AQ-2. Wet Deposition Trends For Sulfate and Nitrate (kg/ha year^{-1}) at the NADP Monitoring Site in Parsons, Tucker County West Virginia



While the wet component of acidic deposition is important, as previously discussed, precipitation is not the only mechanism by which acidic compounds are deposited on the earth. Acidic compounds are also deposited in dry form as particles or gasses. For this reason, only looking at trends in wet deposition will not show the total acidic loading. The Clean Air Status and Trends Network (CASTNET) monitors concentrations of dry acidic compounds in the ambient atmosphere. These monitored concentrations are then converted to loading values based on estimated deposition flux rates. Figure AQ-3 shows the compositions of the various components of sulfur and nitrogen deposition for 2002-2004 at the CASTNET site in Tucker County, Parsons, WV. (Source: Clean Air Status and Trends Network – CASTNET, 2006.)

Figure AQ-3. Composition of Sulfur and Nitrogen Deposition, Wet versus Dry, for 2002-2004 at the Parsons CASTNET Site



It is important to note that trend analyses for NADP sites show a general decrease in the levels of wet sulfate (SO_4) deposition throughout the nation, especially over the last ten years. Of the West Virginia monitoring sites, this observed trend is most prominent in the data from the Tucker County site. Total annual sulfur deposition on the MNF in the late 1980s ranged from 19 $kgha^{-1}$ at the lower elevations to 26 $kgha^{-1}$ at high elevations (Adams et al. 1991). Few areas of the United States showed higher sulfur deposition. Current monitoring results show that wet sulfate deposition has decreased 29 percent in the mid-Atlantic region. The decline in SO_4 deposition at NADP sites is consistent with the decreases in utility SO_2 emissions brought about by the Acid Rain Program (Title IV) of the 1990 Amendments to the Clean Air Act. The Acid Rain provision mandated significant reductions in SO_2 emissions. The greatest percentage decreases in atmospheric sulfate (SO_4) concentrations occurred in the eastern states north of Tennessee and North Carolina, and the highest absolute decrease (73%) occurred at the Bearden Knob air monitoring station on the MNF (often referred to as Dolly Sods in the literature) (Malm et al. 2002). These reductions are attributable to large reductions in SO_2 emission at sources upwind from the MNF between 1990 and 1999: Indiana, -44%; Ohio, -35%; West Virginia, -34%; Kentucky, -29%; and Illinois, -13%. In these five states, SO_2 emissions decreased by 2.5 million tons between 1990 and 1999. Trends in nitrate deposition do not show as obvious or dramatic reductions as those for sulfate.

Downward trends in SO_2 emissions and SO_4 deposition are predicted to have a positive effect on aquatic and soil resources on the MNF; however in many streams the reductions are not great enough to reverse all of the degradation that has already taken place. For example, a number of streams on the Forest have been acidified to the point where they are no longer capable of sustaining aquatic life or have acidified to where only the most tolerant aquatic species remain. According to modeling projections (SAMI 2002, Sullivan and Cosby 2004), which take into account historic deposition rates, reductions in SO_2 emissions resulting from the 1990 Clean Air Act amendments will not be enough to restore the chemistry in many of these sensitive and acidified streams to levels where aquatic life can thrive, even after 100 years. Significant additional emission reductions will be needed to restore already degraded streams, and to protect streams that have not yet degraded significantly.

Critical Loads and Acid Deposition

A critical load is a quantified estimate of *pollutant exposure or loading* below which harmful effects to environmental receptors do not occur. A critical load can be developed for a variety of pollutants and receptors within a particular ecosystem. It is a scientific number based on modeled or measured dose-response data. Given the current pollution loadings or exposures and the sensitivity of the receptors in an area, this number may or may not be exceeded. Receptors or indicators chosen for a critical load can be aquatic or terrestrial ecosystem components, and indicator measures can be either biological or physical parameters of those ecosystem components.

Because the critical load(s) may or may not have been exceeded, target loads are selected to reflect policy or management goals, using scientific information along with social, economic, spatial and temporal considerations. "Federal area managers are beginning to use critical loads as tools for quantifying harmful pollution levels and setting goals for resource protection or restoration on federal lands" (Porter et al. 2005). Using this definition, target loads would be set for areas on the Monongahela based on the critical load(s) and the current levels of deposition in the area. Land management goals may be a factor that assists the MNF in choosing the target load, but because this is a pollutant exposure or loading, it would not be chosen to reflect management decisions, but rather to reflect air quality goals.

A critical load could be used when assessing how certain management activities may exacerbate air pollution related problems in certain sensitive areas, or to identify areas where mitigations may be an option for resources that have been negatively affected, but neither the critical nor target load determinations would be driven by these activities. Additionally, critical and target loads will help the Forest define the effects of acidic deposition from new and existing pollution sources on aquatic and terrestrial ecosystems as we continue to work with state and federal air quality regulators to reduce regional levels of deposition. This is potentially the most beneficial application of critical and target loads, because it will assist the MNF in demonstrating to air regulators the level of pollution reductions needed to restore or maintain ecosystems of concern. Currently, the types of data needed to calculate critical loads are being collected to determine these values for the MNF.

Sulfur Dioxide and Regional Haze

During the last four decades, the eastern United States has seen a significant regional reduction in visibility, brought on by a corresponding increase in ambient levels of visibility-impairing pollutants often referred to as fine particulates (Malm 1999). The estimated natural background visibility for the eastern United States is 93 ± 28 miles (NAPAP 1990), but average annual visibility at Dolly Sods and Otter Creek Wildernesses is now only 40 miles (VIEWS 2003). This degradation of visibility, both in terms of how far one can see and the clarity of the view is called regional haze. Although many fine particulate components such as elemental and organic carbon and nitrates contribute to visibility impairment, the major visibility-impairing pollutant in the eastern United States again is sulfate; which comprises most of the measured fine particle mass (IMPROVE Data 2003). Furthermore, sulfate particles are considered hygroscopic, which means their effectiveness in impairing visibility is magnified with increasing relative humidity. A humid atmosphere alone does not result in visibility reductions, but sulfate particles grow in size when they attach to atmospheric water molecules; a size that is more effective at scattering the sun's light (Malm 1999). About 60 percent of SO_2 emitted nationally comes from coal-fired power plants (US EPA, National Air Quality and Emissions Trends Report Data 2003). Organics (released primarily from vegetation as volatile organic compounds (VOCs) are the second most important fine particles measured.

The Inter-agency Monitoring of Protected Visual Environments (IMPROVE), a national network of particulate monitors established for the protection of Class I wilderness areas, has monitored the constituents of regional haze for more than two decades. The IMPROVE monitor located closest to the MNF is at Bearden Knob near Dolly Sods Class I area. IMPROVE data from the Bearden Knob monitoring site were used in the visibility description that follows.

The clearest days at Dolly Sods have the lowest fine particle mass (3.4 ug/m3), with estimated visibility at 78 miles (using the annual average relative humidity of 82 percent). Sulfates comprise approximately 56 percent of the total fine particulate mass on these low mass days. On the highest mass (18.2 ug/m3) days, the visibility is reduced significantly to 15 miles (IMPROVE Data 2003). Sulfates comprise 85 percent of the total fine particulate mass on these high mass days. The days with the poorest visibility are most likely to occur May through September (Air Resource Specialists 1995), the time of year when the Forest sees the most visitor use. Throughout the year, people are most likely to see a uniform haze, like a white or gray veil, that obscures the scenery (Air Resource Specialists 1995). Trend plots from the IMPROVE monitoring site at Bearden Knob show that for the 20 percent worst visibility days, the extinction values are decreasing and visibility is improving (Figure AQ-2). The 20 percent best visibility days are not showing similar improvements (http://vista.cira.colostate.edu/views/) (Figure AQ-3). However, the Regional Haze Rule, a regulation aimed at reducing haze forming pollutants in federally mandated Class I areas, is concerned mainly with improvements on the worst visibility days, and maintaining visibility on the best days. The trend plots below show visibility data measured in inverse megameters; a low measurement constitutes minimal light extinction and thus a good visibility day, a high measurement constitutes high light extinction and thus a poor visibility day.

A recent study assessed the spatial and temporal trends of sulfates monitored by the IMPROVE network over the last 10 years. The results show that the greatest statistically significant percent reduction in sulfates in the eastern United States, a reduction of 73%, occurred at Dolly Sods Wilderness (Malm et al. 2002). Again, this reduction in monitored sulfate levels is most likely attributable to recent reductions in sulfur dioxide emissions from implementation of the acid rain program. However, despite these reductions in visibility impairing pollutants, levels of these pollutants still exceed natural background conditions, and visibility is still impaired.

Figure AQ-4. Light Extinction Monitored at Dolly Sods on the 20% Worst Days - IMPROVE

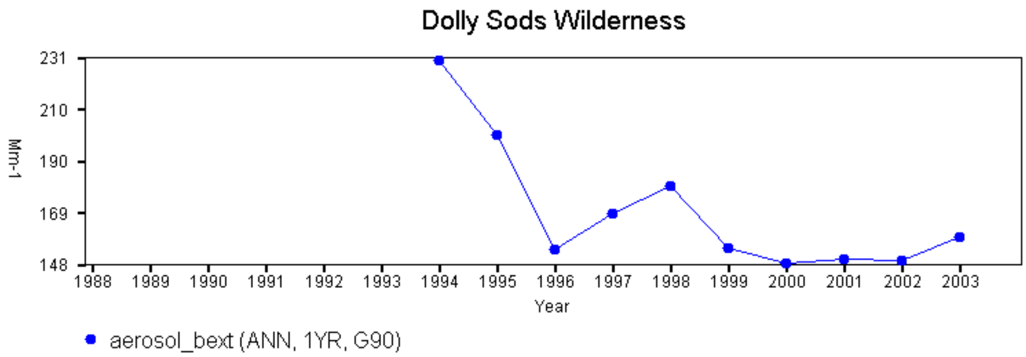
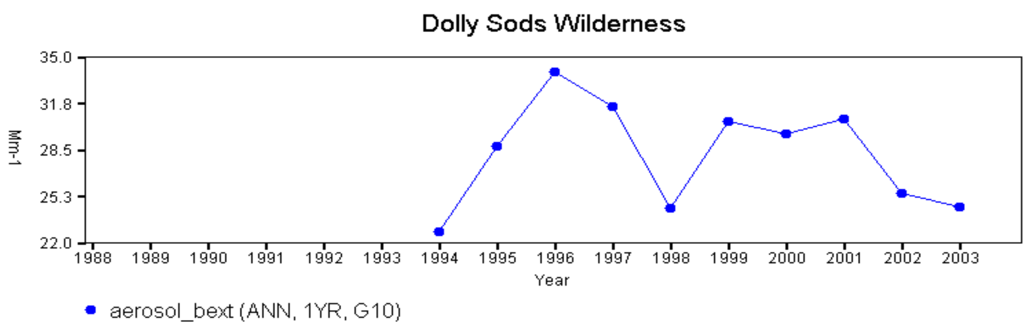


Figure AQ-5. Light Extinction Monitored at Dolly Sods on the 20% Best Days - IMPROVE



Nitrogen Oxides

More than 95 percent of nitrogen oxides or NOx emissions are in the form of nitric oxide. The primary source of NOx emissions is the transportation sector. Point sources such as coal-burning electric generation facilities also contribute ambient NOx levels. Smoke from wild and prescribed fire is also a contributor to NOx production, and is a concern for federal land managers. However it should be noted that thermal NOx production increases with increased burn temperature. Relatively low-temperature prescribed burns emit very little NOx as compared to wildfires. When trapped in sufficient quantities, nitrogen dioxide can be seen as a brownish haze. Secondary pollutants formed from nitrogen oxides such as nitrates also reduce visibility and contribute to acid deposition (discussed in the Visibility and Acidic Deposition sections above). In the presence of VOCs and sunlight, nitrogen oxides rapidly contribute to the formation of ozone. Available evidence suggests that nitrogen oxides are a controlling factor in the formation of ground-level ozone in rural areas of the Southern United States (Chameides and Cowling, 1995).

Ozone

As stated above, ground level ozone (O_3) is a secondary pollutant, and its production is highly dependent on the presence of nitrogen oxides and VOCs in the right ratios, sunshine, and elevated temperatures. Therefore, high ozone levels will occur only during periods of warm weather, plentiful sunshine, and high levels of ozone-forming pollutants. For this reason, the ozone monitoring season extends from April to October. It is important to note that there are two locations in the atmosphere where ozone occurs; the stratosphere (upper atmosphere) and the troposphere (ground level). Although the presence of ozone in the upper atmosphere is highly beneficial, in sufficient doses at ground level, ozone is considered a free radical; capable of killing living tissue in plants and in the human lung. Ozone's harmful effects are due to the pollutant's chemical make-up. The compound ozone is composed of three oxygen molecules, and is less stable than diatomic oxygen (the oxygen our bodies need). This unstable molecule reacts with the tissues inside the leaf of a plant, sometimes causing the death of those tissues. This same ozone radical also reacts with tissues in the human lung, causing inflammation and respiratory ailments, and in extreme cases premature death. The NAAQS standard for ozone is set at levels considered protective of human health; however damage to plants occurs at levels below the NAAQS standard for ozone. The ozone standard for human health is set at .085 parts per million (ppm) for a rolling 8-hour average, but injury to plants is common at levels below the standard.

The .085 8-hour standard for ozone is a new standard, which was promulgated in July of 1997 (CAAA sec 50.10). Attainment of the ozone NAAQS is based upon a three-year average of the 4^{th} highest daily 8-hour running average. Areas that have an EPA Federal Reference Method (FRM) ozone monitoring site must meet these criteria; otherwise the area is designated non-attainment for ozone. However, areas that do not have a FRM ozone monitoring site are designated as unclassifiable. Therefore, statewide attainment of the NAAQS is sometimes only as certain as the extent of the monitoring network. There are eight FRM ozone monitoring sites in eight different counties in West Virginia, which are operated by the West Virginia Department of Environmental Protection (WVDEP). Most of these lie in metropolitan areas. Of these eight counties, only one, Greenbrier County, contains NFS lands. Averaged data from the 2001 through 2003 monitoring seasons show that this site is just below the NAAQS, at .080 ppm. Of the remaining seven FRM ozone monitoring sites, six are exceeding the standard and one is just below it for the 2001 through 2003 monitoring season.

There are two additional ozone monitoring sites in West Virginia that are not part of the state's network. These sites are operated by the USDA Forest Service Northeastern Research Station in Parsons, West Virginia. One is part of the Clean Air Status and Trends Network (CASNET) rural area monitoring network and is located in the Nursery Bottom near the research station (1673 ft elevation). The other is located at a higher elevation site, Bearden Knob (3855 ft elevation), outside of Davis, WV. Although neither site is used to determine attainment of the NAAQS, a recent review of the monitoring data from Bearden Knob shows that the NAAQS were exceeded (based on the attainment criteria described above) from 1995-1999. More recent data from 2000-2003 show that the NAAQS have not been exceeded, but levels remain just below the standard.

Ozone effects to vegetation are highly variable and are dependent on factors such as the sensitivity of a given species, the magnitude and duration of ozone exposure and climatic factors. In terms of vegetation exposures, continuous moderate-to-high ozone exposures are sometimes of greater biological significance than very high concentration exposures for a short period of time, depending on the magnitude of the concentrations. Consequently, vegetation effects can be observed even at moderate ozone exposures. Additionally, ozone exposures at high elevation sites can often be greater than those for low elevations sites because these sites to not exhibit the diurnal fluctuations of high concentrations during the daytime hours and low ozone concentrations during the night as is observed at the lower elevation sites. This pattern is reflected through a comparison of the data from the high elevation Bearden Knob monitoring site and the low elevation Nursery Bottom site; ozone concentrations at Bearden Knob show relatively little (or a flat) diurnal variation, while those at the Nursery Bottom are variable throughout the day, with the greatest differences occurring between the midday and nighttime hours (Lefohn et al. 1994). Ozone exposures at levels sufficient to cause foliar injury in sensitive species have been recorded at these sites (Edwards et al. 1991; Lefohn et al. 1994), and some ozone symptoms on foliage have been observed in Otter Creek (Jackson et al. 1992).

While foliar ozone symptoms have been observed in Otter Creek, widespread injury is not apparent. Despite the record of ozone concentrations at levels indicative of vegetation injury, plants to not always exhibit the predictive response. This is in part due to climatic factors which influence plant stomatal functions. Generally speaking, vegetation response to ozone increases with increasing exposures, however this response is only apparent during periods of adequate moisture and nutrient availability; during periods of moderate to extreme drought, stomata closure increases, and thus the amount of ozone that enters the leaf decreases. Because of this, predicted vegetation responses to ozone levels should be evaluated in the context of concurrent climatic conditions. Taking these factors into account, a recent study (Edwards et al. 2004) evaluated the response of vegetation on the MNF to ozone for the years 1988 through 1999. Vegetation response was predicted using a combination of two metrics; the W126 values (sigmoidally weighted exposure index), and the number of hours that average concentrations were greater than or equal to 0.10 ppm (N100) at monitoring sites near the MNF. These metrics were then assessed in the context of the Palmer drought index for the given year and location of monitored ozone data. The results of this comparison showed minimal ozone effects, or effects only to highly sensitive tree species, with the exception of 1988. However when these predicted vegetation effects were evaluated along with the average Palmer drought index conditions for 1988, it was found that West Virginia experienced severe drought that year, and as a result substantial ozone damage would have been unlikely. To further support this finding, the authors reviewed ozone injury surveys conducted in Dolly Sods and Otter Creek Wildernesses for the years of concern. They found that in 1988 observed ozone symptoms were less frequent than those in 1989-1990 under near normal precipitation conditions (Edwards et al. 2004).

Particulate Matter

Particulate matter (PM) refers to any suspended atmospheric particle and is comprised of many different elements or compounds. It is defined based on various size classes of the particle's aerodynamic diameter, i.e. particles with an aerodynamic diameter of 10 microns are referred to as PM_{10} and particles with an aerodynamic diameter of 2.5 microns are referred to as $PM_{2.5}$. PM can be either a primary or a secondary pollutant, both of which affect Forest resources. Primary particulates tend to be larger in size, and are directly emitted from a combination of sources including combustion sources, agriculture, and road construction. Secondary fine particles are formed when combustion gases are chemically transformed into particles. The bulk of regional fine particles within the analysis area are the result of these chemically transformed combustion gases, such as sulfates and nitrates; mainly sulfate particles (transformed SO_2) from coal-fired power plants. These smaller, chemically transformed fine particles are largely responsible for regional haze.

While sources of PM outside of the Forest have a major impact on air quality, Forest Service activities also can affect air quality. Smoke emitted from forest fires, both prescribed and wild, is a major concern in terms of Forest activities that have the potential to affect air quality. Soot particles from wildland fires are a small, but significant part of the total $PM_{2.5}$ load. The 2006 Forest Plan prescribes smoke management standards and guidelines that would minimize the impacts of smoke from prescribed burning on smoke-sensitive sites.

There are NAAQS standards for two size classes of fine particulates, one for PM_{10} and $PM_{2.5}$. The $PM_{2.5}$ standard is newer and more stringent, and is the standard of concern, since particles with a diameter of 2.5 microns or less have a greater ability to impair visibility and impact human health. The NAAQS standard for $PM_{2.5}$ is a 24-hour average of no greater than 65 micrograms/m^3, or an annual arithmetic mean of no more than 15 micrograms/m^3. Currently there are no areas near the Forest that have been designated as non-attainment for fine particulate matter, however there are also no monitoring sites in counties containing or adjacent to NFS lands. There are 14 counties in West Virginia that have a FRM $PM_{2.5}$ monitoring site, and out of these 14, 9 are exceeding the annual standard.

Summary

Air quality data are collected for various pollutants in areas around the Forest. We have found that regional sources of air pollution are having an adverse affect on Forest resources. Visibility in the East has been reduced from a natural background range of 90 to 130 kilometers to an average visual range of 30 to 40 kilometers. Acid deposition is having a negative impact on West Virginia's aquatic ecosystems, and many of the Forest's trout streams are classified as moderately to highly acid sensitive. Additionally, current data suggest that soil nutrient losses may be occurring in sensitive soils on the Forest due to historical and current high acidic deposition levels combined with low buffering capacity of sensitive sites (see *Soil Resource* section). Ozone injury, though not widespread, has been documented on the foliage of ozone-sensitive species, such as black cherry and blackberry, in the Otter Creek Wilderness. Given these adverse impacts currently occurring on the National Forest, air quality in the region cannot be labeled as good.

ENVIRONMENTAL CONSEQUENCES

Resource Protection Methods

Prescribed fire is the main management activity on the Forest that can affect local and regional air quality. However, the current National Fire Plan and the Healthy Forest Initiative both direct the Forest Service to utilize prescribed fire more frequently. Despite potential air quality effects from prescribed fire, it can provide important and necessary ecological benefits in forested landscapes. EPA recognized these ecological benefits and developed the Interim Air Quality Policy on Wildland and Prescribed Fires (US EPA 1998) in an effort to help states implement smoke management programs in cooperation with federal and other land management agencies. This policy provides incentive and guidance to states for developing smoke management programs for dealing with the NAAQS and emissions from prescribed fires, while allowing burning programs to continue. Currently, there are no major wildland burning programs in West Virginia relative to other states, and WVDEP has not developed a smoke management program. However, they may do so in the future, particularly if state-wide prescribed burning programs increase. If the state chooses to develop a smoke management program, it is crucial for the Forest to be involved. In the meantime, however, there are smoke management techniques that the Forest can and should utilize to protect smoke sensitive areas and public welfare, and to meet the NAAQS. Revised Forest-wide management direction states that the Forest will use best available smoke management techniques.

Section 176 (c) of the CAA prohibits Federal agencies from engaging in or supporting any activity that does not conform to a State's Implementation Plan to bring an area back into attainment. As stated previously, there are currently no counties that contain or are adjacent to MNF lands that are in non-attainment status. Greenbrier County near the southern end of the Forest is the only county that contains MNF lands and has a FRM NAAQS ozone monitor. Ozone data from this monitor shows that the area is just below the standard, and it should be identified as a smoke sensitive area.

Effects Common to All Alternatives

An additional alternative, Alternative 2 Modified, was generated between the draft and final stages of the Forest Plan Revision. The only change under Alternative 2 Modified that affects the air quality analysis is the ASQ estimate, which impacts the estimated amount of emissions produced during timber harvest emissions. Prescribed fire activity will be the same under Alternative 2 Modified as under Alternative 2. The air quality effects under Alternative 2 Modified have been added to the emissions tables below.

The level of prescribed fire use is expected to increase under Alternatives 2 and 4, the Need for Change and Vegetation Restoration alternatives, respectively. However, the level of increase varies between these alternatives. The level of prescribed fire use is expected to remain at current levels under Alternatives 1 and 3, the No Action and Backcountry Recreation alternatives, respectively. Despite the varying levels of prescribed fire usage, all wildland fires result in pollutant emissions, which can impact air quality on and off the Forest. Fine particulate is the major pollutant of concern emitted from prescribed fires and is also a criteria pollutant regulated under the CAA. As described previously, fine particulates are a concern in terms of human health and visibility impairment. Prescribed fires also to a lesser extent emit nitrogen oxides, which are precursors to ozone formation and are regulated as a surrogate for ozone. Though both VOCs and NOx contribute to ozone formation, NOx is the limiting factor in ozone production. Because of this, NOx emissions from prescribed fires will be assessed in this analysis in addition to PM emissions. Again, it needs to be stressed that thermal NOx production increases with increased burn temperature. Relatively low-temperature prescribed fires emit very little NOx as compared to wildfires. Prescribed fire situations provide land management agencies with the opportunity to minimize the impacts of smoke on local communities, while a wildfire situation does not typically afford such an opportunity.

To a lesser extent, emissions from equipment used during timber harvest operations also contribute to the total pollution load. Emissions from harvesting equipment include NOx, particulate matter, and hydrocarbons; all of which are criteria pollutants. Although other types of management activities can result in pollutant emissions, timber production is the only other activity that is predicted to change within the next planning period. It is therefore the only other management activity that will analyzed for air quality effects.

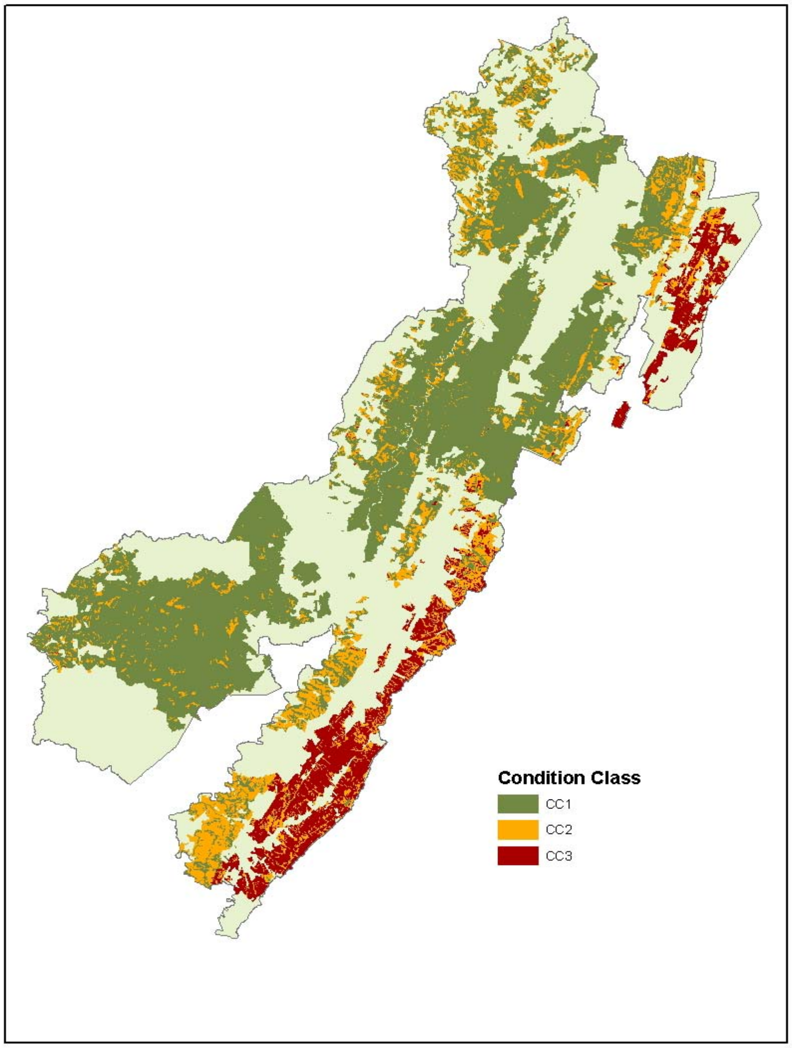
Direct and Indirect Effects by Alternative

Different methods were used in this assessment to derive emission estimates for prescribed fire and timber harvest activities. However, similar methods were used to interpret air quality impacts resulting from the predicted emissions. These analyses and the results by alternative are described below.

Prescribed Fire Emissions

Because prescribed fire activity on the MNF has been minimal in the past, the need to increase the number of acres treated with prescribed fire is understood, but site-specific burn units have not been identified within the scope of this large-scale assessment. The areas on the Forest that are most suitable for, and in the most need of prescribed fire treatments were identified based on best estimates of the fire regimes for the Forest landscape and current Condition Classes of these fire regimes, given the historic fire activity. Figure AQ-4 shows the estimated Condition Classes on the Forest.

Figure AQ-6. Best Estimates of Fire Condition Classes on the MNF



Areas in Condition Class 3 are considered to be the furthest from the natural fire cycle for that area, while those in Condition Class 1 are more or less within the natural cycle. However, the role of fire in the development of eastern forests before European settlement is still being investigated and is not well known for West Virginia and the Monongahela. The ecological role of fire in regeneration of oaks is better documented, and silvicultural systems including prescribed fire have been developed (for example: Schuler and McClain 2003; Brose et al. 2001; and Sutherland 1997). So it must be stressed that prescribed fire usage predictions per alternative are a best estimate that could change in the future as more information on condition class and natural fire cycles for this region becomes available.

Locations of areas in Condition Classes 2 and 3 demonstrate that the eastern and southern portions of the Forest, which lie in the Northern Ridge and Valley section of the Forest, are both more fire dependent, and further from their natural fire cycles. This makes sense because this section of the Forest lies in the rain shadow of the Allegheny Mountains, and tends to be dryer than other sections of the Forest. It is also where oak regeneration is a goal. Prescribed fire activities will be concentrated in the areas that are in Condition Classes 2 and 3.

Management prescriptions were assessed in conjunction with the condition class categories to determine the relative number of acres suitable for prescribed burning within each alternative based on its management emphasis. Using this number, an estimate of potentially treatable acres was developed for each alternative.

Emissions estimates per acre burned in each alternative were derived using the First Order Fire Effects Model (FOFEM, Version 5.00; Rocky Mountain Research Station). This emissions estimate was then multiplied by the number of acres that would be burned each year in each alternative to get an annual emissions estimate. To assess air quality effects, these annual emissions estimates from prescribed fire have been compared to regional annual emissions (all counties within 50 kilometers of the MNF) in tons per year. It is important to note that the number of acres treated with prescribed fire annually is highly dependent on weather and climatic conditions among other local factors. Because there is no way to predict where and when individual prescribed burns will occur, this analysis broadly assumes that the same number of acres will be treated with prescribed fire annually at the maximum level for each alternative. In reality, there would likely be some years with little prescribed fire activity, while others may be much closer to the maximum annual estimate.

The regional emissions data were obtained from the most recent and accurate emissions database available. Currently, this is the 2002 VISTAS base case emissions database. It can be assumed that if predicted emissions from the proposed prescribed fire activities contribute a small enough percentage to the total pollution load, they would not impact attainment of the NAAQS. Most counties within 50 kilometers of the MNF are either in attainment or unclassifiable status. (The exception is Marion County to the North of the MNF; only a portion of the county is within 50 kilometers of the MNF. Marion County is currently exceeding the annual $PM_{2.5}$ standard). A percentage threshold of 5 percent[2] has been chosen for the emissions comparison. If emissions from prescribed fire activities do not exceed 5 percent of the total pollution load in the region, they will be considered below our level of concern.

Because site-specific burn units have not been identified within the scope of this large-scale assessment, fuel loading characteristics are unknown at this time. For this reason a range of fuel loading characteristics that were deemed representative of portions of the Forest with potentially treatable acres were used in the emissions analysis. Fuel loading characteristics for more mesic sites with mixed oak and hardwood species were modeled to represent the treatable acres on the western side of the Forest, and fuel loading characteristics for dryer mixed oak and chestnut oak sites were modeled to represent the eastern sites. The range of potential emissions from the various fuel loading characteristics and their effects on air quality are presented in Table AQ-1.

[2] The threshold of 5% was chosen to be very conservative in protecting air quality. Air regulations often include a 5% change as a significance threshold for more rigorous or refined air quality analyses. Though we are more concerned with Forest emissions on the NAAQS, this threshold seemed appropriate for this analysis because PSD increments represent a percentage of the total NAAQS. Also, this percentage is significantly less than the percentage that conformity thresholds comprise of the total NAAQS for NO_x and PM_{10}.

Alternative Comparison - Emission estimates per acre burned were derived from the FOFEM model. The number of acres burned varied by alternative, and thus the prescribed fire annual emissions also varied. Under Alternatives 1 and 3, maximum prescribed fire usage is expected to remain at current levels, which is 300 acres treated per year. Under Alternative 2 and Alternative 2 Modified, prescribed fire usage would increase to a maximum 3,000 acres per year. Under Alternative 4, prescribed fire usage would increase to a maximum 7,500 acres per year. The results for each alternative are presented in Table AQ-1.

Table AQ-1. Fire Emissions from Predicted Prescribed Fire on the MNF

Alternative	Pollutant	Rx Fire Emissions (Tons per Year)	Total Regional Emissions (Tons per year)	Percent Rx Fire of Total Regional Emissions
Alternative 1 300 Acres Treated	**PM 10**	12.2 – 22.7	122,957	0.01% – 0.02%
	PM 2.5	10.4 – 19.4	38,968	0.03% – 0.05%
	NOx	2.0 – 5.7	212,477	0.001% – 0.003%
Alternative 2 3,000 Acres Treated	**PM 10**	121.5 – 226.5	122,957	0.10% – 0.18%
	PM 2.5	103.5 – 193.5	38,968	0.27% – 0.50%
	NOx	19.5 – 57	212,477	0.01% – 0.03%
Alternative 2M 3,000 Acres Treated	**PM 10**	121.5 – 226.5	122,957	0.10% – 0.18%
	PM 2.5	103.5 – 193.5	38,968	0.27% – 0.50%
	NOx	19.5 – 57	212,477	0.01% – 0.03%
Alternative 3 300 Acres Treated	**PM 10**	12.2 – 22.7	122,957	0.01% – 0.02%
	PM 2.5	10.4 – 19.4	38,968	0.03% – 0.05%
	NOx	2.0 – 5.7	212,477	0.001% – 0.003%
Alternative 4 7,500 Acres Treated	**PM 10**	303.8 – 566.3	122,957	0.25% – 0.46%
	PM 2.5	258.8 – 483.8	38,968	0.66% – 1.24%
	NOx	48.8 – 142.5	212,477	0.02% – 0.07%

Annual emission estimates from prescribed fire activity in all alternatives are well below the regional pollution contribution threshold of 5 percent and therefore are not a major concern. This however does not preclude the Forest from using the best available smoke management techniques and technology to alleviate nuisance or human health impacts of smoke in local communities and smoke sensitive areas, or from avoiding impacting attainment status for any criteria pollutant in areas where burns are conducted.

Timber Harvest Emissions

Rough emissions estimates were made using some basic assumptions that have been developed for typical timber harvests in mountainous areas, such as the types of equipment that are likely to be used, the number of hours a day this equipment would be operating, and how many days out of the year this will occur based on the total volume of timber removed. Using these assumptions, an estimate of the hours of operation for each piece of equipment was derived and this was multiplied by an emissions factor (in pounds per hour) for each type of equipment. Emission factors used were developed by the Environmental Protection Agency (EPA)[3]. These emissions were then converted to tons per year for comparison to regional emissions.

Between the draft and final version of this analysis, a method for estimating emissions from helicopters during helicopter yarding operations was developed. Emission factors for helicopter engines were taken from EPA's Procedures for Emission Inventory Preparation Volume IV (EPA, 1992). As with emission estimates for conventional harvest operations, basic assumptions were made to determine the average hours of operation for the helicopter in the varying range of flight modes, as well as other associated equipment used at the site during a typical helicopter yarding operation. These estimates were multiplied by the EPA emission factors to get the total annualized emissions estimates for each alternative. In this FEIS, the estimates of total emissions generated by timber harvest activities under each alternative reflect the updated information for helicopter yarding; in the calculations, harvest operations were broken out by harvesting method and emissions were estimated for each using the appropriate emission factors and then combined to get the total emissions estimate. Therefore, emission estimates reported in this version of the EIS will vary from those reported in the draft version.

Because the exact timing of harvesting activities can not be predicted within the scope of this large-scale assessment, the estimates are based on the total volume removed in each alternative, which was apportioned equally over the ten-year planning period for which harvest activities are expected to occur. For example, the total volume of timber that could be removed in each alternative was divided by 10, to get an annual estimate of timber harvested each year.

As in the prescribed fire analysis, emissions from timber harvest activities were interpreted in the context of the regional pollution load. The estimated annual emissions were compared to total annual emissions from all counties within 50 kilometers of the Forest. Again, the emissions data for the analysis area were obtained from the 2002 VISTAS base case emissions database, and the 5 percent of total region emissions threshold was used for the comparison.

Alternative Comparison - Table AQ-2 shows that annual emission estimates from timber harvest activities in all alternatives are well below the regional pollution contribution threshold of 5 percent and therefore are not a major concern.

[3] EPA420-F-97-014 - Emission Standards Reference Guide for Heavy-Duty & Nonroad Engines, September 1997, EPA420-R-979-009 - Exhaust Emission Factors for Nonroad Engine Modeling - Spark Ignition, Feb. 24, 1998, Revised March 30, 1999, EPA420-P-02-016- Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition, November 2002

Table AQ-2. Emissions from Timber Harvest on the MNF

Alternative	Pollutant	Timber Harvest Related Emissions (Tons per Year)	Total Regional Emissions (Tons per year)	Percent Timber Harvest of Total Regional Emissions
Alternative 1	**VOC**	110.8	118,251	0.094%
	NO_x	85.5	212,477	0.040%
	PM	5.1	161,925	0.003%
Alternative 2	**VOC**	110.2	118,251	0.093%
	NO_x	84.1	212,477	0.040%
	PM	5.05	161,925	0.003%
Alternative 2 Modified	**VOC**	109.7	118,251	0.093%
	NO_x	83.7	212,477	0.039%
	PM	5.03	161,925	0.003%
Alternative 3	**VOC**	87.4	118,251	0.074%
	NO_x	66.5	212,477	0.031%
	PM	3.99	161,925	0.003%
Alternative 4	**VOC**	115.2	118,251	0.097%
	NO_x	87.3	212,477	0.041%
	PM	5.2	161,925	0.003%

*Emissions estimates are based on an estimated annual average ASQ (CCF) over the life of the plan. This is a conservative estimate, as the actual volume of timber removed will likely be less than the ASQ.

Cumulative Effects

Cumulative effects of air pollution from Forest management activities were assessed using the combined effect of prescribed fire and timber harvest emissions by alternative. These results are in Table AQ-3. The cumulative effects were derived using the upper range of emissions from prescribed fire activity based on fuel loadings. Also particulate matter was broken out into the $PM_{2.5}$ and PM_{10} size classes for the prescribed fire analysis; these values were summed with the timber harvest particulate estimates, to get the cumulative estimate.

Given that the both prescribed fire and timber harvest emissions comprise such a small percentage of the regional pollution load, the cumulative effects of these Forest management emissions are still below the 5 percent emissions threshold and are therefore not a major concern.

Table AQ-3. Cumulative Emission Estimates for Management Activities on the MNF

Alternative	Pollutant	MNF Total Management Emissions (Tons per Year)	Total Regional Emissions (Tons per year)	Percent MNF Management Activities of Total Regional Emissions
Alternative 1	**VOC**	110.8	118,251	0.09%
	NO_x	91.2	212,477	0.04%
	PM	47.2	161,925	0.03%
Alternative 2	**VOC**	110.2	118,251	0.09%
	NO_x	141.1	212,477	0.07%
	PM	425.1	161,925	0.26%
Alternative 2 Modified	**VOC**	109.7	118,251	0.09%
	NO_x	83.7	212,477	0.04%
	PM	5.0	161,925	0.00%
Alternative 3	**VOC**	87.4	118,251	0.07%
	NO_x	72.2	212,477	0.03%
	PM	46.1	161,925	0.03%
Alternative 4	**VOC**	115.2	118,251	0.10%
	NO_x	229.8	212,477	0.11%
	PM	1,055.3	161,925	0.65%

The previous analyses show that estimated emissions from MNF management activities are expected to comprise only a small percentage of the total regional pollution load. While the MNF must be cognizant of air quality effects resulting from management activities, the Forest must also consider how air pollution from sources external to the MNF affect forest resources such as water quality and soil productivity, and in turn how this may guide management decisions. Air pollution disperses beyond political or jurisdictional boundaries, and regardless of the pollution source, air pollutants can have adverse effects on Forest resources and visitor experience. The Current Conditions section documents that some sensitive resources on the MNF are already adversely affected. A general misconception is that the MNF has no role to play in reducing, minimizing, or mitigating adverse air pollution impacts to the Forest from external sources, such as electric generating stations, industrial processes, and automobiles. Although it has been stated elsewhere in this document, there are ways in which the MNF can participate in the regulatory arena; these have been reiterated below.

First, federal land managers can, and in some cases are required by law, to participate in regulatory actions such as PSD permitting processes and Regional Planning Organizations aimed at reducing the impacts of regional haze and other pollution related impacts in Class I areas. Though these regulatory processes, federal land managers advise and provide consultation to state and federal air regulatory agencies on how new and existing sources of air pollution are affecting the resources and Class I areas on the MNF. This process of consultation has the potential to directly affect the outcome of regulatory decisions related to air quality. The revised MNF Forest Plan contains goals, objectives and standards aimed at continued involvement in these regulatory processes in effort to reduce, to the greatest extent possible, harmful levels of pollution inputs on the Forest.

Second, it is important not only to understand not only how much pollution is reaching the Forest, but how these current levels of pollution are affecting Forest resources. Long-term air quality monitoring on and near the MNF has helped establish air pollution trends, but determining what levels of pollution reductions are needed to restore areas already negatively affected and protect those that are at risk but not yet showing decline is not as well understood. For example, it is well known that many streams on the MNF have been adversely affected by acid deposition and have exhibited changes in stream chemistry, but changes in soil chemistry, and in turn, changes in vegetation are not as well documented or studied. Having a better understanding how sensitive soils are being affected would provide a more complete picture of the pollution problem and valuable information for resource management decisions. The MNF has begun to address this issue in this Forest Plan revision, and will continue to initiate and support monitoring and information-gathering efforts on the Forest. Additionally, determining terrestrial and aquatic critical loads (and setting target loads) for the MNF would assist resource manager in understanding the impacts of current levels of acidic deposition as well as effectively communicating these impacts to state air regulators and members of the public.