2.2 AIR

Under the 2012 Planning Rule, National Forests and Grasslands are required to consider air quality when developing Plan components. As set forth in the Rule, air resources should be treated similarly to water and soil resources. The recently proposed Planning Rule Directives require the following to be included in the air quality section of each National Forest's Assessment:

1. Airshed identification;
2. Location and extent of known sensitive air quality areas;
3. Emissions inventories, conditions and trends;
4. Analysis of State Implementation Plans (SIPs); and
5. Critical Loads identification, as appropriate.

2.2.1 EXISITING INFORMATION

Current Forest Plan: The overarching goal regarding air quality in the current Francis Marion National Forest Plan is to "take care of the land by continuing to restore and sustain the integrity of its…air". The desired future condition is to maintain air quality, and ensure that air quality near Cape Romain National Wildlife Refuge complements the high air quality standards found at that Class I Area. The plan recognizes that portions of the Forest may experience some localized and temporary reductions in air quality due to prescribed burning. The Forest Plan requires the use of best and emerging smoke management technologies to reduce downwind impacts from smoke and ensure compliance with the Clean Air Act (including visibility at the nearby Class I Area) and South Carolina's Smoke Management Guidelines. Per the Plan, all management activities, not just prescribed fire, should comply with air quality standards.

Current Air Quality Concerns: In addition to causing human health concerns, air pollution can also affect natural and scenic resources such as lakes, streams, plants, wildlife and scenic vistas. Each year, air pollution sources including power plants, industrial facilities, automobiles and wildland fires release millions of tons of pollutants into the atmosphere. These pollutants, either by themselves or after chemical transformations in the lower atmosphere, can cause negative impacts to ecosystems, including changes to soil and water chemistry from acidic deposition, nutrient enrichment (i.e. nitrogen saturation) from too much nitrogen deposition, impacts to sensitive vegetation due to elevated ozone exposures, and increased visibility impairment – or haze – of scenic areas.

Air pollutants of most concern to natural resources on the Francis Marion National Forest include ozone, particulate matter, sulfur dioxide, nitrogen oxides and mercury. Ozone is a pollutant formed by emissions of nitrogen oxides and volatile organic compounds in the presence of sunlight. Nitrogen oxides (NO_x) are released when any fuel is combusted at very high temperatures; major sources of NO_x include automobiles, power plants and industrial boilers. Volatile organic compounds (VOCs) are emitted from both manmade and natural sources, including chemical manufacturing, gasoline-powered vehicles, trees and vegetation. Research has shown that in the southern US there is an overabundance of naturally-occurring VOCs, and thus ozone formation is "NO_x-limited.” This means that the concentration of ambient ozone is primarily dependent on the amount of nitrogen oxide emitted into the air. When ozone is formed, it causes human health concerns as well as negative impacts to vegetation. Specifically, elevated ozone concentrations can reduce the health and vigor of sensitive vegetation and reduce plant growth. The US Environmental Protection Agency (EPA), as directed by Congress, has set a national ambient air quality standard (NAAQS) of 0.075 parts per million (ppm) to protect both human health and the environment.

Particulate matter is a mixture of extremely small particles made up of soil, dust, organic chemicals, metals, and sulfate and nitrate acids. The size of the particles is directly linked to health effects, with smaller particles causing the worst impacts to human health. Additionally, particulate matter is the main cause of visibility impairment. These tiny particles absorb and reflect light which diminishes spectacular views in National Forests. Regional haze usually covers large geographical areas, and many local and regional sources of pollution contribute to the degraded visibility conditions. EPA has set NAAQS for ultra-small (less than 2.5 microns in diameter) particulate matter on both a short-term (24-hour) and annual basis to protect human health and visibility. The 24-hour fine particulate matter ($PM_{2.5}$) NAAQS to protect both humans and the environment is currently set at 35 $\mu g/m^3$, while the annual $PM_{2.5}$ NAAQS for human health is 12 $\mu g/m^3$.

Sulfur and nitrogen deposition can cause stream acidification and leaching of important soil nutrients needed for healthy terrestrial and aquatic biota. Nitrogen deposition can also cause eutrophication or nutrient enrichment that negatively impacts water quality, aquatic biota, and may increase invasive plant growth. Sulfur comes primarily from the combustion of coal at electrical generating units. Nitrogen compounds are derived from both the combustion of fuel at very high temperatures (such as in power plants, industrial boilers, and automobiles) as well as from various agricultural processes. Although EPA has considered setting a multi-pollutant NAAQS to address deposition-related affects, they have decided there currently is not enough scientific information to set one standard that would adequately protect the diverse ecosystems across the country.

Mercury is another important environmental contaminant that reaches the forest primarily through atmospheric deposition. The primary source of anthropogenic (manmade) mercury is the combustion of coal. Mercury is fairly stable and accumulates in the environment until conditions are right for dispersal. This can occur by wildland fires ejecting the mercury back into the atmosphere, or when associated with wetlands it can be converted via sulfate reduction to its most toxic form, methyl mercury (MeHg). The MeHg is ingested by aquatic organisms and bioaccumulates as it is transported through the food web, and can affect humans when too many fish are consumed in one week. Unhealthy levels of MeHg have led to fish consumption advisories in almost every state. Methyl mercury has also been found in numerous species of wildlife. EPA regulates the amount of mercury that is emitted into the air from many different sources, including power plants, municipal waste combustors and medical waste incinerators. Additionally, each state is required by EPA to develop a list of water bodies that don’t meet water quality standards – including those impaired by mercury, if applicable – and establish a total maximum daily loads (TMDLs) for these waters.

Air pollution can come from local sources – such as activities within the National Forests – or may be transported from distant sources hundreds of miles upwind by weather patterns. Therefore, it is important to identify the airshed around an area of interest, such as the Francis Marion National Forest. An airshed is defined as a geographic area that, due to topography, meteorology and/or climate, is frequently affected by the same air mass. For the purposes of this assessment, the airshed for the Francis Marion National Forest is defined as the counties that fall within a 124-mile radius around the Forest. Figure 2.2.1.1 shows the counties (shaded) located within 124 miles of the Forest as well as known sensitive air quality areas. These sensitive areas include the location of Class I and Nonattainment areas within the designated airshed. As shown, the only Class I area is Cape Romain National Wildlife Refuge (NWR), located just east of the Francis Marion National Forest. There is one nonattainment area partially located within the airshed, the Charlotte-Rock Hill Nonattainment Area for ozone. There are no other nonattainment or maintenance areas within the airshed.

Figure 2.2.1: Map of Francis Marion National Forest airshed (shaded) and known sensitive air quality areas.

2.2.2 CURRENT CONDITION AND TRENDS

To assess current air quality conditions and trends on the Francis Marion National Forest, there are four categories of data to examine. The first category involves inventories of emissions from air pollution sources both on and off the Forest. The second category includes measured ambient concentrations of air pollution, especially ozone and fine particulate matter. The third category of data is measured deposition of sulfates, total nitrogen and mercury. Finally, the last category of data includes any site-specific monitoring of air quality impacts (e.g., ozone surveys) that has occurred on the Forest.

2.2.2.1 Air Pollution Emissions Trends

The National Emissions Inventory (NEI) (http://www.epa.gov/ttn/chief/eiinformation.html) was used to assess the historic trends of air pollution emissions near the Francis Marion National Forest. Local, state and tribal air regulatory agencies are required by the EPA to periodically inventory the amount of emissions within their respective jurisdictions. These inventories form the basis for air pollution trends analysis, air quality modeling efforts and regulatory impact assessments. At this time, the NEI website has inventory data for the years 2002, 2005 and 2008 available for download. County emissions estimates for the 59 counties that fall within 124 miles of the Francis Marion National Forest were downloaded and compiled for each of three years.

The pollutants that are of most concern to resources on the National Forests are those that have the potential to cause the negative impacts that have been outlined in Section 2.2.1, above. Of those, the NEI inventories emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM). The table below shows the total emissions within the airshed for each of these pollutants for 2002, 2005 and 2008.

Table 2.2.2.1: Emission of sulfur dioxide, nitrogen oxides and particulate matter within the airshed for the years 2002, 2005, and 2008.

Pollutant	***Emissions (tons/year)***			***Percent (%) Change in Emissions (2002-2008)***
	2002	***2005***	***2008***	
Sulfur Dioxide (SO_2)	382,580	380,422	260,698	-31.8%
Nitrogen Oxides (NO_x)	425,217	386,348	350,047	-17.7%
Particulate Matter < 10 µm in diameter (PM_{10})	347,000	352,730	329,259	-5.1%
Particulate Matter < 2.5 µm in diameter ($PM_{2.5}$)	103,769	112,506	114,651	+10.5%

The reductions identified above mirror national trends as outlined in "Our Nation's Air: Status and Trends through 2010" (http://www.epa.gov/airtrends/2011/report/fullreport.pdf). Since 1990, annual emissions of SO_2 have declined by more than 60 percent, while emissions of NO_x have fallen by more than 40 percent in the United States. These reductions have taken place despite increases in population, energy consumption and the number of miles driven. Figure 2.2.2.1 shows these trends. Trends on mercury emissions, another pollutant of concern, have been difficult to evaluate due to the lack of appropriate emission factors, lack of speciated data, and lack of acceptable tests for mercury-emitting sources (SC Mercury Assessment and Reduction Initiative, 2010).

Emission reductions over the past decade have been achieved as a result of new regulations, voluntary measures taken by industry, and the development of public-private partnerships. It is expected that air quality will continue to improve as recently adopted regulations are fully implemented, and as a result, it is anticipated that emissions of air pollution released within 124 miles of the Francis Marion National Forest will continue to decline.

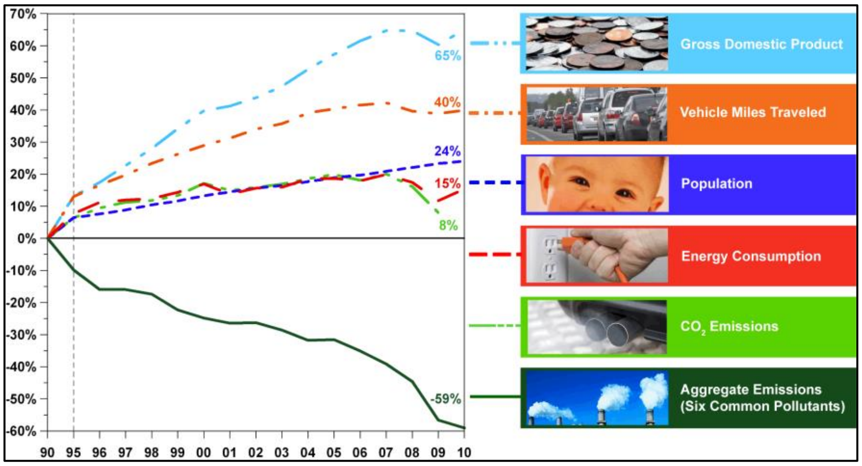


Figure 2.2.2.1: Comparison of growth measures and emissions, 1990-2010 (taken from http://www.epa.gov/airtrends/2011/report/fullreport.pdf).

In addition to emissions of sources near the Forest, emissions from Forest activities, specifically prescribed fire, were calculated. Figure 2.2.2.1 shows the trends in fine particulate matter emissions from prescribed fires on the Francis Marion National Forest from 2006 through 2011.

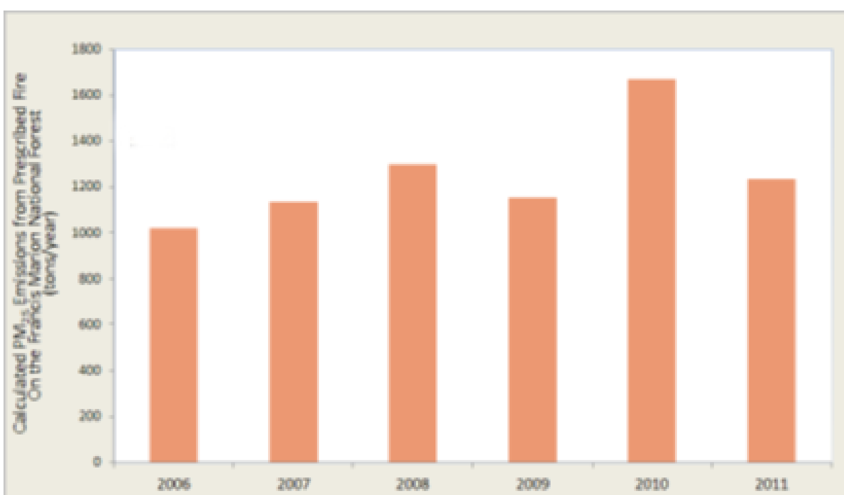


Figure 2.2.2.1: Emissions of fine particulate matter from prescribed fires on the Francis Marion National Forest, 2006 through 2011.

2.2.2.2 Ambient Air Quality Trends

Ambient concentrations of air pollutants, including ozone and fine particulate matter, are measured by the South Carolina Department of Health and Environmental Control (SC DHEC) at locations near the Forest. The map shown in Figure 2.2.2.2.1 displays the location of the monitoring sites used in this assessment. This includes ground-level ozone concentrations at two locations and fine particulate matter monitoring at two locations near the Forest. The measurements are compared to the appropriate NAAQS to assess whether air quality is healthy or not.

Figure 2.2.2.2.1: Location of ozone and fine particulate matter monitoring sites used in this assessment of air quality.

Figure 2.2.2.2.2 shows the ozone concentrations at two monitoring sites close to the National Forest. The measured concentrations (blue open circles) for the years 2004-2012 are compared to ozone NAAQS (red line), and results are also given on the statistical trends. Ozone monitors near the Francis Marion National Forest have not exceeded the current ozone standard since 2005. Ozone levels appear to be fairly level, with no statistically significant trend either upward or downward. EPA is required to reassess the standards every five years based on most recent scientific research, and as a result more stringent standards may be proposed sometime in the future.

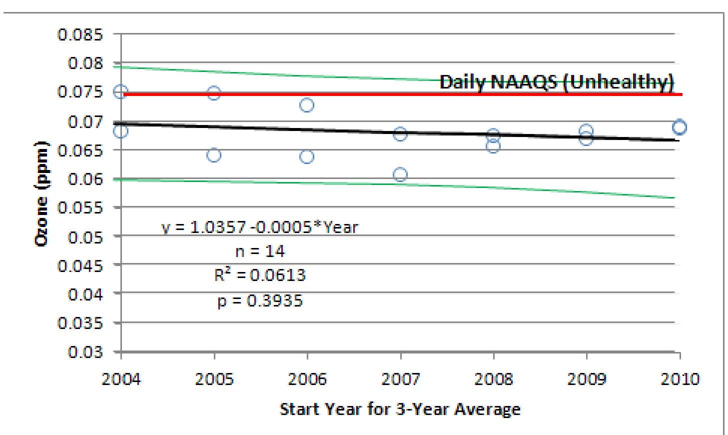


Figure 2.2.2.2.2: Statistical trend in ozone near the Francis Marion National Forest. The blue open circles are the 3-year average of the

4th highest ozone concentrations at the monitoring sites in Berkeley or Charleston County. The black line is the predicted values for ozone, while the green lines are the 95% confidence intervals for the estimate. The red line is the current National Ambient Air Quality Standard (NAAQS). The downward trend of ozone is not significant ($p > 0.05$). The unit of measure is parts per million (ppm).

The next set of figures show the fine particulate matter concentrations at monitoring sites close to the National Forest. In Figure 2.2.2.2.4, the measured concentrations (open blue circles) for the years 2004-2012 are compared to both the daily (24-hour) and annual NAAQS (red lines). The monitors near Francis Marion National Forest have not exceeded either the daily or the current annual fine particulate matter standard since 2006. Levels of ambient fine particulate matter are experiencing a statistically significant downward trend over the same time period. As with ozone, EPA is required to reassess the standards every five years based on most recent scientific research, and as a result more stringent standards may be proposed sometime in the future.

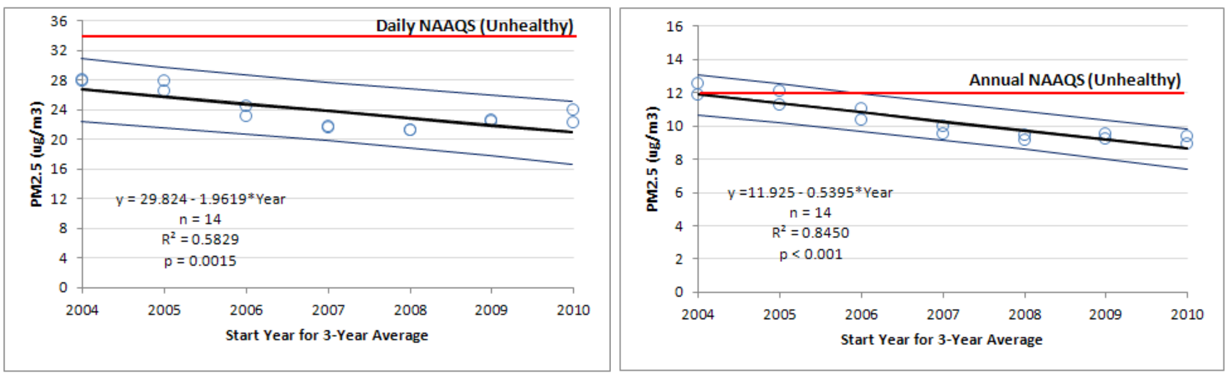
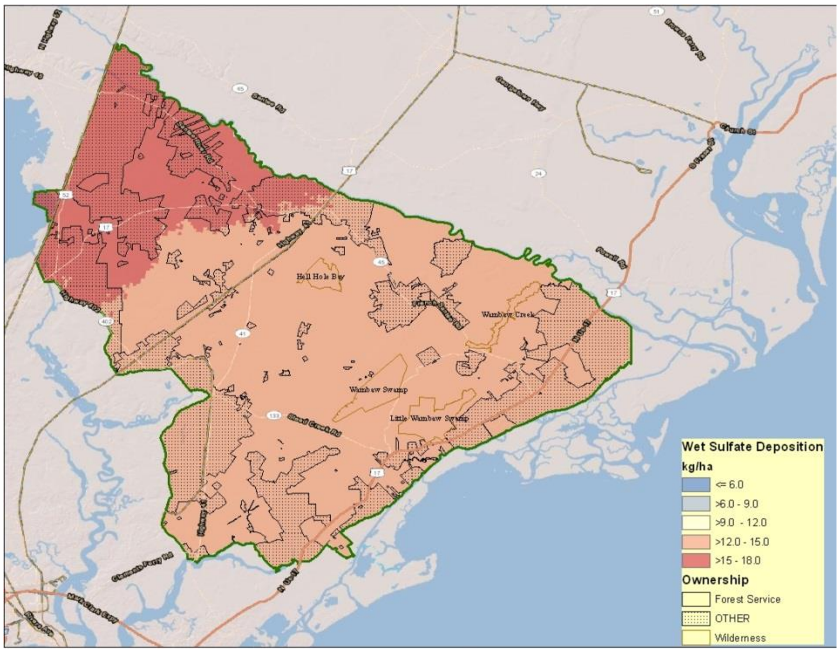


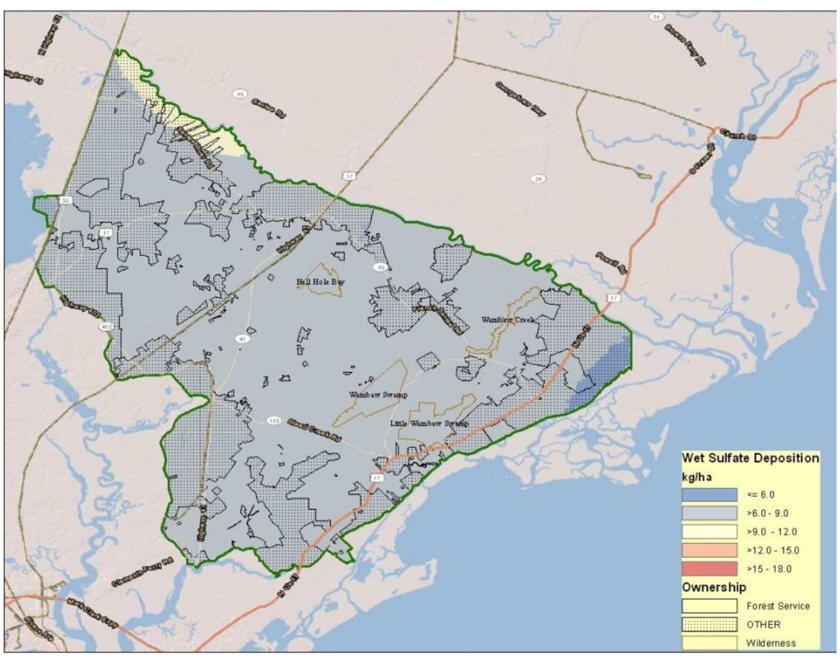
Figure 2.2.2.2.4: Statistical trends in fine particulate matter ($PM_{2.5}$) near the Francis Marion National Forest for the daily (left) and annual (right) National Ambient Air Quality Standard (NAAQS). The blue open circles are the 3-year average of the concentrations measured at the monitoring sites in Charleston County. The black line is the predicted values for ozone, while the blue lines are the 95% confidence intervals for the estimate. The red line is the current NAAQS. The downward trend in fine particulate matter is significant ($p < 0.05$). The unit of measure is micrograms per cubic meter ($\mu g/m^3$).

2.2.2.3 Deposition of Sulfates, Total Nitrogen, and Mercury

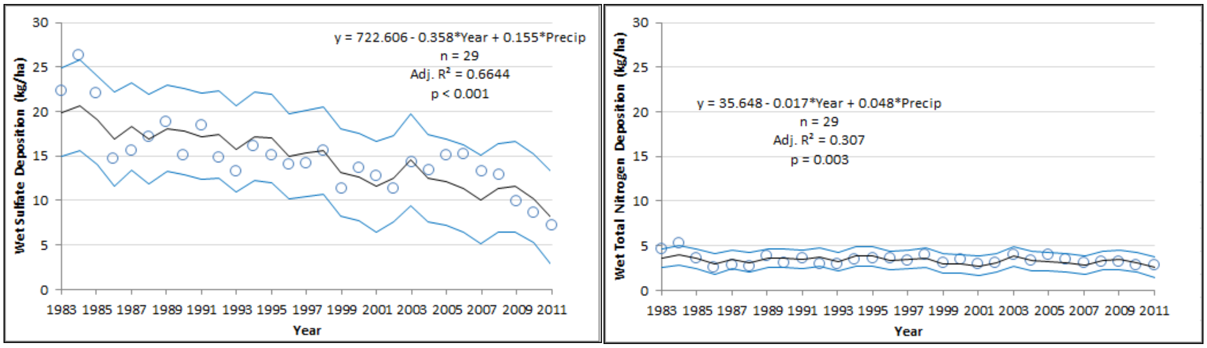
Acidic (sulfur and nitrogen) compounds can be deposited from the atmosphere in a dry form (first seen as haze), in rainfall (wet), and in clouds or fog. Most of the deposition of sulfates and total nitrogen (nitrates and ammonia) on the Francis Marion National Forest occurs in the rain. The National Atmospheric Deposition Program (NADP) provides a long-term record of acidic deposition at sites located throughout the United States and monitoring of deposition has occurred on Cape Romain NWR since the year 2000. The NADP acidic deposition data was combined with precipitation and other data to statistically estimate the forest-wide annual sulfate and total nitrogen deposition from rainfall for the years 1983 through 2011 (Grimm and Lynch, 2004).

Sulfates are the most abundant acid compound deposited from the atmosphere and they continue to impact the soils on the Francis Marion National Forest. In 1983, the amount of sulfate deposition from the rainfall was greater than 12 kilograms per hectare (which is roughly equivalent to 12 pounds per acre) with the greatest deposition occurring in the northwest corner of the Forest. Large reductions of sulfur dioxide (the precursor to sulfates) have decreased significantly since 1977 and the 2011 estimated sulfate deposition for most of the Forest was 9 kg/ha or less (Figure 2.2.2.3.1). Figure 2.2.2.3.2 shows that forest-wide annual average sulfate and total nitrogen deposition from rainfall has significantly declined between 1983 and 2011.





Figures 2.2.2.3.1: Estimated forest-wide wet sulfate deposition for 1983 (top) and 2011 (bottom) have shown a significant decline. The unit of measure is kilograms per hectare (kg/ha). One kg/ha is approximately the same as one pound per acre. Deposition estimates based upon the approach used by Grimm and Lynch (2004).



Figures 2.2.2.3.2: Trends in the average annual sulfate (left) and total nitrogen (right) wet deposition estimates (blue open circles) within the Francis Marion National Forest proclamation boundary (Grimm and Lynch, 2004). The black line is the predicted wet sulfate or total nitrogen deposition, while the blue lines are the 95% confidence intervals for the estimates. The downward trend in wet sulfate and wet total nitrogen deposition is significant ($p < 0.05$). The unit of measure is kilograms per hectare (kg/ha). One kg/ha is approximately the same as one pound per acre.

Another air pollutant that can be deposited and have a negative impact on the ecosystem is mercury. Once mercury deposition occurs, it is often transformed by wetlands into methyl mercury (MeHg), which bioaccumulates in fish. Wetlands, which are found throughout the Francis Marion National Forest, are important sinks for mercury, as well as sources of methyl mercury. Fish consumption advisories are common throughout coastal South Carolina due to methyl mercury, as shown in Figure 2.2.2.3.3. The National Water-Quality Assessment Program (NAWQA) established by the US Geological Survey found that the Santee Basin (which includes the Forest) has the highest methylation efficiency in the nation.

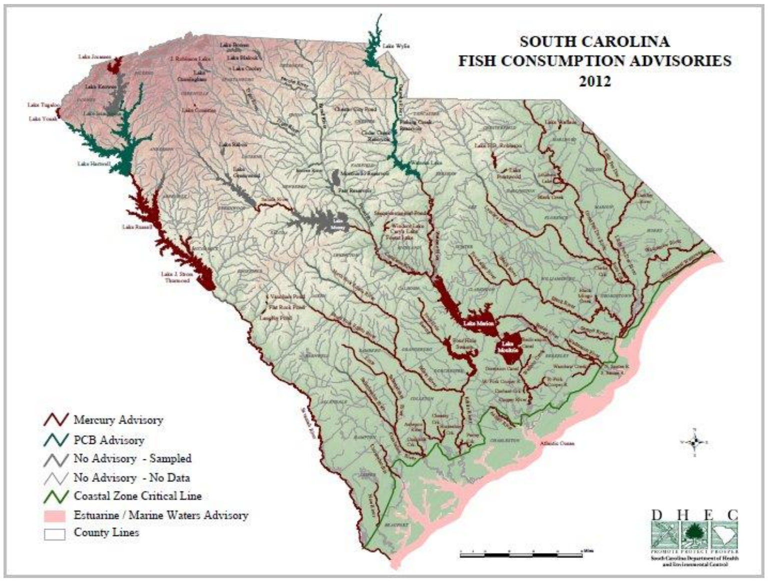


Figure 2.2.2.3.3: Fish consumption advisories in South Carolina (taken from http://www.scdhec.gov/environment/water/fish/docs/map.pdf).

NADP operates the Mercury Deposition Network (MDN) which provides data on geographic distributions and trends of mercury in precipitation. MDN has operated a site on Cape Romain NWR since 2004. Results from the monitoring (http://nadp.sws.uiuc.edu/mdn/) indicate that Cape Romain (and likely the nearby Francis Marion National Forest) receives more than 10 micrograms per square meter of mercury deposition.

In the past, South Carolina has recognized that many water bodies within the state, including those adjacent to the Francis Marion National Forest, do not meet state water quality standards for mercury (http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_06-303d.pdf). More recently, SC DHEC has listed mercury as a 303D pollutant, but has not included the parameter of mercury when setting forth TMDLs, because procedures to deal with this pollutant have not been developed. (http://www.scdhec.gov/environment/water/tmdl/tmdlsc.htm).

2.2.2.4 Site-Specific Monitoring

As part of the Wilderness Challenge, in 2011 an ozone biomonitoring project occurred on the Francis Marion National Forest in four Wilderness Areas: Hell Hole Bay, Wambaw Swamp, Little Wambaw Swamp, and Wambaw Creek. The purpose of this project was to determine whether ozone exposures in the wilderness areas, as measured via symptoms, where causing a physiological response to sensitive vegetation. Nearby ambient monitoring data were also utilized to examine if ozone exposures could be causing biomass reductions to tulip poplar (an ozone sensitive species). The results of this project indicate that ozone is causing minimal impacts to sensitive vegetation occurring in these wilderness areas (Stratton, 2011).

Other water inventories and assessments near the Wildernesses have focused on mercury and methylmercury in fish, rather than acid deposition. In 2003 Koman and Hanson reported on the status of water quality information on the Forest and focused on parameters such as fecal coliform, dissolved oxygen, conductivity and salinity, total mercury and methylmercury in fish, mud and water (Koman and Hanson, 2003).

2.2.2.5 Involvement with State Implementation Plans (SIPs) for Regional Haze

The USDA Forest Service is cooperating with the SC DHEC and other air regulatory agencies to identify air pollution emission reduction strategies to achieve natural background visibility at federally mandated Class I Areas. Additionally, the Forest Service has worked with the Regional Planning Organization (VISTAS) to ensure that emissions from Forest Service activities, especially prescribed fires, are included in the emissions inventories for the respective SIPs.

Measurements of visibility-impairing pollutants are made at the IMPROVE (Interagency Monitoring of Protected Visual Environments) site located at Cape Romain NWR, a federally mandated Class I Area, just to the east of Francis Marion National Forest. The IMPROVE monitor measures the concentration of different types of fine particles and these measurements are used to estimate visibility in deciviews. Each change in deciview is equivalent to a noticeable change in visibility; higher deciview values indicate hazier conditions, while lower values signify clearer air. The IMPROVE data are used to determine whether visibility is improving at the level required by the Regional Haze Rule. The Regional Haze Rule established a uniform rate of progress, also called a glide path, for each Class I Area to measure if enough progress is being made to meet natural background conditions by the year 2064. Figure 2.2.2.5.1 shows the 5-year average haziness index (light blue line) at Cape Romain NWR increased above the glide path (pink line), but recently improved for the most recent 5-year average to match the glide path required by the Regional Haze Rule.

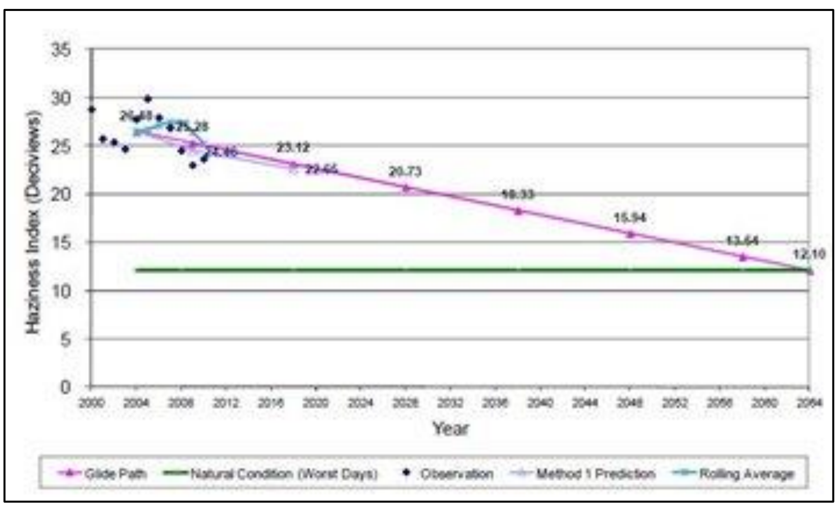


Figure 2.2.2.5.1: Measured visibility (worst visibility days) as compared to the glide path at Cape Romain NWR Class I Area (taken from SC SIPR: Regional Haze Periodic Report).

National and regional databases are weak at providing estimates of the amount of air pollution emissions from prescribed fires. To overcome this weakness, the USDA Forest Service assisted the VISTAS and the state air regulatory agencies by providing information on the time of the prescribed fires, location, and size of prescribed fires that occurred in 2002 and estimates for

2018. There were an estimated 23,962 blackened acres in 2002 and by 2018 the number of acres is projected to increase to 45,206 acres (Figure 2.2.2.5.2). The estimated number of blackened acres has been less than 45,000 acres between 2005 and 2011, except there were 50,569 blackened acres reported in 2010. Figure 2.2.2.5.1 shows the 2010 observed haziness index (blue dot) was below the glide path, which indicates the higher than projected blackened acres from prescribed fires in 2010 did not impede the regional haze goal at Cape Romain NWR.

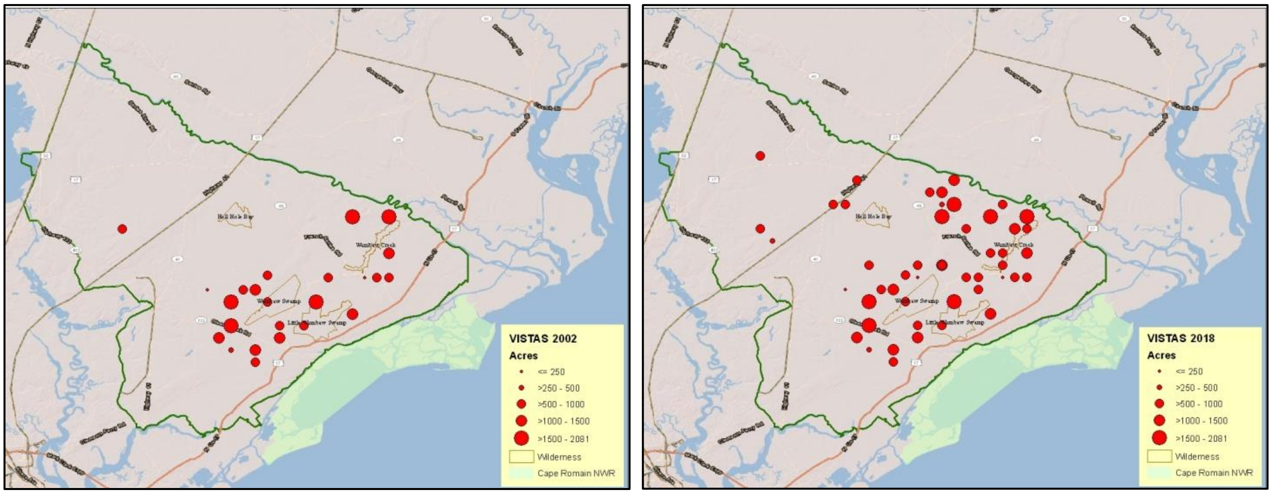


Figure 2.2.2.5.2: Location of prescribed fires in 2002 and those planned for 2018 on the Francis Marion National Forest. The data was utilized in an atmospheric dispersion modeling analysis to evaluate if visibility at Cape Romain National Wildlife Refuge (NWR) is predicted to improve by 2018.

2.2.2.6 Critical Loads for Soil Acidification on the Francis Marion National Forest

Many people are concerned that acidic deposition has and will continue to severely impact the health of terrestrial and aquatic resources. The deposition of sulfur and nitrogen compounds from the atmosphere can accelerate the loss of base cations (calcium, magnesium, and potassium) from the soils. Adequate supplies of base cations are needed in the soil to maintain healthy forests. One question that may be asked: Is the current sulfur and nitrogen deposition exceeding a level where no harm is likely to occur to sensitive components of the ecosystem? The total amount of sulfur plus nitrogen deposition that can be tolerated is called a critical load and it can be established to protect forest soils and/or sensitive biota. Current scientific knowledge is to be used when establishing critical loads for acidification. Estimates developed by McNulty et al. (2007) are being used in this assessment to identify if acidic deposition on any areas on the Francis Marion National Forest is exceeding the critical load.

McNulty et al. (2007) calculated the steady state critical load by obtaining spatial information for the Francis Marion National Forest. Estimates for some of the information needed included:

1. The annual amount of base cations (calcium, magnesium, potassium, and sodium) deposited from the atmosphere.
2. The base cation (calcium, magnesium, and potassium) weathering rate based upon the percent clay in the soils, and the parent geology.

3. The amount of base cations and nitrogen removed from a site when periodic timber harvesting occurs.
4. The amount of inorganic nitrogen deposited from the atmosphere that is converted to organic nitrogen in the soils.
5. The average annual runoff based upon data collected between 1951 and 1990.
6. The critical base cations to aluminum ratio that was set to 1.0 for conifer forests and 10.0 for deciduous forests.

The information obtained for these variables, along with others, were used in an equation to estimate the forest soil acid load. McNulty et al. (2007) subtracted the forest soil acid load from the average (1994 – 2000) annual acidity deposition estimates (sulfur plus nitrogen). Values that were zero or a negative number means the deposition of acids from the atmosphere did not exceed the calculated forest soil acid load; whereas values above zero indicate the average acidic deposition exceeds the amount the soils can buffer to maintain the long-term health of the ecosystem. Table 2.2.2.6.1 and Figure 2.2.2.6.1 show the acidic deposition does not exceed the critical load for most (64%) of the area within the proclamation boundary. This is expected because large portions of the Forest soils are derived from limestone or other carbonate sources (Cameron and Martin, 1984), which account for the high presence of base cations in the soils. About 25% of the soils are being impacted by total acidic deposition above the critical load and most (15%) is Forest Service ownership. Figures 2.2.2.3.2 shows that acidic deposition has been significantly decreasing since 2000. Calculations performed for this assessment estimate that there may have been an additional annual average reduction of 96 equivalents per hectare per year (eq/ha/yr) between 2005 and 2011 when compared to 1994 to 2000. Even with this reduction there will still be at least 18% of the area where the acidic deposition is exceeding the critical load.

Table 2.2.2.6.1. Percentage of ownership in each of the soil acidic deposition critical load exceedance categories based upon McNulty et al. (2007).

	Ownership		
Acidic Deposition Exceedance	**Forest Service**	**Other**	**Total**
No Exceedance	43.23%	20.87%	64.10%
0 - 250 eq/ha/yr	4.17%	2.62%	6.79%
250 - 500 eq/ha/yr	11.17%	7.01%	18.18%
No Estimate	3.68%	7.25%	10.93%

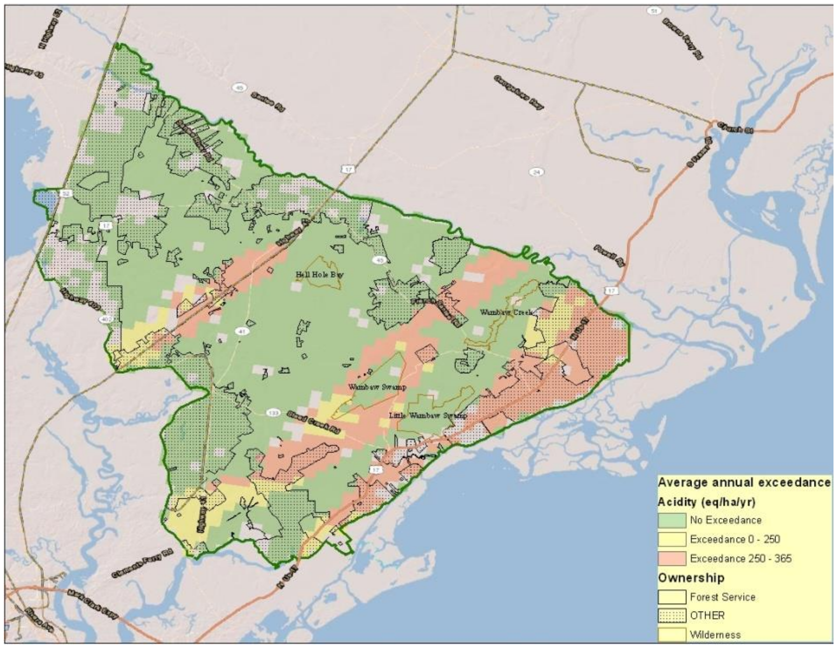


Figure 2.2.2.6.1: Areas (yellow or red) where the average (1994 – 2000) atmospheric sulfur plus nitrogen deposition exceeds the soils critical loads (taken from spatial data following McNulty et al., 2007). The units of measure are equivalents per hectare per year (eq/ha/yr).

Caution should be used when interpreting these critical load exceedance results. First, McNulty et al. (2007) were providing initial estimates for the conterminous United States to "… locate forest soil areas that could potentially be in exceedance of the…" critical load. Second, the deposition of sulfur and nitrogen compounds has decreased since the McNulty et al. (2007) was completed. Finally, steady state critical loads do not take time into consideration; although critical load exceedances indicate the potential for ecosystem damage, this damage may not be currently ongoing, and may not occur for centuries. Therefore, establishing an acidic deposition target load is not recommended for the Francis Marion National Forest, until further soil sampling and other site-specific measurements are conducted within the areas (Figure 2.2.2.6.1) identified as exceeding the critical load. The critical load exceedances calculated by McNulty et al. (2007) can be used to develop monitoring plans to verify critical load exceedance calculations.

2.2.3 INFORMATION NEEDS

The review of current conditions and trends on the Francis Marion National Forest shows that mercury deposition may be having an effect on both water and aquatic fauna, although SC DHEC's decision to not include mercury as a parameter in recent listing of impaired waterbodies may indicate that the situation is improving. At the same time, several of the black water areas on the Forest are affected by fish-consumption advisories due to mercury. However, measurement of mercury and its impacts are expensive and require exacting sampling techniques most appropriately done in conjunction with research scientists. At this time, the Forest Service has not adopted a standard protocol for measuring and monitoring the effects of mercury and therefore specific recommendations on monitoring the effects of mercury have not been made.

Considering the impact mercury deposition might be having, the Forest may want to look for additional opportunities to partner with the state or a research group to measure impacts on Forest Service ownership, especially any which are dominated by wetlands.

An initial estimate suggests that about 15% of the Forest Service ownership on the Francis Marion National Forest is exceeding critical loads of acidity, indicating the potential for harm to sensitive components of the ecosystem. However, the results in this assessment should not be used to establish a target load. Instead, further soils and other data collection should be obtained and used in an ecological model to estimate more precisely when unacceptable impacts are likely to occur, and what level of acidic deposition can be tolerated so there are no impacts to forest soils and/or terrestrial or aquatic biota.

2.2.4 LITERATURE CITED

AirData: Access to monitored air quality data from EPA's Air Quality System (AQS) Data Mart. *www.epa.gov/airdata.* Accessed 4 Feb. 2013.

Cameron, C.C. and C.M. Martin. 1984. Hell Hole Bay, Wambaw Swamp, Little Wambaw Swamp, and Wambaw Creek Wildernesses, South Carolina. In: Wilderness Mineral Potential - Assessment of Mineral Resource Potential in US Forest Service Lands Studied 1964-1984. Edited by S.P. Marsh, S.J. Kropschot and R.G. Dickinson. Geological Survey Professional Paper 1300. Volume 2, p. 939-941.

Grimm, J.W. and J.A. Lynch. 2004. Enhanced Wet Deposition Estimates Using Modeled Precipitation Inputs. Environmental Monitoring and Assessment 90: 243-268.

Koman, T. and W. Hanson. 2003. "Current Status of Water Quality Information on the Francis Marion National Forest." Report to Forest dated June 39, 2003. 43 p.

National Atmospheric Deposition Program: Mercury Deposition Network. *http://nadp.sws.uiuc.edu/mdn*. Accessed 3 Mar. 2013.

EPA. 2012. Our Nation's Air: Status and Trends through 2010. *www.epa.gov/airtrends/2011*. Accessed 16 Dec. 2012.

McNulty, S.G., E.C. Cohen, J.A. Moore Myers, and T.S. Sullivan. 2007. Estimates of critical loads and exceedances for forest soils across the conterminous United States. Environmental Pollution. 149: 281-292.

SC DHEC. 2012. Regional Haze State Implementation Plan Periodic Report: South Carolina Class I Areas.

https://www.scdhec.gov/environment/baq/docs/regs/SIP/Regional_Haze/SC_Haze_SIPR_Periodic_Review_20121228.pdf)

South Carolina 303(d) List of Impaired Waters and TMDL Program. *http://www.scdhec.gov/environment/water/tmdl/index.htm* Web 3 Mar 2013.

South Carolina Fish Consumption Advisories. *http://www.scdhec.gov/environment/water/fish/index* Web 3 Mar. 2013.

"South Carolina Mercury Assessment and Reduction Initiative". *https://www.scdhec.gov/environment/admin/mercury/docs/Mercury%20Final.doc*. Web 19 Mar. 2013

Stratton, D. 2011. Ambient Ozone and Biomonitoring Report: Hell Hole Bay Wilderness and Three Other Wildernesses on the Francis Marion National Forest. USDA Forest Service.

Technology Transfer Network Clearinghouse for Inventories & Emission Factors. *www.epa.gov/ttnchie1/trends*. Accessed 16 Dec 2012.