Southeast Regional Partnership for Planning and Sustainability (SERPPAS) Smoke Management Recommendations and Prescribed Fire Tracking

SERPPAS Smoke Management and Air Quality Subcommittee
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SERPPAS

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I. Introduction

The Southeast Regional Partnership for Planning and Sustainability (SERPPAS) is a partnership of state environmental and natural resource officials with the U.S. Department of Defense (DOD), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service, the U.S. Department of Agriculture Forest Service (FS) and other federal agencies. SERPPAS works to prevent encroachment around military lands, encourage compatible resource-use decisions, and improve coordination among regions, states, communities, and military services. One of SERPPAS' top conservation priorities is "Sustaining the Land of the Longleaf Pine." In partnership with *America's Longleaf*, SERPPAS members helped develop the "Range-Wide Conservation Plan for Longleaf Pine (RCPLP)," which was published in March 2009. This plan contains strategies for longleaf conservation and identifies priority actions that should be undertaken.

The RCPLP contains a 15-year goal to increase longleaf pine forests from the current 3.4 million acres to 8 million acres. Fire is an essential component of natural longleaf pine ecosystems. Therefore, applying appropriate fire regimes in longleaf forests is essential to achieving the goals of the RCPLP. As the acres of longleaf pine forests grow, so will the acres of land that need regular application of prescribed fire. One of the primary challenges associated with this increased level of prescribed burning will be addressing issues related to smoke management and air quality. This document describes activities and recommendations for addressing smoke management and air quality issues. This document provides recommendations and information and is not regulatory (i.e., the recommendations are suggested best practices for reducing impacts on air quality but are not mandatory). While implementation of the actions and recommendations presented in this document are not required by regulations, we believe that they are likely to reduce smoke impacts on air quality and thus reduce impacts on human health and the environment. Actions which limit air quality impacts help to ensure that the increased prescribed burning needed to meet the RCPLP goals can be performed.

Page 17 of the RCPLP lists the following "key action" in relation to smoke management and air quality:

> ***RCPLP Key Action*** *- Work cooperatively with the U.S. EPA and the state air quality agencies to address smoke management for fire management and to facilitate increased burning while complying with state air quality laws. Recognize the positive aspects of fire management on air quality in state plans. A key activity is the participation in the development and/or updating of Smoke Management Programs prepared by state air quality and land management agencies.*

From this Key Action, the SERPPAS Smoke Management and Air Quality Subcommittee identified actions that will be pursued in the near term to further the goals of the RCPLP. Two primary actions that were identified in relation to smoke management and air quality were:

- Develop and Share Consistent Fire Activity and Emissions Tracking Data; and

- Provide Recommended Best Management Practices (Smoke Management Recommendations)

This document provides information on each of these two actions. Before discussing these two topics in detail, it is important to have a basic understanding of air quality regulations. Therefore, Section II of this document provides a summary of the important air quality requirements of the Clean Air Act. These air quality requirements provide context for the smoke management recommendations being put forth later in this document. However, as stated above, this document is not regulatory and does not establish any binding requirements on prescribed burners.

In February 2011, the SERPPAS partner's hosted a workshop titled: "Meeting Air Quality and Ecological Goals: Restoring and Protecting Our Forests, Air Quality and Our Health." One of the main purposes of this workshop was to solicit input on an earlier draft of this "Smoke Management Recommendations and Prescribed Fire Tracking" document. Comments and feedback provided at the workshop have been incorporated into the current version of the document.

II. Air Quality, the Clean Air Act, and Prescribed Burning

An air quality manager's goal is a sustainable environment that provides a foundation for a vibrant economy and healthy communities. Effective communication and coordination among all stakeholders, including prescribed burning practitioners, is critical in moving towards this goal.

Landowners and land managers should work with state air quality agencies to coordinate prescribed fire activities, minimize air pollutant emissions, manage smoke from prescribed fires, and establish emergency action plans to mitigate negative impacts on public health.

Smoke management plans for prescribed burns should be designed so that smoke-sensitive areas like roads and residences, etc. are not negatively affected by the burn.

Most prescribed burning in the Southeast is done during the winter and early spring when particulate matter and ozone levels are generally at their lowest. However, uncontrolled wildfires often occur during the summer and fall when particulate matter and ozone levels are at their highest. The risk of wildfires and the resulting smoke or air quality problems can be reduced with well-timed and well-planned prescribed fires.

II.a. National Ambient Air Quality Standards (NAAQS)

One of the key indicators of air quality is whether ambient monitors show compliance with the National Ambient Air Quality Standards (NAAQS).

Section 109 of the Clean Air Act directs the EPA to promulgate "primary" and "secondary" NAAQS for pollutants for which air quality criteria are issued. There are NAAQS for six criteria[1] pollutants (i.e., ozone (O3), particulate matter (PM), sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and lead (Pb)). The Clean Air Act requires EPA to review the NAAQS every five years to determine if they are still adequately protective of public health and the environment.

Section 109(b)(1) defines a primary standard as one "the attainment and maintenance of which in the judgment of the Administrator, based on [air quality] criteria and allowing an adequate margin of safety, are requisite to protect the public health." A secondary standard, as defined in Section 109(b)(2), must "specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on such [air quality] criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air."

The requirement that primary standards include an adequate margin of safety was intended to address uncertainties associated with inconclusive scientific and technical

[1] Section 108 of the Clean Air Act describes the process for EPA to establish a "criteria" pollutant.

information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. The current NAAQS are shown in Table 1.

Table 1. Current and Proposed National Ambient Air Quality Standards

	National Ambient Air Quality Standards	
Pollutant	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour
	35 ppm (40 mg/m^3)	1-hour
Lead	0.15 $\mu g/m^3$	Rolling 3-Month Average
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)
	0.10 ppm	1-hour (effective April 12, 2010)
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (Arithmetic Mean)
	35 $\mu g/m^3$	24-hour
Ozone	0.075 ppm (2008 std)	8-hour
	0.08 ppm (1997 std)	8-hour
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)
	0.14 ppm	24-hour
	0.5 ppm	3-hour
	0.075 ppm	1-hour – (effective August 23, 2010)

Emissions of nitrogen oxide compounds (NOx), volatile organic carbon compounds (VOC), PM and CO from fires can impact ambient levels of NO_2, PM and CO. NOx, VOC, and some forms of PM emitted from fires may also be precursors for atmospheric formation of ozone and PM. It is believed that O_3 and PM are the pollutants significantly impacted by prescribed fire, with PM being the most significantly impacted. Therefore the following discussion focuses on PM impacts. It is worth noting that the smoke management recommendations discussed later in this document, which are primarily geared toward limiting PM emissions, will likely also help control transport and formation of other pollutants, including ozone. However, the impacts of smoke emissions on ozone formation are not as well understood as the impacts on PM emissions. Additional research is needed in this area.

The first NAAQS for particulate matter was established for total suspended particulate (TSP) in 1971. Since then, the NAAQS for particulate matter have become much more stringent and has moved towards regulating smaller particles. Table 2 shows the progress over time of the particulate matter NAAQS.

Table 2. Changes in Particulate Matter NAAQS Over Time

Final Rule	Indicator	Ave. Time	Level
1971 (36 FR 8186; April 30, 1971)	TSP	24-hour	260 μg/m^3 (primary) 150 μg/m^3 (secondary)
		Annual	75 μg/m^3 (primary)
1987 (52 FR 24634; July 1, 1987)	PM_{10}	24-hour	150 μg/m^3
		Annual	50 μg/m^3
1997 (62 FR 38652; July 18, 1997)	$PM_{2.5}$	24-hour	65 μg/m^3
		Annual	15 μg/m^3
	PM_{10}	24-hour	150 μg/m^3
		Annual	50 μg/m^3
2006 (71 FR 61144; October 17, 2006)	$PM_{2.5}$	24-hour	35 μg/m^3
		Annual	15 μg/m^3
	PM_{10}	24-hour	150 μg/m^3

Smoke is made up of a complex mixture of gases and fine particles produced when wood and other organic matter burn. The biggest health threat from smoke comes from fine particles ($PM_{2.5}$). These microscopic particles can get into the eyes and respiratory system, where they can cause health problems such as burning eyes, runny nose, and illnesses such as bronchitis. Numerous studies link particle levels to increased hospital admissions and emergency room visits. Fine particles also can aggravate chronic heart and lung diseases and even are linked to premature deaths in people with these conditions. In addition, particles can act as carriers to deliver toxic agents into the respiratory tract.[2]

As mentioned previously, the Clean Air Act requires EPA to review, and revise if necessary, the NAAQS every five years. EPA has historically reviewed the NAAQS at a much slower pace than every five years, but recently has made efforts to review them on much quicker pace. EPA has already initiated the review of the Particulate Matter NAAQS and there are signs that it may get more stringent again in 2012. In April 2011, EPA released its "Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards." In the report, EPA staff suggests that the Agency consider setting the annual and 24-hour PM2.5 standards so that the annual standard would provide long-term protection against long- and short-term exposures in conjunction with a tighter 24-hour standard to protect against high peak concentrations. The report indicates that "the currently available evidence and information from a quantitative risk assessment and air quality analyses provide support for considering revision of the level of the *annual standard* to within a range of 13 to 11 μg/m3. Staff further concludes that the evidence most strongly supports consideration of an alternative annual standard level in the range of 12 to

[2] U.S. EPA. Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009.

11 μg/m3." The report also states "In conjunction with consideration of an annual standard level in the range of 12 to11 μg/m3, staff concludes it is appropriate to consider retaining the current *24-hour standard* level at 35 μg/m3. In conjunction with consideration of an annual standard level of 13 μg/m3, staff concludes that there is limited support to consider revising the 24-hour standard level to somewhat below 35 μg/m3, such as down to 30 μg/m3."[3] The report also indicates that "consideration should be given to revising the current suite of $PM_{2.5}$ secondary standards to provide increased public welfare protection from $PM_{2.5}$-related visibility impairment, primarily in urban areas," and that "consideration should be given to establishing a new calculated $PM_{2.5}$ light extinction *indicator*." Note that smoke from prescribed fires may be an important issue for complying with any new visibility standard. The final decision on whether to revise both the primary and sencondary PM standards based on these findings will be made by the EPA Administrator.

Figures and 1 and 2 display maps of recent annual and 24-hr ambient air PM2.5 concentrations for the States in the SERPPAS region. The maps also display areas which currently have longleaf pine ecosystems and longleaf pine historic range. As can be seen on the maps, both the annual and 24-hr PM2.5 concentrations are below the current NAAQS in the longleaf pine areas. Note in Figures 1 and 2 that in many of the areas in the longleaf historic range, the values are shown in green, meaning that they are well below the current NAAQS and would be below any new more stringent PM2.5 NAAQS currently being considered by EPA as discussed above. This is good news for the longleaf pine restoration effort. However, this does not mean impacts of prescribed burning on PM2.5 air quality can be ignored. On the contrary, it is important to consider the impacts of the increased prescribed burning associated with the restoration effort and to implement the smoke management recommendations in Section IV of this document to help ensure that the NAAQS are not violated and therefore the health of nearby communities are not adversely impacted.

[3] "Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards," EPA 452/R-11-003, April 2011.

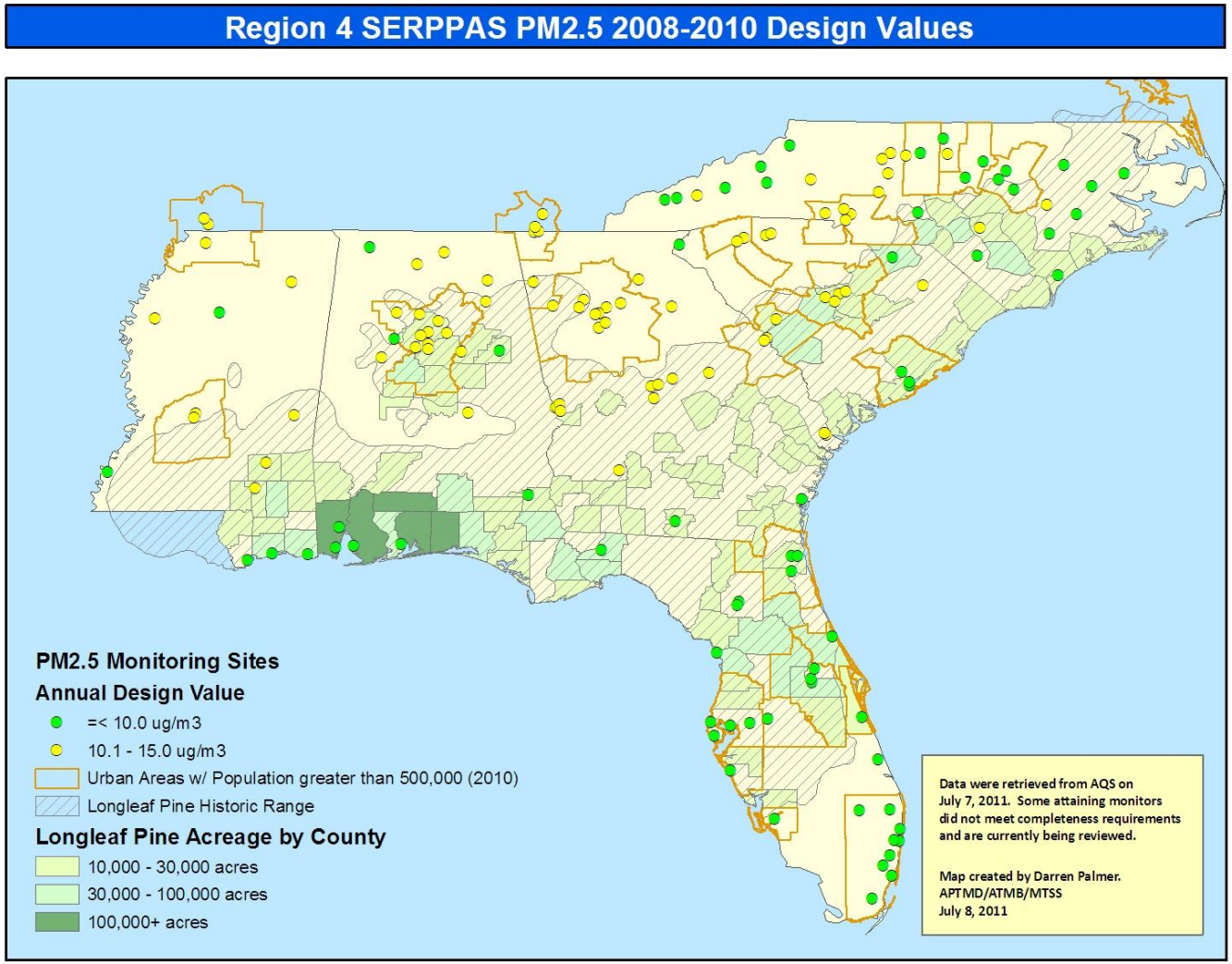

Figure 1. Map showing PM2.5 annual average ambient air concentrations at monitoring sites in the SERPPAS region. The ambient concentration data represent a 3-year (2008-2010) "design value." The design value is the ambient concentration calculated according to the Clean Air Act regulations for comparison to the National Ambient Air Quality Standards (NAAQS).

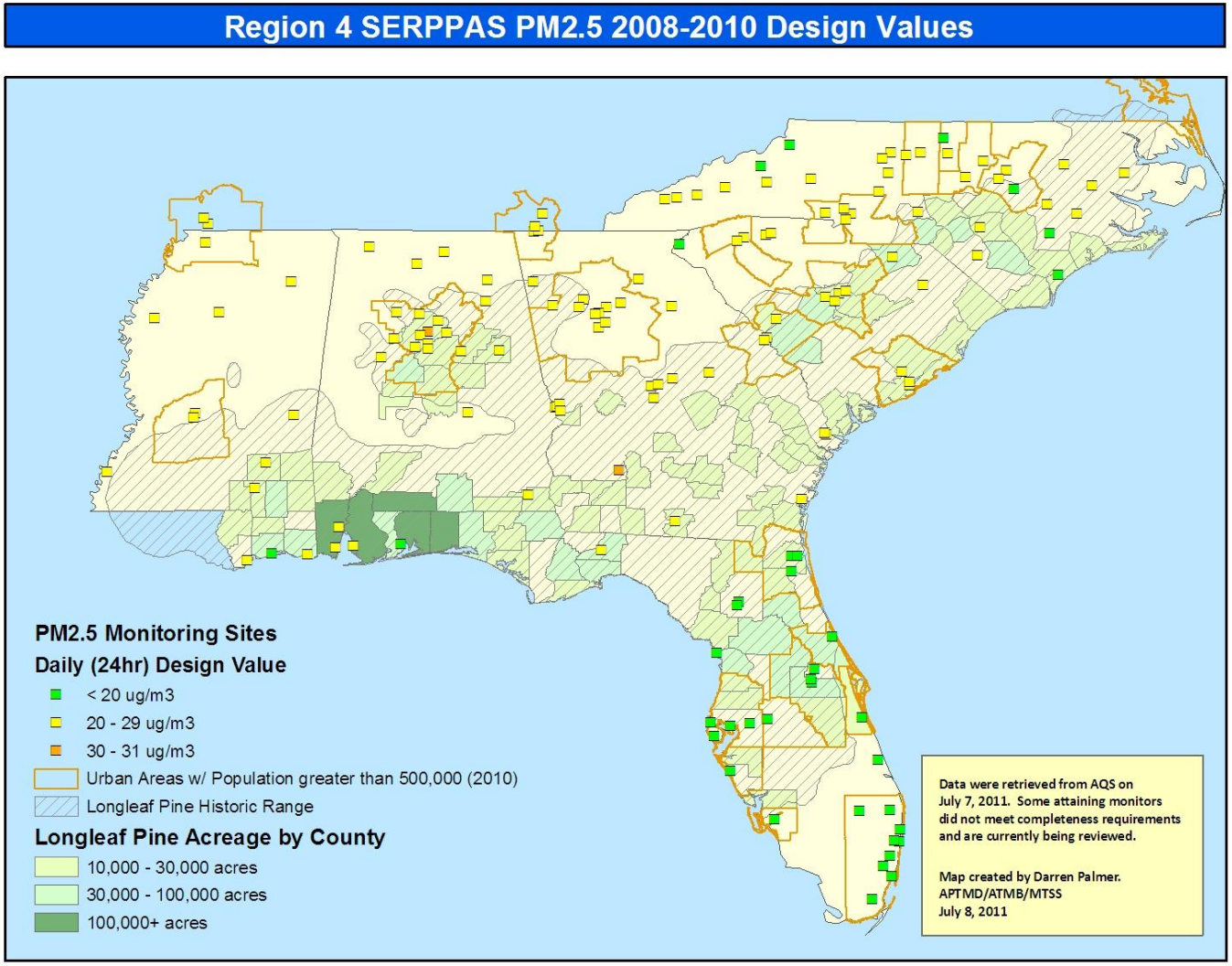

Figure 2. Map showing PM2.5 24-hr average ambient air concentrations at monitoring sites in the SERPPAS region. The ambient concentration data represent a 3-year (2008-2010) "design value." The design value is the ambient concentration calculated according to the Clean Air Act regulations for comparison to the National Ambient Air Quality Standards (NAAQS).

II.b. Nonattainment Areas and Nonattainment Designations

A geographical area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) a national primary or secondary ambient air quality standard for any criteria pollutant may be designated as a nonattainment area by EPA.

An area would typically be designated as a nonattainment area by EPA shortly after the promulgation of new, or more stringent, NAAQS. This process is outlined in Section 107(d)(1) of the Clean Air Act. In general:

- Within 1 year (EPA may shorten this deadline if it is reasonable to do so) of a new or revised NAAQS, a state may recommend to EPA those areas of the state that should be designated "nonattainment."
- Within 2 years of a new or revised NAAQS, EPA shall promulgate the nonattainment area designations, which includes establishing the geographical boundary of each area.
- If the state submits a recommendation, but EPA plans to propose something different from the state's recommendation, EPA must provide at least 120 days notice to the state.

While most area designations are made following the promulgation or revision of a NAAQS, Section 107(d)(3) of the Clean Air Act allows EPA to designate an area as a nonattainment area at any time. This could occur if additional ambient monitors are installed pursuant to federal regulations after a new or revised NAAQS is established and these monitors indicate NAAQS violations. Another cause for redesignation might be the result of an attainment area experiencing deteriorating air quality to the point of violating the standard in a non-designation year. Since air quality in the United States has generally been improving over time, this latter occurrence is unusual.

Section 107(d)(3) lays out the procedure for EPA to designate an area as a nonattainment area outside the normal NAAQS establishment process.

- EPA must give the state notice of the intent to establish a new nonattainment area.
- The state must then respond with any geographical boundary recommendations within 120 days.
- If the state submits a recommendation, but EPA plans to propose something different from the state's recommendation, EPA must provide at least 60 days notice to the state.

II.c. State Implementation Plans (SIPs) to Demonstrate Attainment with NAAQS

Once an area is designated as a Nonattainment area by EPA, the State must develop and submit to EPA a plan that shows how the area will get back into attainment with the NAAQS.

The plan must show attainment with the NAAQS within 5 years[4] (or up to 10 years if State demonstrates that more time is needed) after the area was designated by EPA [172(a)(2)]. The plan must be submitted to EPA within 3 years after the area designated by EPA [172(b)].

Section 172(c) of the Clean Air Act lists all of the required elements of the plan. Some of the most significant elements include:

- All reasonably available control measures as expeditiously as practicable
- Reasonable further progress
- Nonattainment New Source Review for new and modified major stationary sources

In addition to the elements required in Section 172(c) of the Clean Air Act, both transportation and general conformity are required under Clean Air Act section 176(c) to ensure that federally funded or approved activities are consistent with ("conform to") the purpose of the state air quality implementation plan (SIP). Conformity to the purpose of the SIP means that the activities will not cause or contribute to new air quality violations, worsen existing violations, or delay timely attainment or any interim milestones of the relevant NAAQS.

EPA has issued implementing regulations that provide specific requirements for both transportation and general conformity. The General Conformity regulations contained in 40 CFR Part 93 are of particular importance for prescribed burning activities in nonattainment areas. The revised General Conformity regulations issued 2010 specifically address air emissions from prescribed burning activities. In accordance with 40 CFR 93.153(i)(2), a presumption of conformity is granted for prescribed fires that are conducted in compliance with state-specific Smoke Management Programs (SMPs) which meet the requirements of EPA's Interim Air Quality Policy on Wildland and Prescribed Fires or an equivalent replacement policy (see Section IV of this document for more discussion of SMPs). Additionally, prescribed fires employing basic smoke management practices (BSMPs) may be able to meet a presumption of conformity if approved by EPA or the State subject to the provisions of the regulations.

II.d. Redesignation Back to Attainment

In order for an area to be reclassified from nonattainment back to attainment[5]:

- EPA must determine that the area has attained the NAAQS;
- EPA must fully approve the applicable implementation plan for the area under section 110(k);
- EPA must determine that the improvement in air quality is due to permanent and enforceable reductions in emissions resulting from implementation of the

[4] The Clean Air Act provides a different schedule for Ozone. Section 181 of the Clean Air Act
[5] Section 107(d)(3)(E) of the Clean Air Act

applicable implementation plan and applicable Federal air pollutant control regulations and other permanent and enforceable reductions;
- The State must develop and submit to EPA a maintenance plan that demonstrates that the area will maintain attainment with the NAAQS;
- EPA must fully approve a maintenance plan for the area as meeting the requirements of section 175A; and
- The State containing such area has met all requirements applicable to the area under section 110 and part D.

II.e. Sanctions and Consequences of Failure to Attain

The Clean Air Act contains provisions for sanctions against states if they fail to satisfy the requirements of the Act for nonattainment areas. A State may be subject to sanctions if:

- State fails to submit a plan (or required element of a plan) [179(a)(1) and (3)]
- EPA disapproves a plan (or required element of a plan) [179(a)(2) and (3)]
- State fails to implement the plan [179(a)(4)]

Sanctions that EPA may employ on a State include:

- Loss of federal transportation funds
- Increase in the amount of offsets required by stationary sources
- Loss of federal grant funds under Section 105 of the Act

Within 1 year after EPA publishes the notice that the State failed to meet a NAAQS by the attainment date, the State must revise the plan to include all measures that can be feasibly implemented in the area in light of technological achievability, costs, and any non-air quality and other air quality related health and environmental impacts[6]. The State then gets a new attainment date that is 5 years (or up to 10 years if State demonstrates that more time is needed) from the date of EPA's notice that the area failed to attain.

II.f. Exceptional Events

Ideally, prescribed fires conducted to maintain healthy longleaf pine ecosystems will not result in adverse air quality impacts. Prescribed fires will, however, produce smoke containing air pollutants. To minimize potential adverse air quality impacts and possible NAAQS exceedances at ambient air monitoring locations caused by these pollutants, prescribed fires should be conducted following the principles in the Smoke Management Recommendations presented in Section IV of this document. If a prescribed fire generates smoke that is believed to impact an ambient air monitor and result in an exceedance of a NAAQS despite being conducted according to the management

[6] Section 179(d) of the Clean Air Act

techniques in a Smoke Management Plan, the prescribed fire could be considered an exceptional event if it meets all of the criteria identified in the Exceptional Events Rule.

EPA published its final rule on the Treatment of Data Influenced by Exceptional Events (72 FR 13560) on March 22, 2007, as required by section 319 of the Clean Air Act. The Exceptional Events Rule (EER) establishes procedures and criteria for identifying, evaluating, interpreting and using air quality monitoring data affected by exceptional events and provides a mechanism by which air quality data may be excluded from regulatory decisions and actions such as NAAQS designation determinations. The EER recognizes that each potential event could have different or unique characteristics, and thus, requires a case-by-case demonstration and evaluation. The remainder of this section provides a discussion of the prescribed fire aspects of EPA's Exceptional Events Rule.

For data to be excluded in determinations of exceedances and NAAQS violations as a result of a specific prescribed fire, a state must demonstrate, subject to EPA's review and concurrence, the following for each exceedance event [40 CFR 50.14(b)(3)]:

1. The prescribed fires caused a specific air pollution concentration in excess of one or more NAAQS at a particular air quality monitoring location.
2. The state has certified to EPA that it has adopted and is implementing a Smoke Management Program (or "basic smoke management practices" (BSMP)[7]). This is a critical element of the demonstration to show that efforts were made to minimize air quality impacts from the prescribed fire.
3. The prescribed fire meets the definition of "exceptional event" at 40 CFR 50.1(j), "Exceptional event means an event that affects air quality, is *not reasonably controllable or preventable*, is an event caused by human activity that is *unlikely to recur at a particular location* or a natural event, and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event."
    a. Not reasonably controllable or preventable: The EER says "A prescribed fire may meet the condition of ,,,not reasonably controllable or preventable'' by examining whether there are reasonable alternatives to the use of fire in light of the needs and objectives to be served by it." [72 FR 13567]
    b. Unlikely to recur at a particular location: The EER says "A prescribed fire carried out for resource management objectives is frequently designed to restore essential ecological processes of fire and mimic fire under natural conditions. As such, a prescribed fire's expected frequency can vary widely, depending on the natural fire return interval of a particular landscape or wildland ecosystem. The natural fire return interval can range from once every year to less frequently than once in more than 200 years. Thus, in many, though not all cases, it may be possible to demonstrate that the likelihood of recurrence is sufficiently small enough to show that a prescribed fire under these conditions meets the ,,,unlikely to recur at a

[7] A good discussion of BSMPs is contained in the "Smoke Management and Air Quality for Land Managers" on-line training available at http://www.cnr.uidaho.edu/wildlandfire/lesson_3.htm

particular location'' requirement of the statutory language." [72 FR 13566-13567]

4. Additional demonstration requirements identified in the EER at 40 CFR 50.14(c)(3)(iii) include providing evidence that:
    a. The event is associated with a measured concentration in excess of normal historical fluctuations, including background
    b. There would have been no exceedance or violation but for the event.

For the Longleaf Pine restoration project, periodic fire is critical for creating and maintaining an environment where Longleaf Pine can thrive.[8] There are no practical or reasonable alternatives to the use of fire for Longleaf Pine survival and the restoration project.[9] In situations where it can be shown that prescribed fire caused a exceedance of a NAAQS at a specific ambient air monitoring location, documentation demonstrating that the prescribed fire was necessary for maintaining a healthy longleaf pine ecosystem may be helpful for making the case that the prescribed fire meets the criteria for being „„not reasonably controllable or preventable'' as that term used in the EER.

For the Longleaf Pine restoration project, prescribed burning needs to occur at intervals ranging from 2-4 years for the species to take hold and thrive. This frequency is consistent with the natural fire return interval (1-4 years) that allowed this species to be so prevalent in the Southeast U.S. prior to man's alteration of the landscape through land use and development.[10] In situations where it can be shown that prescribed fire caused an exceedance of a NAAQS at a specific ambient air monitoring location, documentation supporting the needed fire return interval necessary for maintaining a healthy longleaf pine ecosystem may be helpful for making the case that the prescribed fire meets the criteria for being "unlikely to recur at a particular location" as that term is used in the EER.

Additionally, the EER at 40 CFR 51.930 contains mitigation requirements for states, including public notification, public education, and appropriate measures to protect public health from exceedances or violations of the NAAQS caused by exceptional events (including burns). These mitigation requirements apply to all states experiencing exceptional events, and are not preconditions for EPA approval to exclude data affected by specific exceptional events.

The rule states that EPA shall exclude data from use in determinations of exceedances and NAAQS violations, where a State demonstrates to EPA's satisfaction that emissions from prescribed fires caused a specific air pollution concentration in excess of one or

[8] See the "Fire Management Strategy" discussion on pages 15-17 of the RCPLP available at http://www.serppas.org/Files/Projects/LLP_Conservation_Plan_LowRes_Final.pdf

[9] Forest Encyclopedia Network, "Managing Longleaf Pine with Prescribed Fire" http://www.forestencyclopedia.net/p/p227

[10] See Table 25.1 on page 611 of: Stanturf, J.A.; Wade, D.D.; Waldrop, T.A.; Kennard, D.K.; Achtemeier, G.L. 2002. Background paper: fire in southern forest landscapes. In: Wear, D.N.; Greis, J.G. Southern forest resource assessment. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 607-622.

more national ambient air quality standards at a particular air quality monitoring location and otherwise satisfies the requirements of the rule. Therefore, the final approval of an exceptional event rests upon EPA's review and concurrence that the requirements of the rule have been met.

The rule preamble states that the level of documentation may vary by the type of event and can be guided in part by the relative magnitude of the observed concentrations and that to obtain concurrence, EPA must determine that the demonstration is complete and provides a reasonable technical demonstration.

Of particular concern to state/local air quality agencies is the time and technical resources it takes to prepare the request for EPA to consider an exceptional event. Because there are no set parameters for what must be included in the demonstration, the requesting agency must rely upon their own judgment and communication with and guidance from the reviewing EPA regional office. If the EPA regional office is unable to provide timely and meaningful feedback to the state/local air quality agency or if the EPA regional office makes multiple requests for demonstration revisions after the state/local air quality agency has submitted the demonstration, the strain on agency resources is likely to have a negative effect on the effective implementation of this, and other requirements.

We would like to reiterate our recommendation to follow the Smoke Management Recommendations contained in Section IV of this document for prescribed fires that are performed for longleaf pine conservation. These recommendations were developed to prevent adverse impacts on air quality while allowing both ecosystem restoration and air quality protection to be achieved.

III. Develop and Share Consistent Fire Activity and Emissions Tracking Data

Fire activity and air emissions data are essential for evaluating air quality impacts from prescribed burn activities. Existing systems for tracking this data vary greatly among the different states in SERPPAS Region. A database containing consistent fire activity and air emissions data from each of the states would be a valuable tool for helping to meet the goals of the RCPLP. A database containing up-to-date, consistent data from each of the SERPPAS states on fire activity and air pollutant emissions would provide the information needed to evaluate air quality impacts from the prescribed burning activities. This is important because air emissions from wildland and prescribed fires are one of the many different air emission sources (e.g., power plants, other industrial sources such as refineries and paper mills, vehicles, etc) that are evaluated by EPA and State Air Quality Agencies when determining what sources of emissions need to be controlled to meet the NAAQS (see the discussion of air quality regulations in Section II of this document for more details). Having a database well populated with quality data will prevent the need for making assumptions about emissions from prescribed fires which could lead to un-necessary limitations on the use of prescribed fire. This information will be critical for States with PM2.5 and ozone nonattainment areas as they develop emissions inventories for use in attainment demonstrations.

A high quality database will also have other beneficial uses, including:

- The fire activity and emissions data would be very beneficial for developing exceptional event demonstrations when the need arises.
- The data could be used to substantiate the claim that air emissions from multiple short burn-interval prescribed fires are lower than a major catastrophic wildfire with high fuel loads that could result without periodic prescribed burning.
- The database could be used in conjunction with screening-level air models (e.g., VSMOKE-GIS or BlueSky) to evaluate potential air quality impacts, which could allow a burn to be conducted when other factors such as dispersion indicies may indicate that burning should not be done that day.

This section describes information and actions needed to develop such a system.

III.a. Summary of Existing Fire Activity and Emissions Tracking Systems

There are four states in the SERPPAS region which currently have electronic databases for tracking fire activity. These states are Florida, South Carolina, Alabama and Mississippi. Also, there are tracking systems being effectively used in other regions of the United States, for example the western states' Fire Emissions Tracking System (FETS). The following discussion provides a brief summary of the Florida and South Carolina systems and the FETS.

<u>Florida</u>

The Florida Fire Management Information System (FFMIS) is designed to manage all aspects of the agency's wildland fire program, both prescribed fire and wildfires. The system collects relevant information in real-time, tracking size and geographic location of all fires. For prescribed fires the systems cross references burn location with a Geographical Information System (GIS) layer of fuel type and loading developed as part of the State's Wildfire Risk Assessment project. Using these estimates of fuel loading, emissions are calculated for each burn and a screening smoke dispersion model is run to determine whether the burn is likely to impact a smoke sensitive area. The focus of the screening model is to primarily determine whether the burn represents a surface visibility (smoke management) hazard.

Additional details on the FFMIS are available at: http://flame.fl-dof.com/wildfire/tools_fmis.html

South Carolina

The SC Forestry Commission utilizes a computer-aided dispatch system (CADS) to maintain records for wildland fires and prescribed fires. For prescribed burns conducted for forestry, wildlife, and agriculture, dispatchers collect information from the fire manager, including location, time of burn, fuel type, available tons to be burned, acres to be burned, nearest downwind smoke sensitive area, purpose for the burn, and other pertinent information. This data is entered into the CADS system, which determines if the planned burn is in compliance with Smoke Management Guidelines for Vegetative Debris Burning Operations in the State of South Carolina. These guidelines utilize predicted fire weather to assign category days for burning. These weather forecasts also include a prediction of nighttime dispersion, the presence of inversion layers, and the low visibility occurrence risk index (LVORI).

Fire Emissions Tracking System (FETS)

The Western Regional Air Partnership (WRAP) has developed a Fire Emissions Tracking System (FETS) for states in the western U.S. FETS is a database with a web interface for planned and unplanned fire events. The design of FETS enables data acquisition, data storage and availability, real-time coordination among smoke managers, and development of fire emission inventories. Reliable and accepted technical methods to estimate fuel consumption and emissions from fire events are implemented in FETS as are tools to estimate emissions averted due to the application Emission Reduction Techniques. Users can view fire data on-screen with a mapping tool and query the database for downloads of data into model-ready formats.

The database tracks the following data elements for individual fires:

- Date of Burn
- Burn Location
- Area of Burn
- Fuel Type
- Pre-Burn Fuel Loading

- Type of Burn
- "Natural" or "Anthropogenic" classification
- Annual emission goal information
- Projections
- Emissions.

Currently, FETS collects data from the states of Alaska, Montana, Idaho, Oregon, Washington, New Mexico, Nez Perce Tribe, Wyoming, Arizona, and federal wildland fire data. Also, the system interfaces with data systems in the states of California, Colorado, Utah, and Nevada.

Additional information about FETS is available on the following website: http://www.wrapfets.org/ .

III.b. Current Efforts to Develop a Fire Activity and Emissions Tracking System for the Southeast States

A collaborative effort of five Southeastern states is underway to develop a fire activity and emissions tracking system. The five states involved in the project are: Georgia, North Carolina, Tennessee, South Carolina, and Louisiana. This effort has recently received a grant from the U.S. Department of Agriculture Forest Service to aid in the development of the system. The following provides a brief discussion of the vision for this system.

The Fire Activity and Emissions Tracking System (FAETS) Project is a database effort that is being undertaken in the Southeast in order to enhance natural resource management as well as the functionality to collaborate with other resource databases. Wildland fire and emissions from planned or unplanned ignitions are major contributors to air quality and threaten unique vegetative landscapes and communities. FAETS is being designed to be a flexible, adaptable framework with customized components for states to manage prescribed fire and wildfire programs. It uses and builds upon existing systems. Ideally, FAETS will track both prescribed fires and wild fires.

Participating states will contract with an information technology firm to build upon the Florida Fire Management Information System (FFMIS) and the Fire Emissions Tracking System (FETS) developed by the Western Regional Air Partnership (WRAP). The North Carolina Division of Forestry Resources (NCDFR) Project Manager and the Southern High Resolution Modeling Consortium (SHRMC) will provide lead and technical guidance in designing FAETS. It will be designed and tested by the contracted technology firm on a development server provided by the firm. This firm will also collaborate with USGS and the Fire Research and Management Exchange System (FRAMES) staffs to insure that FAETS can be migrated to a FRAMES production server. FRAMES will provide long-term hosting and backup of FAETS. Partners or systems may be contracted as determined on an as need basis. FAETS is envisioned to assist

prescribed fire and fire suppression programs for participating state and federal agencies. It will also provide value added GIS data.

Additionally, the Georgia Forestry Commission (GFC) is currently working with Esri (Geographic Information System (GIS) consultant), using American Recovery and Reinvestment Act funding to computerize and perform real time spatial analysis of burn authorizations. Stakeholder meetings have been conducted from among the ranks of prescribed fire practitioners, GFC employees, and Georgia DNR/EPD to develop data collection needs for this system. A rapid process improvement team has been assigned to assist the project manager, along with Esri, in development of the system. All burn authorizations -- some 700,000 annually-- will be issued via computer and spatially displayed in near real time.

III.c. Relationship Between Existing Efforts and SERPPAS Effort for Longleaf Pine Restoration

Because there is a current on-going effort to develop a fire activity and emissions tracking system (FAETS, as discussed in Section III.b.) which would include the states in the SERPPAS region, it is recommended that SERPPAS not pursue an independent effort to establish a duplicate system. Instead, it is recommended that the SERPPAS partners collaborate with the States developing FAETS. This collaboration would make the best use of limited resources and hopefully produce a consistent system that could be used by all the SERPPAS states for tracking prescribed fire activity for the longleaf pine restoration effort.

III.d. Recommended Data Elements for a Regional System

It is unknown at this point how much information will be tracked in the fire activity and emissions tracking system (FAETS). The system could range from a simple tracking system for essential information related to individual fires to a more complex system that could be used to evaluate smoke dispersion for use in making decisions of whether to issue burn permits or not (like Florida's FFMIS). The agencies responsible for burn permitting in each of the SERPPAS states were surveyed to determine what information is currently being tracked in each State. Table 3 provides the results of the informal survey. As can been seen in Table 3, all the states are currently collecting useful information. However, the format of the data varies and is only available electronically in four of the six states. It is envisioned that development and implementation of FAETS could provide a consistent dataset for use by interested stakeholders.

In order to have the ability to analyze air quality impacts from frequent prescribed burning of longleaf pine ecosystems, SERPPAS recommends that, at a minimum, the following data elements be tracked in FAETS:

- Agency/individual responsible for the burn
- Acres burned
- Location (latitude and longitude), ideally the center of the burn area

- Date and time of the burn (and duration if available)
- Fuel type
- Fuel loading (tons/acre)
- Fuel consumption (tons/acre)
- Emission factors [Dependent on fuel type]
- Air Emissions (PM, NOx, VOCs, etc) [This could be accomplished via ambient air monitoring, however, more likely the emissions would be calculated from fuel type, fuel loading, fuel consumption and pollutant-specific emissions factors. **It is not envisioned that wide-scale additional ambient monitoring would be instituted to collect air emissions data.**]

During the February 7-8, 2011, SERPPAS Workshop, additional data elements that should be tracked in FAETS were identified. The following five additional elements were suggested:

- Actual acres burned aka "blackened acres"(in addition to the planned number of acres to be burned when burn permit is requested)
- In addition to burn date, time and duration, also track time when the burn stopped spreading (particularly for wildfires)
- Ignition method and fire type (e.g., head, backing or flanking fire)
- Date of last burn on a particular tract of land (i.e., "x" years of rough)
- Provide a comment section to include additional information about the burn.

During the Workshop, much discussion took place about the tracking of the individual data elements presented above. Recommendations were provided for methods to obtain information for some of the data elements. For example, it was suggested that the Landfire database would be useful for estimating the fuel loading.

Additionally, as the FAETS is being developed, the following issues should be considered:

- Who will be responsible for housing and maintaining the system?
- How will the data get into the system (e.g., from individual state systems or directly from burners)?
- Whether the system will provide real-time access to potentially be used for smoke impact modeling prior to burns or be used primary to provide a record of the data for later analyses
- Format of the data from each state
- What are the quality assurance and quality control procedures for ensuring that data is as accurate as possible?

The SERPPAS Smoke Management and Air Quality Subcommittee is committed to working with the states involved in the development of FAETS to create a system that will meet the needs of all the stakeholders. It is anticipated that this commitment will involve the dedication of time and resources by the SERPPAS subcommittee members and their parent organizations.

Table 3. Prescribed Fire Data Currently Collected by States in the SERPPAS Region

State	Data Available Electron-ically	Smoke Dispersion Forecast	Lat/ Long or STR	Street Location	Date of Burn	Dura-tion of Burn	Type of Burn	Size of Burn	Fuel loading (tons/ acre)	Land-owner Info.	Respon-sible Person	Firing Technique Identified	Smoke Plume Generat-ed	Smoke Sensitive Areas Identified
Alabama	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Currently being worked on	No
Florida	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Georgia	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No
Mississippi	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No
North Carolina	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No	No	Yes
South Carolina	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes

Smoke Management Recommendations

IV.a. Prescribed Burning, Smoke Management and Air Quality

As indicated in Section I, meeting the objectives of the RCPLP will potentially require large increases in the amount of longleaf pine forest land that needs regular application of prescribed fire.[11] It is important to minimize the impacts on air quality and public health from these fires. This section contains Smoke Management Recommendations to limit the impacts as much as possible.

First, it is important for prescribed burners to know about the prescribed burning regulations and requirements in the State where they will be conducting their burns. Also, many states have developed Smoke Management Programs (SMPs) which contain recommended procedures for limiting smoke impacts from prescribed fire. Ideally, the prescribed burning regulations and SMPs would be consistent across all the States in the SERPPAS region. It would be a commendable goal for the States to work together to make them as consistent as possible and SERPPAS supports coordination in this area. However, it is recognized that widely varying state statues, regulations and policies make this a difficult goal to achieve. Section IV.b., provides summary information related to regulations and smoke management requirements for individual states. Knowledge of the specific requirements in the individual states is a good first step toward understanding ways that consistent requires could be developed.

Second, a set of recommendations for reducing smoke impacts" has been developed to provide guidance for conducting frequent prescribed burning for maintaining longleaf pine ecosystems. These recommendations are contained in Section IV.c. It is important to note that the recommendations in Section IV.c., are just that - recommendations - and are not required by regulations.

Use of the smoke management recommendations presented in Section IV.c, may be helpful for making the case that "basic smoke management practices" (BSMPs) were followed for exceptional event demonstrations or compliance with the General Conformity regulation requirements. Many of the recommendations are similar to BSMPs that are identified by other organizations (e.g., the BSMPs identified in the "Smoke Management and Air Quality for Land Managers" on-line training available at http://www.cnr.uidaho.edu/wildlandfire/lesson_3.htm).

[11] Meeting the RCPLP goals of 5 million additional acres of longleaf pine ecosystems will likely require a significant increase in the number of acres that need frequent prescribed burning. However, it is important to note that some of the land that is targeted for longleaf resoration may already be subject to periodic prescribed burning for other purposes. For example, loblolly pine stands in the Oconee National Forest that are currently deciling may be targeted for replacement by longleaf.

IV.b. Individual State Regulations and Smoke Management Programs (SMP)

In each of the six SERPPAS States (North Carolina, South Carolina, Georgia, Florida, Alabama and Mississippi), a permit is required for performing prescribed burns. Table 4 provides a brief summary of the permitting programs for each of the States. Any prescribed burning done for maintaining longleaf pine ecosystems should comply with the applicable State burn permitting requirements.

Many of the States in the SERPPAS region also have "state-certified"[12] Smoke Management Programs (SMP). These SMPs were developed by the states in accordance with EPA's "Interim Air Quality Policy on Wildland and Prescribed Fires" (U.S. EPA, 1998). This policy was developed by EPA in an attempt to integrate two public policy goals: (1) To allow fire to function in its natural role in maintaining healthy wildland ecosystems; and (2) To protect public health and welfare by mitigating the impacts of air pollutant emissions on air quality and visibility. To meet these goals, EPA's policy encourages States and Tribes to develop SMPs for addressing smoke impacts.[13]

As outlined in the policy, the purposes of a SMP are: to mitigate nuisance and public safety hazards from smoke being transported into populated areas; to prevent deterioration of air quality and NAAQS violations; and to address visibility impacts in Mandatory Class I Federal areas. The policy recommends that a SMP should address the following issues:

- A process for authorizing or granting approval to manage fires for resource benefits (e.g., burn permits)
- Consideration of methods for minimizing air pollutant emissions by using alternative treatments or reducing fuel levels before burning
- Consideration of the need for Burn Plans which address the following:
    - Actions to minimize fire emissions
    - Evaluation of smoke dispersion
    - Public notification and exposure reduction procedures
    - Air quality monitoring.
- Public education and awareness programs
- Surveillance and enforcement programs for ensuring that the SMP is effective and
- Procedures for periodically evaluating the SMP

[12] The term "state-certified" SMP is used in EPA's Exceptional Events rule. EPA's interpretation of the this term is that a state should certify to EPA that it has adopted a SMP and is implementing it if it is making an exceptional events claim. EPA is not required to approve or "certify" the SMP.

[13] Note that EPA is in the process of updating the 1998 Interim Policy. It is anticipated that States will revisit their SMPs to determine if any changes are needed to address EPA's updated policy after it is released.

Table 4. Summary of Prescribed Burns Permitting Criteria for SERPPAS States					
State	Burner Notification Process	Notification	Burn Permit Decision Criteria	State Regulations	Website
Alabama	1) Burners phone 1 of 10 AFC dispatch centers to obtain a Burn Permit; 2) Dispatcher collects burn information and consults weather/air quality conditions; 3) Permit granted or denied	Day of Burn or earlier	Weather conditions; air quality; safety; & perceived ability of permittee to control fire. AFC can deny permit if landowner appears unable to control fire or State Forester issues a Fire Alert based on adverse fire weather conditions or air quality impairment	Alabama Prescribed Burning Act - Section 9-13-270	http://www.forestry.state.al.us/BurnPermit.aspx?bv=1&s=1
Florida	Burners supply burn info to DOF via internet, or phone. Cumulative modeling is conducted and provides DOF with potential hazard info that is integrated into the authorization process. Authorization approval process is same statewide.	Day of burn, or after 4pm of the previous day.	Modeling using FMIS is conducted by FL DOF to determine whether multiple burns will cause visibility impairment in smoke sensitive areas. PM2.5 conc of 300 ug/m3 is the threshold used. (Burner assesses screening for health and other air quality concerns.) Info maintained in FMIS	Title XXXV, Chapter 590 Forest Protection: 590.125 Open burning authorized by the Division (of Forestry).	http://www.fl-dof.com/wildfire/rx_index.html
Georgia	Permits are required for all prescribed fires except agricultural burning and leaf pile burning. Burners obtain permit from county forestry office. Contact information for each county is available online.	Day of burn	The size, date, type of burn, county location, weather, and air quality conditions are used by the county ranger to decide if a permit will be issued. Burns > 1 acre are screened to determine if smoke-sensitive airsheds or populations are threatened. Also review of previous day ozone and PM air quality.	Georgia Forest Fire Protection Act (GA Gode Ann. 12-6-80 - 12-6-93), Georgia Prescribed Burning Act (GA Code Ann. 12-6-145 - 12-6-149), Georgia Open Burning Regulations (Section 391-3-1-.02(5),"Open Burning")	http://www.gfc.state.ga.us/OnlinePermits/ http://www.georgiaepd.org/air/airpermit/smoke_plan/SMP.htm
Mississippi	Burners call local Central Dispatch Center and provide type of burn, acres, purpose, landowner name, person responsible for fire, address, phone number, location, beginning and end date of fire.		Daily Fire Weather Forecast	MS Code Section 49-19-3	http://www.mfc.state.ms.us/wildfire_control.htm#Burning%20Permits
North Carolina	Burners inform local DOF ranger		Coastal: Ability of the atmosphere to disperse smoke away from populated areas. Uses Burning Categories based on Ventilation Index, type of burn, and Fuel Loading. Similar criteria are used in the Voluntary program in the remainder of the state.	N.C. Prescribed Burning Act (GS 113-60)	http://www.dfr.state.nc.us/fire_control/fire_control.htm
South Carolina	Burners inform SC Forestry Dispatch Center of: 1) time of burn; 2) location of burn; 3) type of burn; 4) Tonnage or acreage to be burned 5) Distance and identify of nearest downwind receptor; 6) Person in charge of burn and contact info.	Day of burn	General Burning Limitations defined by relationship between Category Day, distance to nearest downwind receptor and tons of fuel to be burned per day per 16,000 acres. If burning for a single burn causes fuel tonnage to be exceeded for a given 16,000 acres, SC Forestry Commission advises burner to alter the burn.	Title 48, CH 34 SC Prescribed Fire Act; and SC DHEC Regulation 62.2 - Prohibition of Open Burning. Fires conducted according to the *Smoke Management Guidelines for Vegetative Debris Burning Operations in South Carolina* are NOT prohibited	http://www.state.sc.us/forest/srefsmg.htm

Any prescribed burning done in states with SMPs should follow the criteria contained in the appropriate SMP. The States of Alabama, Florida, Georgia and South Carolina have state-certified SMPs. EPA has reviewed each of these SMPs and has confirmed that they address each of the areas outlined in the 1998 Interim Policy. North Carolina and Mississippi are working on developing SMPs. Table 5 provides the websites where each of these SMPs are available.

Table 5. Smoke Management Programs

State	Website for SMP
Alabama	http://www.alpfc.org/archives/docs/Alabama%20Smoke%20Management%20Program.pdf
Georgia	http://www.gaepd.org/air/airpermit/html/planningsupport/regdev/smoke_plan/SMP.htm
Florida	http://www.dep.state.fl.us/air/rules/regulatory/regional_haze_imp/app_n.pdf
Mississippi	http://www.mfc.state.ms.us/wildfire_control.htm#Burning%20Permits (SMP not currently available)
North Carolina	http://www.dfr.state.nc.us/fire_control/fc_smoke_management_guidelines.htm (currently Voluntary Smoke Management Guidelines)
South Carolina	http://www.state.sc.us/forest/srefsmg.htm

IV.c. SERPPAS Recommendations for Reducing Smoke Impacts

These recommendations are divided into two sections. The first section is associated with State and multi-state level practices designed to promote responsible prescribed fires or controlled burns, but minimize the impacts on National Ambient Air Quality Standards (NAAQS), including identified nonattainment areas and sensitive populations. The recommendations are designed to better inform the decision process by the State in issuing burn permits in a given airshed. The second section is aimed at best management practices for the landowner or organization that will implement the actual burn. It is designed to utilize the best information and experience available to manage those conditions under their control so as to minimize the impact of the specific burn, including sensitive populations, nuisance smoke and visibility on highways. Alternative practices to prescribed fire are identified, but are largely limited due to very high costs and lack of understanding of their long-term benefits to the landowners.

The Role of Fire in Restoring and Maintaining Longleaf Savanna Systems

Fire is an essential process in natural longleaf pine (*Pinus palustris L.*) savanna systems that are characterized by diverse plant and animal communities, including many threatened and endangered species[1]. These systems include inclusions of wetlands, hardwoods, and riparian zones as well as other southern pine species when considered across the local landscape and Southeastern region. Fire is critical because it effectively alters the forest structure and dynamics in a manner that increases the competitive advantage of characteristic plant species and provides suitable habitat for many animal species. The landowner's objectives may include:

1) Eliminate pine straw litter, woody shrubs and small trees that suppress the development of longleaf seedlings and characteristic savanna grasses and forbs.
2) Sustain suitable habitat structure for the endangered red-cockaded woodpecker and other fire savanna dependent wildlife species.
3) Reduce hazardous fuel loading in order to prevent large wildfires and associated impacts to neighboring communities, infrastructure, and public safety.
4) Improve access for application of silvicultural practices and access to timber.

IV.c.1. State Level Recommendations

The recommendations are developed within the framework of SERPPAS to expand prescribed fire area treated to restore and sustain longleaf pine savanna systems without adversely impacting air quality. As such, they are limited in scope relative to the full range of forestry prescribed burning activities regulated by the States and EPA. These recommendations are aimed at improving management decisions to authorize or regulate prescribed burning in order to limit the potential impact of expanding the acres treated.

States are encouraged to:

- Authorize burning permits in a manner that can control the location and/or number of prescribed fire ignitions and the total acres burned on a daily basis. This ability to control ignitions will allow State agencies to adapt permitting to air pollution conditions, weather conditions that control transport and dispersion of smoke, and occurrence of wildfires that may interact within an air shed to degrade air-quality.

- Postpone or reschedule prescribed burning *within* an airshed (e.g., county or larger area for large burns) if forecasted $PM_{2.5}$ or O_3 will exceed NAAQS for that day (considering air quality forecasts posted on EPA's AIRNow website - http://www.airnow.gov/ - and other State or Local Air Quality Agency forecasts). Consider actions to seasonally limit (e.g., May to August) prescribed fires within an O_3 nonattainment airshed or as an early action to bring the airshed into compliance. Limit the number of burns or total acres burned on a given day if the dominant transport wind speed and distance to the nonattainment area results in an expectation that NAAQS levels for $PM_{2.5}$ or O_3 will be exceeded. It is worth noting that meteorological conditions conducive to increased ozone formation would likely also be poor conditions for prescribed burning (e.g., hot, dry, stagnant low wind speeds).

- Set ignition termination times for the day and ignition locations (airshed) based on dispersion conditions, expectations for frequent inversions, and forecast predictions of fog. Setting end times will help reduce trapping residual smoke near the burn and the formation of smoke-fog visibility problems. While starting ignitions later in the day (e.g., noon) can reduce downwind smoke by taking advantage of drier fuels and increased mixing conditions[2], mandating later ignitions can severely limit burning because midday humidity, temperature and winds may dry fuel sufficiently to make conditions for controlling the burns unsafe or burns too intense.

- Estimate emissions from average fuel consumption and emission factors for the regional area that represent the vegetation conditions. The available data on prescribed burn $PM_{2.5}$ emissions in the Southeast do not indicate any significant difference in emission factors between longleaf pine savanna systems and other forest vegetation types[3]. While PM2.5 emission factors are not significantly

different, available fuel loads are much lower[4,5,6] and therefore total emissions will be lower. The authors of CONSUME 3.0 (http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml) have agreed to publish the original and current southeast data sets and equations.

- Consider use of empirical data on downwind $PM_{2.5}$ within 6-8 miles of the ignition to set limits for daily and local impacts to sensitive populations and areas[7] (See Fig. 3). There appear to be no published validated models that can reliably predict observed $PM_{2.5}$ close to prescribed burns in all situations. The reason for this is likely due to several factors that make it difficult to predict PM2.5 emissions near prescribed burns, such as incomplete mixing, plume dominated conditions near the burn, complex surface roughness downwind and an unknown vertical smoke distribution as well as uncertain penetration of the mixing layer by the plume[8]. Even with this uncertainty, models may be helpful to help inform burn decisions as they can provide estimates of smoke impacts that can supplement other evaluations discussed in this section. Examples of available models are provided in Appendix II.

- Minimize (or in some cases prohibit) ignitions under poor dispersion or mixing conditions: Utilize reliable methods for atmospheric dispersion forecasting and, where available, meteorological and smoke observations/data to adjust burn authorizations according to expected smoke dispersion conditions. It is important not to wholly rely on smoke dispersion indicies as there are situations where the dispersion index may indicate that it would be a "good burn day" (dispersion index >70), but the high winds could cause tumbling of smoke and the inability to establish a good smoke column. Also, some low wind days (dispersion index 30-40) may be good days to burn if other conditions are favorable. This issue highlights the importance of consulting experienced prescribed burners when planning for burns.

- Consider the time between prescribed burns (burn intervals) and seasonality when evaluating burn requests. For longer burn intervals and thus greater fuel loads, consider limiting the size of the burn and the time of year (e.g., it is better to burn areas with high fuel loads during the winter to limit smoke and PM emissions and avoid ozone issues that may occur in the warmer seasons). For shorter burn intervals and lower fuel loads, warm season burning may be acceptable. More frequent burns to limit fuel loads and allow for summer burning would also have the added benefit of hardwood control for the longleaf pine ecosystems.

Additional Recommendations: A number of actions are incorporated in terms of recommendations to help significantly decrease impacts of prescribed burning on air quality. Implementation of the following technical items would help to minimize the impact of prescribed burning on air quality.

1) Develop an incentive program to encourage landowners to reduce fuel loading and to burn under more favorable weather conditions particularly when wind

direction limits downwind impacts and average to good dispersion or mixing conditions exist.

2) Encourage validation of models to reliably predict long distance transport and mixing of $PM_{2.5}$ in the atmosphere in the Southeast. A large number of undesirable air quality problems appear to be the result of: a) convergence of multiple ignitions (including across state boundaries); b) large ignitions in which smoke is transported in the air above the mixing layer for long distances; and c) unusual events in which either large eddies or deepening mixing layers in mid-day bring smoke to the ground.
3) Create simple tables or graphs from empirical data on fuel consumption, fuel loading and emissions, along with appropriate errors. Use a simple web-based map similar to Simple Smoke Screening (http://shrmc.ggy.uga.edu/maps/screen.html to project the mileage distance boundaries, wind direction uncertainty boundaries, and any simple rules within the immediate downwind zone to help landowners visualize impacts.
4) Work with the National Weather Service and other responsible agencies to improve the accuracy of wind direction and other atmospheric forecasts essential to reduce both local and long distance smoke impacts.

IV.c.2. Landowner Level Recommendations

IV.c.2.a. Advance Planning

- Permits and Training: Know your state prescribed burning regulations, training and permitting requirements[10] (http://www.nifc.gov/smoke/). These conditions vary from state to state. Air quality restrictions may apply near nonattainment areas at all times, seasonally or daily whenever air quality is predicted to exceed NAAQS for $PM_{2.5}$ or O_3 (consult EPA's air quality forecasts posted on EPA's AIRNow website - http://www.airnow.gov/ - and other State or Local Air Quality Agency forecasts). Obtain as much training as possible and/or work directly with experienced prescribed burning managers. Participate in the State Prescribed Fire Manager Certification programs. For large landowners that do frequent burning, completion of the federal land managers' RX410-Smoke Management Techniques training is recommended. The on-line training titled "Smoke Management and Air Quality for Land Managers" available at http://www.cnr.uidaho.edu/wildlandfire/lesson_3.htm is recommended for all other prescribed burn practioners. The following documents also provide useful guidance: "A guide for Prescribed Fire in Southern Forests" and the National Wildfire Coordination Group (NWCG) "Smoke Management Guide for Prescribed and Wildland Fire 2001 Edition." Both documents are available at http://www.nifc.gov/smoke/smoke_publications.html .

- Suitable Areas for Burning: Identify areas suitable for burning based on wind direction and distance downwind relative to sensitive populations such as occupied facilities, hospitals, nursing homes, schools, airports and major highways and Class I areas (Designated Wildernesses and National Parks). This procedure helps anticipate possible conflicts and populations in those locations that may be inadvertently affected if wind direction changes. Sensitive populations should be at least 1 mile downwind to avoid air quality impacts (Fig. 3) and depending on the size and fuel loading of the area to be burned, sensitive populations further downwind may need to be considered.

- Notification of Sensitive Populations: Notify adjacent property owners and other adjacent entities such as towns, schools, nursing homes and hospitals that you will be burning in the area and that practices will be implemented to avoid any direct impact. Let them know that they may smell or see smoke. Also, visually monitor smoke plumes throughout the burn to verify that conditions have not changed causing higher smoke impacts to sensitive areas. If impacts are not what was planned or predicted, take corrective actions including additional notification of sensitive populations so that they can take necessary actions (e.g., stay inside with air conditioning systems on).

- Prescribed Fire Frequency: Use prescribed fire on an interval of 2 to 4 years. Objectives for restoring and maintaining longleaf systems and reducing hazardous fuels are best achieved whenever the average periodic interval is short[11, 12]. This

interval will substantially reduce available dead fuels, woody shrubs, and organic layers and therefore will reduce total emissions as well as smoldering or residual smoke that can be trapped near the surface during inversions. Frequent burning also makes control of the burn easier.

- Available Fuel Loading: Where possible reduce the available fuels. Emissions are directly related to available fuels for a given fuel moisture and weather conditions. Normal silvicultural and harvesting practices help reduce fuel loads in conjunction with prescribed fire and other understory management treatments.

- Weather Conditions: Know your local weather and where and how reliable weather forecasts can be obtained. Wind direction is the single most important predictor of downwind impacts, but forecasts the morning prior to ignition are subject to error. Forecasts are within +/- 30^{o} arc about 40% of the time and within +/- 67^{o} arc up to 80% of the time[13] and the direction may shift during the burn. Reliability of forecasts is poor when the wind speeds are low. Evening and nighttime air inversions that trap residual smoke are very common in the southern U.S. and should be expected to occur almost every evening[14]. Residual smoke interacts with fog to impair visibility along roads and therefore burning should be completed early in the day whenever fog is predicted, or if nighttime relative humidity is expected to be >80%[15]. Drier conditions, such as consecutive days without rain, low humidity and wind, promote greater fuel consumption[4,12].

- Burn Size: Take advantage of good weather, particularly wind direction, to complete large burns of several hundred acres or more in size. A major concern with large burns is ignition patterns and the ability the complete burning before the onset of nighttime inversions.

- Ignition Methods: When feasible and when it will not lead to tree damage, use ignition patterns and methods[16] (http://www.shrmc.org/misc) that will develop a coherent smoke plume to lift the smoke to the upper portion of the mixing layer (2-3,000 feet) and even penetrate the mixing layer, especially for large burns[16]. Backfiring burns (against the wind) consume more fuel and take much longer to complete for a given area than other methods[4,12]. Both hand and helicopter ignitions can lead to high downwind smoke concentrations depending upon the firing pattern.

  Alternative Methods to Burning: In smaller, more urban areas, evaluate options to use alternatives to burning if you may routinely impact sensitive populations or busy highways, or if frequent burning is not possible. Herbicides and mechanical shredding/mowing can be used selectively to reduce competing shrubs and other

[16] Using ignition methods that will rapidly lift smoke will reduce smoke impacts near the burn. However, caution should be exercised to consider the potential for a coherent plume being transported above the mixing layer and then being mixed back down to the ground producing elevated smoke concentrations at large distances from the burn. Fire weather forcasts should be carefully evaluated on the day of the burn to avoid this situation.

woody vegetation[17]. These methods generally cost 10-20 times per acre the cost of prescribed burning, lead to large additions of fine fuels and must be re-applied periodically if burning is not used. In some areas, during appropriate periods in stand development, pine straw raking is economical and can also reduce hazardous fuels

- Smoke "Watch Out" Checklist: Consider the following issues that could lead to smoke problems. If these situations are encountered, contact the appropriate State agency responsible for authorizing the burn for advice on addressing the issues.
    - High winds
    - Sea Breeze, when burning in coastal areas
    - Sending smoke towards the coast or large water bodies where a local stable airmass has built in
    - Conducting multiple large burns in the same area
    - Smoke behavior in mountainous terrain

IV.c.2.b. Implementation (Day of the Burn)

- Change Ignition Plans if the wind forecast is uncertain or variable. Consider a) cancelling the burn; b) burning an alternate unit(s) with fewer smoke concerns; or c) delaying ignition until later in the day in hopes of obtaining a more reliable forecast.

- Conduct Small Test Fires prior to ignition of the unit to identify the pattern and direction of smoke dispersion. One option is to use Pilot Balloons (PiBals) to verify winds prior to ignition. If the smoke or fire behavior is not consistent with acceptable objectives, discontinue ignition.

- Confirm Wind Direction before, during and after burning has been completed. Actual transport wind speed and direction may differ from surface wind speed and direction. If possible, obtain spot weather forecasts from the nearest National Weather Service or State Forestry Agency. At very low wind speeds the uncertainty in the wind direction prediction is large.

- Complete the Burn as soon as possible in the afternoon or by the State designated authorization time to avoid trapping residual smoke during nighttime inversions, especially if fog is predicted. During ignition, if the smoke behavior is not consistent with acceptable objectives and impacts, discontinue ignition (if it is safe to do so). If humidity, temperature and wind conditions later in the day will not likely create unsafe control problems or burn intensity, beginning ignitions around noon can reduce downwind smoke because fuels will be drier and mixing layer depth and surface heating will be greater and therefore enhance plume lift and dispersion.

- Conduct Post-ignition Patrol to observe smoke and plume behavior downwind to mitigate possible impacts. If residual smoke occurs and is being trapped near the ground, notify local law enforcement authorities, the Department of Transportation and patrol-sign major public roads adjacent to the burn. Smoke can accumulate readily in adjacent drainages and move long distances down drainage. Smoke-fog interactions are a serious cause of accidents on roads and require additional diligence with regard to patrol-signing and notification of law enforcement. Safety of all parties involved in the response is a top priority. Therefore, appropriate safety procedures should be followed.

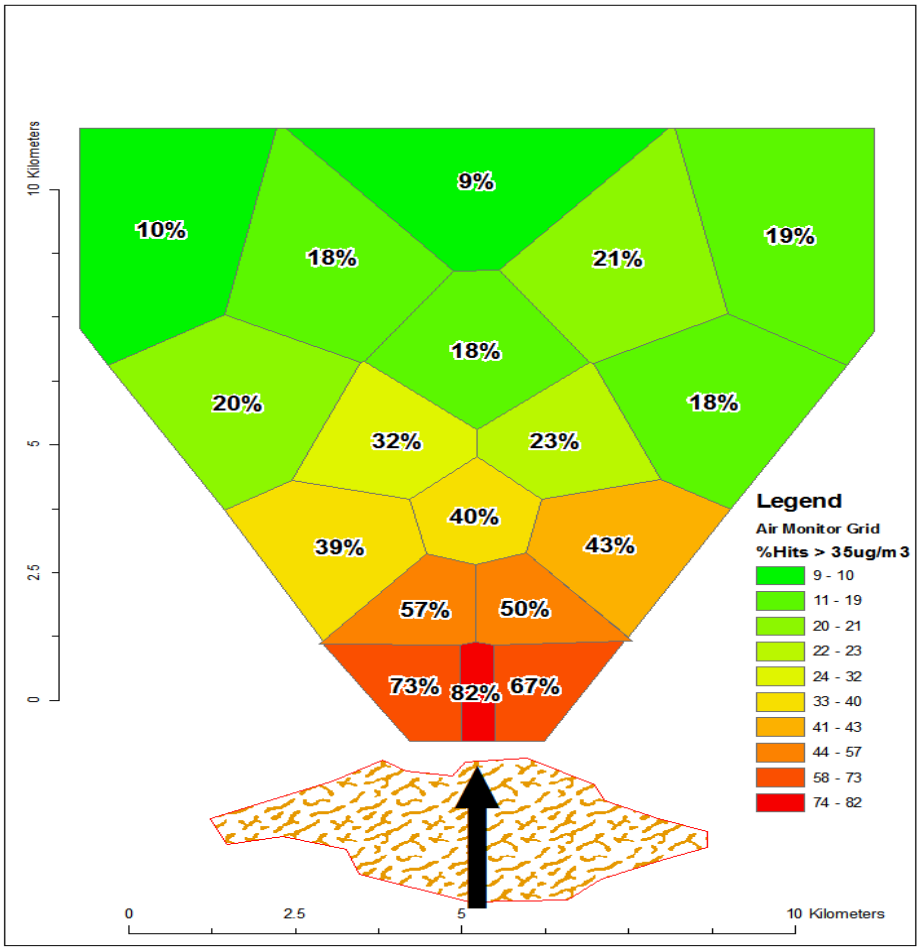

Figure 3. Percent of the number of observations from 52 prescribed fires at the Savannah River Site in which $PM_{2.5}$ exceeded 35 ug/m^3. (Adapted from Naeher and Pearce 2010)

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Background Documents

Express Team Document (http://www.treesearch.fs.fed.us/pubs/2990)

New Orleans Emissions Inventory Meeting (http://www.epa.gov/ttn/chief/conference/ei15/index.html)

Effects of Fire on Air Publication (http://www.fs.fed.us/rm/pubs/rmrs_gtr042_5.pdf)

Briggs Equations Explanation (http://en.wikipedia.org/wiki/Atmospheric dispersion_modeling)

Smoke Model Overview (PPT presentation at National meeting) (http://eamcweb4.usfs.msu.edu/meeting/2006/Heilman_EAMC5_Smoke_Model_Overview.ppt#1)

Effects of Wood Smoke on Health: Naeher, L., M. Brauer, M. Lipsett, J.T. Zelikoff, C.D. Simpson, J. Q. Koenig, and K.R.Smith. 2007. Wood smoke health effects-a review. Inhalation Toxicology 67:67-106

"Impact of Wildland Fires and Prescribed Burns on Ground Level Ozone Concentration, Review of Current Science Concepts and Analytical Approaches": Nikolov, Ned, PhD, METI Inc., Contractor to U.S. Forest Service, Rocky Mountain Center for Advanced Modeling of Meteorology and Smoke, USDA FS Rocky Mountain Research Station, 2150 Centre Ave., Building A, Room 368, Fort Collins, CO 80526

EPA's 1998 "Interim Air Quality Policy on Wildland and Prescribed Fires" - http://www.epa.gov/ttncaaa1/t1/memoranda/firefnl.pdf

National Interagency Fire Center Smoke Management Website - http://www.nifc.gov/smoke/

"Smoke Management Guide for Prescribed and Wildland Fire 2001 Edition" - http://www.fs.fed.us/pnw/pubs/ottmar-smoke-management-guide.pdf

"Smoke Management – A Guide for Prescribed Fire in Southern Forests" - http://www.bugwood.org/pfire/smoke.html

"Managing Smoke at the Wildland-Urban Interface" - http://www.wildfirelessons.net/uploads/Managing%20Smoke%20at%20the%20WUI%20Wade%20and%20Mobley%20gtr_srs103.pdf

Online Training – Wildland Fire - http://www.cnr.uidaho.edu/wildlandfire/online_training.htm

Forest Encyclopedia – Smoke Management - http://www.forestencyclopedia.net/p/p4/p137

Appendix II: Smoke Models Links

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Fuel Loading Estimation Models

- FCCS (http://www.fs.fed.us/pnw/fera/fccs/index.shtml)
- LANDFIRE (http://www.landfire.gov/)

Fuel Consumption and Emissions Models

- Consume 3 (http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml)
- FOFEM 5 (http://fire.org/index.php?option=content&task=category&sectionid=2&id=12&Itemid=31)
- FEPS (http://www.fs.fed.us/pnw/fera/feps/index.shtml)

Dispersion Models

- CalPuff/CalMet (http://www.src.com/calpuff/calpuff1.htm)
- Hysplit (http://www.arl.noaa.gov/ready/hysplit4.html)
- CMAQ (with SMOKE - emissions calculator) (http://www.cmaq-model.org/)
- PB Piedmont/PB Coastal Plain/PB Mountains (http://shrmc.ggy.uga.edu/smoke/pb-piedmont/index.html; http://www.treesearch.fs.fed.us/pubs/2058)
- SIS (http://www.fs.fed.us/rm/pubs/rmrs_rn023_11.pdf: http://www.airsci.com/SIS.html
- VSMOKE (http://webcam.srs.fs.fed.us/tools/vsmoke/index.shtml; http://www.srs.fs.usda.gov/pubs/gtr/uncaptured/gtr_srs006.pdf; http://www.srs.fs.usda.gov/pubs/rp/uncaptured/rp_srs006.pdf ;http://www.fs.fed.us/rm/pubs/rmrs_p046/rmrs_p046_427_439.pdf)
- Simple Smoke Screening (http://shrmc.ggy.uga.edu/maps/screen.html)

Forecasts and Visualizations

- BlueSky/BlueSkyRAINS (http://www.airfire.org/bluesky/)
- NOAA ARL Smoke Forecasts (http://www.arl.noaa.gov/smoke/)
- NOAA NWS Air Quality Forecasts (http://www.weather.gov/aq/sectors/conus.php)
- EPA AIRNow - http://airnow.gov/
- Wildland Fire Air Quality Tools (WFDSS website) - http://firesmoke.us/wfdss/

Appendix III: Prescribed Burn Plan Template

Simple Understory Prescribed Burning Unit Plan

Landowner_____ Permit no._____
Address_____ Phone no._____
S___ T___ R___ County_____ Acres to Burn_____ Previous burn date_____
Purpose of burn_____
(Draw map on back or on a separate piece of paper and attach)

STAND DESCRIPTION

Overstory type & size_____ Height to bottom of crown_____
Understory type & height_____
Dead fuels: description and amount
_____
_____
_____

PRE-BURN FACTORS

Manpower & equipment needs
_____
List smoke-sensitive area & locate on map
_____
Special precautions
_____
_____
_____
Estimated no. hours to complete _____ Passed smoke screening system _____
Adjacent landowners to notify
_____
_____
_____

WEATHER FACTORS: Desired Range

Surface winds (speed & dir.) _____
Transport winds (speed & dir.) _____
Minimum mixing height _____
Dispersion/stagnation index _____
Minimum relative humidity _____
Maximum temperature _____
Fine-fuel moisture (%) _____
Days since rain _____ Amount _____

FIRE BEHAVIOR: Desired Range

Type fire _____
Best month to burn _____
Flame length _____
Rate of spread _____
Inches of litter to leave _____

EVALUATION: Immediate

Any escapes?_____ Acreage _____
Objective met _____

Smoke problems _____
% of area with crown discoloration of
5-25% ____ 26-50% ____ 51-75% ____ 76%+ ____
Live crown consumption _____
Adverse publicity _____
Technique used OK _____
Remarks _____
_____
_____

Predicted Actual

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

Actual

_____
Date burned _____
_____
_____
_____

Future

Evaluation by _____
Date _____
Insect/disease dam. _____
Crop tree mortality _____
% understory kill _____
Soil movement _____
Other adverse effects _____
_____
Remarks_____
_____
_____
Prescription made by:
_____
Title: _____ Date:
_____/_____/_____

Appendix IV: Smoke Management Recommendations "Pocket Card"

(Under Development)