APPENDICES

2004 BART COMMENTS

APPENDIX A: **Clean Air Task Force, et al., Comments on EPA's "Proposed Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations," 66 Fed. Reg. 38,108 (July 20,2001).**

APPENDIX B: **National Park Service, GPRA 2003 Visibility Dataset**

APPENDIX C: **Class I Areas Not Evaluated by EPA in its "Better than BART" Analysis for the Proposed CAIR**

APPENDIX D: **Emission Reductions Under BART As Compared to CAIR**

APPENDIX A

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APPENDIX A

Clean Air Task Force • Environmental Defense • American Lung Association of Metropolitan Chicago • Center for Energy Efficiency and Renewable Technologies • Clear the Air • Grand Canyon Trust • The Illinois Environmental Council • Izaak Walton League of America • Land & Water Fund of the Rockies • National Environmental Trust • Natural Resources Council of Maine • Natural Resources Defense Council • New Mexico Citizens for Clean Air & Water • The Ohio Environmental Council • Southern Alliance for Clean Energy • Utahns for an Energy-Efficient Economy

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BY EMAIL AND FACSIMILE TRANSMISSION;
HARD COPY TO FOLLOW
Air and Radiation Docket and Information Center (6102)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460
Transmitted by email to: wegman.lydia@epa.gov
smith.tim@epa.gov
damberg.rich@epa.gov
anderson.lea@epa.gov
A-and-R-Docket@epamail.epa.gov

Telefax: (202) 260-4400

Attention: EPA Public Docket No. A-2000-28

Re: Comments on EPA's "Proposed Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations," 66 Fed. Reg. 38,108 (July 20,2001).

The Clean Air Task Force[1] and Environmental Defense[2] are pleased to submit to the Agency the following detailed comments on the proposed BART guidelines, on behalf of themselves and fourteen environmental and public health organizations. The fourteen organizations, including the American Lung Association of Metropolitan Chicago, Center for Energy Efficiency and Renewable Technologies, Clear the Air, Grand Canyon Trust, The Illinois Environmental Council, Izaak Walton League of America, Land & Water Fund of the Rockies, National Environmental Trust, Natural Resources Council of Maine, Natural Resources Defense Council, New Mexico Citizens for Clean Air & Water, The Ohio Environmental Council, Southern Alliance for Clean Energy, and Utahns for an Energy-Efficient Economy are local, regional, and national organizations active in the nationwide effort to reduce the significant environmental impacts of fossil fuel combustion at electric power generating stations and other major sources of harmful air pollution. Commenters represent their many hundreds of thousands of members who live near, visit, and cherish the premier national parks and wilderness areas that will be protected under this important clean air program.

[1] The Clean Air Task Force is a national non-profit environmental organization, working in close collaboration with other non-profit environmental and public health organizations in 30 states and allies in various industry sectors, to advocate state and federal policy change. The goal of the Task Force is to tighten state and federal regulations in order to reduce smog, soot, haze, acid rain, toxic pollution and climate change resulting from power plant air emissions.

[2] Environmental Defense is a non-profit, non-partisan, non-governmental environmental organization dedicated to the creation of innovative, equitable, and cost-effective solutions to the most urgent environmental problems.

Our nation's parks, monuments, and wilderness areas are shrouded in haze. In much of the country, the impairment of visibility is largely due to emissions from old coal-fired power plants and, to a lesser extent, other stationary sources. In the 1977 Clean Air Act Amendments, Congress expressly established " . . . as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Federal Class I areas which impairment results from man-made air pollution."[3] Yet, as shown in Table 1, more than twenty years later, visual air quality is still deteriorating in many of these special places.[4]

Region	General Trend	Example Trend in Haziest Days Deciview / yr[5]	*Airshed*
Northern Great Plains	**Deterioration**	**+ 0.1**	**Badlands NP**
Great Basin	**Deterioration**	**+ 0.23**	**Jarbridge W**
Colorado Plateau	**Deterioration & Improvement**	**+ 0.1**	**Bryce Canyon NP**
Central Rocky Mountains	**Deterioration or little change**	**0.00**	**Rocky Mtn NP**
Sonoran Desert	**Deterioration**	**+ 0.07**	**Chiracahua NM**
West Texas	**Deterioration**	**+ 0.23**	**Big Bend NP**
Appalachian Mountains	**Deterioration**	**+ 0.10**	**Great Smoky Mtns NP**
Far West	**Deterioration &**	**+ 0.13**	**Yosemite NP**

[3] 42 U.S.C. § 7491(a)(1).

[4] Class I areas are designated in the Act as all international parks, national wilderness areas which exceed 5,000 acres in size, national memorial parks which exceed 5,000 acres in size, and national parks which exceed 6,000 acres in size, and which are in existence on August 7, 1977. 42 U.S.C. § 7472 (a)(1)-(4).

[5] Examples of deteriorating airshed given where available; other areas in region may show no change or improvement. Positive slope mean deterioration, negative slope means improvement. Meeting the Regional Haze Rule target depends on a 1-3 dv improvement per decade depending on region.

Northeast	**Improvement Improvement**	**- 0.12**	**Acadia NP**

Table 1: Visibility Trends in the United States based on haziest days (80th percentile value.)[6]

EPA in 1999 promulgated the Regional Haze Rule (RHR), which directs state, regional, and federal efforts aimed at reversing these worsening visibility trends, particularly those caused by "the cumulative air pollutant emissions from numerous sources over a wide geographic area."[7,8] The 1999 RHR was a promising step. It requires the states to identify uniform rates of visibility improvement or progress that will be needed to attain natural background conditions by the year 2064.[9] The poor conditions found in our nation's National Parks and wilderness areas – where the loss in visibility from the clearest days to the haziest days ranges from 43-80 percent – illustrates how much we need to do before realizing that goal.[10]

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[6] CIRA/COLORADO STATE UNIVERSITY, SPATIAL AND SEASONAL PATTERNS AND TEMPORAL VARIABILITY OF HAZE AND ITS CONSTITUENTS IN THE UNITED STATES, REPORT III (May 2000) (hereinafter "CIRA").

[7] 64 Fed. Reg. 35,714 (July 1, 1999).

[8] In 1980, the Agency issued guidelines for BART to correct visibility impairment that is reasonably attributable to a single source or small group of sources. U.S. EPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS, GUIDELINES FOR DETERMINING BEST AVAILABLE RETROFIT TECHNOLOGY FOR COAL-FIRED POWER PLANTS AND OTHER EXISTING STATIONARY FACILITIES, EPA-450/3-80-009b (November 1980) (hereinafter "*1980 BART Guidelines*"). These guidelines (which are slightly revised by the current proposal) were the first of EPA's two-phased approach to the problem of visibility inhibiting emissions from stationary sources. The current proposal addresses visibility problems due to regional haze. *See Maine v. Thomas*, 874 F.2d 883 (1st Cir. 1989).

[9] 64 Fed. Reg. 35,714, 35,732.

[10] *See* Appendix 2 (Regional Haze Summary: Selected Class I Airsheds); *see also* EPA OAR, *Final Regional Haze Regulations for Protection of Visibility in National Parks and Wilderness Areas: Fact Sheet* (filed April 22, 1999) <http://www.epa.gov/ttn/oarpg/tifs.html>.

Indeed, the improvement needed to meet the target of the rule is, for some deteriorating class I areas, two to three times the current rate of decline. For example, the 80th percentile value

As shown herein, the major source of the visibility problem in many Class I areas is the fleet of stationary sources, including grandfathered power plants, built prior to the Clean Air Act's passage in 1977. The success EPA and the states will have in the first planning period of the Haze Rule, through 2018, and ultimately in meeting the visibility goal of the Clean Air Act, therefore depends largely on the development of stringent guidelines that set the best available retrofit technology (BART) for eligible facilities.

As set out more specifically below, the undersigned sixteen groups urge EPA to improve the BART guidelines as proposed at 66 Fed. Reg. 38,108 (July 20, 2001), by addressing the concerns set out herein and in the oral testimony presented by these organizations. First, ***EPA must adopt the top-down approach*** as proposed, rather than the alternative approach, for the states' use in determining BART. This approach should include a ***rebuttable presumption that BART reflects at least 90 percent NOx and 95 percent SO_2 control levels*** on both controlled and uncontrolled power plants. Second, the Agency must in the final rule clarify its intention that ***BART emission reductions must be in excess of the emission cuts required under existing Clean Air Act programs***, including Title IV and the NO_x SIP Call. Third, ***the Cumulative Visibility Analysis may not be used to create an extra-statutory, de minimis exemption*** from the BART requirements. And fourth, if a source's remaining useful life is the basis of any BART decision, that ***determination of remaining useful life—particularly a promise of***

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in Great Smoky Mountains Park, 29 deciviews, must be reduced to +1 deciview of natural to meet the goal in 2064. If this were a static condition, and assuming a 10 deciview natural condition, an 18 deciview increase would need to be achieved by 2064 -- an approximate decrease of 3 deciviews per decade, or 0.3 deciviews per year. However, the 80th percentile value in the Smokies is actually worsening at a rate of 0.1 deciview per year, so achieving the 2064 natural conditions goal will actually require a decrease of 0.4 deciviews per year.

permanent shutdown -- must be legally binding and enforceable. These and a number of other concerns are examined in greater detail below.

I. The Problem Of Regional Haze is Caused, In Large Part, By Air Emissions of Sulfates and Other Pollutants from Power Plants and Other BART-Eligible Sources.

Regional haze visibility impairment results from regionally variable aerosol mixtures including sulfates, nitrates, organics and elemental carbon, as summarized in Table 2.

U.S. Region	Sulfate	Nitrate	Organics	Light Absorbing Carbon	Soil Coarse PM	Class I areas In region (not all-inclusive)
Appalachian	77%	5%	11%	4%	4%	Great Smoky, Shenand.
Midwest	54%	16%	17%	5%	7%	Boundary Waters
Colorado Plateau	37%	7%	28%	9%	19%	GC, Canyonlands
Northeast	68%	7%	14%	6%	6%	Acadia, Lye Brook
N Great Plains	49%	15%	17%	5%	14%	Badlands
N Rocky Mtns	35%	9%	32%	11%	13%	Glacier
Pacific Coast	48%	22%	14%	5%	11%	Redwood, Pt Reyes
Mid-Atlantic	66%	9%	10%	6%	9%	EBForsythe(Brigantine)
Southeast	72%	5%	12%	5%	7%	FL: Chassa, Okefenoke
Washington DC	58%	13%	15%	11%	4%	Wash Mon/not class I
West TX	48%	5%	19%	6%	22%	Big Bend, Guadalupe
Sonoran Desert	38%	6%	23%	9%	24%	Chiracahua
Southern CA	23%	39%	19%	9%	11%	San Gorgonio Wild.
Sierra Nevada	24%	18%	32%	11%	15%	Yosemite, Sequoia

Table 2: Annual average contribution to visibility impairment by region. [11]

It was suggested during the public hearings on this BART proposal that controlling pollutants other than sulfates would provide little or no visibility improvements, or that

[11] CIRA, *supra* note 6.

these controls would not prove cost-effective.[12] This groundless claim is refuted by an overwhelming body of technical evidence.[13]

A. Regional Haze Is Caused Primarily by Sulfates, but Other Pollutants Including Nitrates, Organics, Light Absorbing Carbon and Coarse Particulate Matter Also Play a Significant Role in Visibility Impairment.

Decades of scientific investigation have definitively quantified the role of sulfates in light scattering and its predominant role in forming haze throughout the United States.[14] Sulfates are the largest contributor to visibility impairment in all regions of the United States except southern California, where nitrates are the predominant contributors. Generally, coarse PM, black carbon, organic–forming VOCs, and nitrates also clearly are major contributors and should not be ignored in the BART guidelines. Across the country outside of California, while not predominant, nitrates still have a consequential role in contributing to aerosol light extinction especially in the Winter. For example, IMPROVE data and other information indicate that nitrate contributed to 30% of the Winter aerosol extinction budget at Boundary Waters, 19% in the Cascade Mountains, 12% in the Colorado Plateau, 13% in the Mid-Atlantic, 18% in the Mid-South, 13% in the Northeast, 17% in the Northern Rocky Mountains, and 20% in Washington, D.C.[15] In

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[12] J. Kinsman, Statement on behalf of Edison Electric Institute at Public Hearing on EPA Docket No. A-2000-28, Arlington, VA (August 21, 2001). In a seemingly contradictory remark, Mr. Kinsman also attempts to argue that "sources of fine particles other than sulfate may be more important." This unsupported statement has no merit.

[13] Indeed, as we also will show herein, the analysis of the cost-effectiveness of various levels of control must not become the all-consuming focus of the BART determination; states are required by the statutory and regulatory visibility improvement goals in determining BART to consider *all* of the statutory BART factors.

[14] NATIONAL ACADEMY OF SCIENCES, PROTECTING VISIBILITY IN NATIONAL PARKS AND WILDERNESS AREAS (1993).

[15] *See, e.g.*, CIRA, *supra*, note 6.

the East, Midwest and South, while nitrate aerosols significantly contribute to light extinction, sulfate aerosols typically are a larger contributor, in part because they effectively limit the formation of ammonium nitrate particulate matter. But atmospheric chemistry suggests a progressively increasing role of ammonium nitrate as sulfur dioxide emissions decrease and free up ammonium to allow for the formation of nitrate particles. This means that as sulfate is removed, nitrate will take its place in the haze mix. This increasingly important role of NO_x in the formation of nitrate in the non-summer months and as sulfates decline indicates that deep NO_x reductions will be required simultaneously with the sulfur reductions, if we are to meet the national goal.

B. BART-Eligible Sources Are Largely Responsible for Visibility Deterioration In Class I Areas In All Regions of the United States.

Studies of source regions responsible for haze in some Class I areas suggest that the most culpable regions also have the highest density of "BART-eligible" sources – sources that have the potential to emit 250 tons per year or more of any visibility–impairing pollutant, and that include an emissions unit that was "in existence on August 7, 1977 but ha[d] not been in operation for more than fifteen years as of [that] date."[16] Figures 1 and 2 illustrate this point. Figure 1 is a map of median visibility in the United States, with superimposed bubbles representing power plants, which bubbles are proportional in size to each plant's sulfur dioxide emissions.

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[16] 42 U.S.C. §§ 7491(b)(2)(A), 7491(g)(7).

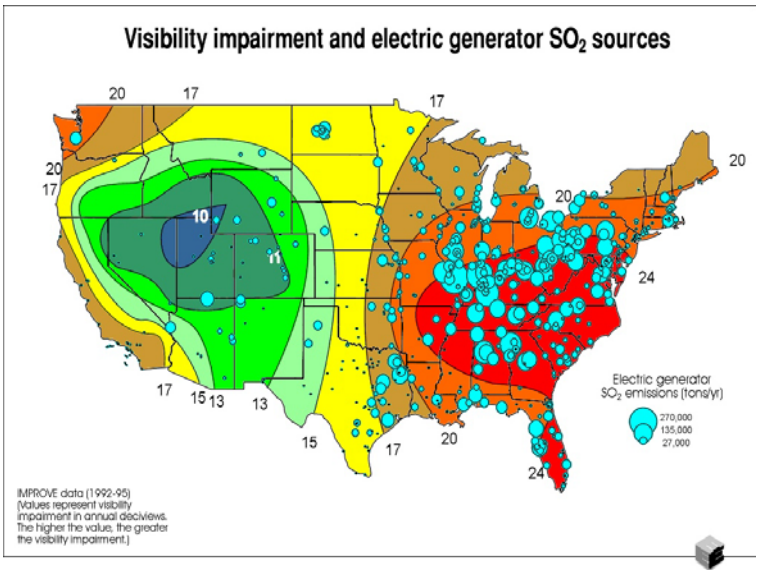

Figure 1: Visibility (median deciview) and sulfur dioxide sources in the U.S. (Source: E3 Ventures)

Figure 2 shows the locations of BART-eligible power plants.

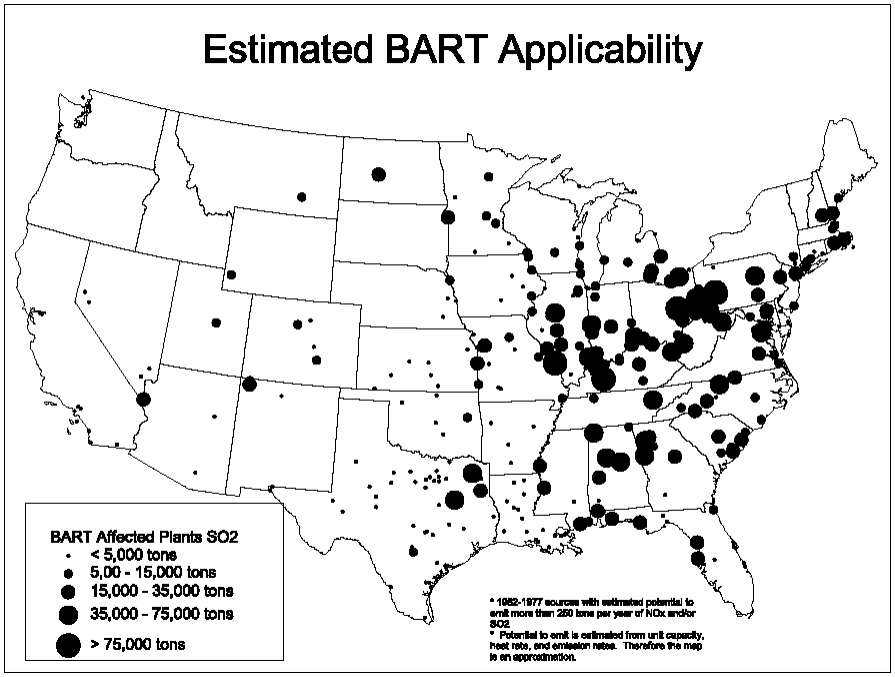

Figure 2: Map of power plants likely to meet criteria for BART eligibility under the Clean Air Act and the proposed BART guidelines (Source: MSB Energy Associates)

Comparing these two Figures shows that an effective BART program will be critical to meeting our national visibility improvement goals. The regions with the worst visibility – and the highest concentrations of BART-eligible sources – are in the Southeast, Northeast and Midwest.

More specifically, the Southeast has the worst annual average visibility conditions and *median* visibility exceeds a hazy 24 deciviews in the region, about 14 or more deciviews above natural conditions. For example, at Shenandoah National Park, estimated natural visibilities of 80-90 miles are typically reduced to an annual average of 18 miles; during the summer, average visibility dips even further to 11 miles.[17] According to EPA data for the six Southeast states adjacent to Great Smoky Mountain National Park (Tennessee, North Carolina, South Carolina, Georgia, Kentucky, and Virginia), 75 percent of the sulfur comes from electric utilities.[18] Of this, we estimate that 41 percent of the SO_2 in the Southeast comes from BART-eligible sources.

Gebhart and Malm's source apportionment analysis of sulfates at three eastern Class I airsheds,[19] originally published in 1989, was recently updated.[20] The study used a simple back trajectory method to apportion measured sulfate at Shenandoah, Great

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[17] US EPA, 2000 NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, EPA 454/R-00-003 (1998).

[18] US EPA, *AIRS Database* (visited Oct. 2, 2001) <http://www.epa.gov/air/data/ net.html>; *compiled by* MSB Energy Associates for Clean Air Task Force, *on file with* Clean Air Task Force.

[19] K.A. Gebhart and W.C. Malm, Source Apportionment for Particulate Sulfate Concentrations at Three National Parks in the Eastern United States, *in* VISIBILITY AND FINE PARTICLES, TRANSACTIONS OF THE A&WMA/EPA INTERNATIONAL SPECIALTY CONFERENCE 898-913 (C.V. Mathai, ed., 1989).

[20] *See* Appendix 3: Kristi Gebhart, Preliminary Update of Source Apportionment at Three Parks in the Eastern United States (August 2001). Unpublished report by National Park Service, Air Resources Division, CIRA/Colorado State University, *on file with* Clean Air Task Force.

Smoky Mountains, and Acadia National Parks to 17 known source areas. For Great Smoky Mountains National Park, sources in only two source regions – western TVA and Columbus-Dayton-Cincinnati – contributed 50 percent of the sulfur that has created the hazy, sulfur-laden atmosphere monitored in the Park throughout the 1990s. The Piedmont-East Tennessee and Atlanta regions were also significant contributors. For Shenandoah National Park, sources in the Pittsburgh, Cleveland, and the Columbus-Dayton-Cincinnati regions proved to be the largest contributors.

SAMI modeling sensitivity runs also confirm the dominant role of sulfates – rather than organic pollutants from mobile sources – in visibility impairing pollution in the Southern Appalachians.[21] Many of the stationary sources in this region are BART-eligible. Another analysis, of visibility impairment in the Great Smoky Mountains National Park, suggests that 77 percent of the visibility impairment under the haziest conditions is due to two TVA power plants.[22]

For the Northeast, the recently released MANE-VU report[23] provides a preliminary estimate of source regions for visibility impacts on the 20 percent haziest days in the Brigantine Class I wilderness in New Jersey. A region including southern Indiana and Ohio, northern Kentucky, and West Virginia that is heavily populated with potential BART-eligible sources is the most likely source area to be upwind of Brigantine

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[21]Georgia Institute of Technology Air Resources Engineering Center, *Southern Appalachian Mountains Initiative* (visited Oct. 2, 2001) <http://environmental.gatech.edu/SAMI/results.htm>.

[22] *See* Appendix 4: D. Pyles, T.A. Cahill, and J. Utz, Sources of Sulfate Trends in the Eastern United States, 1982-1998, *abstract for poster*, Conference on Visibility, Aerosols and Atmospheric Optics (September 2000). *On file with* Clean Air Task Force.

[23] MID-ATLANTIC/NORTHEAST VISIBILITY UNION (MANE-VU), A BASIS FOR CONTROL OF BART-ELIGIBLE SOURCES (2d prtg. July 2001).

on the haziest days. The MANE-VU analysis further showed that coal combustion contributed over 60 percent of visibility-impairing pollution on the haziest days. MANE-VU suggests that the "application of BART on these sources is likely to have a substantial impact on the coal source profile which accounts for over half of the measured mass and more than two-thirds of the visibility impairment on the haziest days."[24] A similar analysis for an IMPROVE monitoring site in northwestern Vermont suggests the same source region is associated with haze in northern New England.[25] And most of the sulfur that causes haze in Acadia National Park in Maine is emitted by sources in Northern New York, and New York City-Philadelphia.[26]

The Midwest also is plagued by regional haze. According to the 2000 IMPROVE report, increased light extinction has resulted in deteriorating visibility in Minnesota's Boundary Waters Canoe Area.[27] In the southern part of the region, Mammoth Caves National Park in Kentucky is one of the haziest parks in the United States.[28] To the west, in the northern Great Plains region, visual air quality in Badlands National Park also is deteriorating.[29] As is the case elsewhere, light extinction in the Midwest is dominated by sulfates. At Boundary Waters Canoe Area, sulfates account for 54 percent of light extinction annually. Nitrate accounts for an additional 16 percent and organics are

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[24] *Id*.

[25] *Id*.

[26] GEBHART, *supra* note 20.

[27] CIRA, *supra* note 6.

[28] *Id*.

[29] *Id*.

responsible for 17 percent.[30] And again, about 73 percent of the sulfur dioxide[31] and a significant proportion of nitrate-forming NO_X in the Midwest is generated from coal-burning power plants, many of which are BART-eligible.

Western vistas – some of America's most well-beloved, such as the view across the Grand Canyon – also are impaired by sulfates, nitrates, organics and light-absorbing carbon. For example, in the Colorado Plateau region and the central Rocky Mountains of Colorado and Wyoming, sulfates (largely a product of coal combustion) accound for 37 percent of the annual average haze. And because vistas in the West are currently not as impaired by haze as those in the East, Western vistas are more sensitive to any additional emissions. For this reason, eliminating tons of visibility causing pollutant emissions from even a single BART-eligible source can be important in the West.

In West Texas, Big Bend National Park is characterized by the greatest rate of visibility deterioration in the United States: about one quarter of a deciview per year.[32] Summed over a decade that would amount to a net deterioration of 2.5 deciviews – the inverse of the amount needed to achieve the RHR's reasonable progress target in 2064. The numerous BART-eligible sources in east Texas are at least partially responsible for this deterioration based on preliminary work of the BRAVO study.[33] Furthermore, prior experience with reasonably attributable BART applications in the West – on the Navajo

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[30] *Id*.

[31] CLEAN AIR TASK FORCE, SULFUR EMISSIONS AND MIDWEST POWER PLANTS (2001).

[32] CIRA, *supra* note 6.

[33] *See* Appendix 5: M. Green, H. Kuhns, and M. Pitchford, An Overview of the Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study, *in* PROCEEDINGS OF THE AIR AND WASTE MANAGEMENT ASSOCIATION'S 93RD ANNUAL CONFERENCE AND EXHIBITION, VIP 97 Session AB-6b, paper 206 (2000).

Generating Station, for example – illustrate the availability and cost-effectiveness of BART controls in the 90-95 percent range for sulfur.[34]

II. Applying BART Will Yield Significant Co-Benefits.

Because the BART program will target some of the largest emitters of sulfate-forming sulfur dioxide and nitrate-forming nitrogen oxides, it will yield significant health co-benefits, for example, easier breathing in our parklands and reduced mortality rural areas near the parks.[35] Furthermore, according to a recent publication from the Hubbard Brook Research Foundation, reduced sulfur dioxide emissions will also help acidic soils and associated ecosystems begin to recover. *Acid Rain Revisited*[36] outlines the continued problems of acid rain and models the sulfur reductions needed to restore ecosystems.

The economic benefits of cleaning up power plant haze are enormous as well. A study conducted in 2000 by Abt Associates for the Clean Air Task Force found that people's willingness to pay for visibly cleaner air where they live and in parks and wilderness areas can be valued at approximately $7.7 billion per year.[37]

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[34] *Central Arizona Water Conserv. Dist. v. EPA*, 990 F.2d 1531 (9th Cir.), *cert. denied*, 114 S.Ct. 94 (1993).

[35] *See* ABT ASSOCIATES, THE PARTICULATE-RELATED HEALTH BENEFITS OF REDUCING POWER EMISSIONS (2000).

[36] C.T. DRISCOLL, G.B. LAWRENCE, ET AL., ACID RAIN REVISITED: ADVANCES IN SCIENTIFIC UNDERSTANDING SINCE THE PASSAGE OF THE 1970 AND 1990 CLEAN AIR ACT AMENDMENTS 19 (2001).

[37] ABT ASSOCIATES, OUT OF SIGHT: THE SCIENCE AND ECONOMICS OF VISIBILITY IMPAIRMENT ES-11 (2000) (*prepared for* Clean Air Task Force).

As documented for sulfur in the 2000 EPA ORD report,[38] and described in more detail below, control technologies for SO_2 and NO_X are available, proven and cost-effective. Technical arguments are not a credible basis for further delay, and in fact strongly support a presumptively stringent top-down BART process for both SO_2 and NO_x.

III. These BART Guidelines Must Be Implemented so as to Further the National Goal of Remedying *Any* Existing Visibility Impairment and Preventing *Any* Future Deterioration.

Congress has established as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution."[39] That goal requires EPA to arrest and reverse the trends toward impaired visibility in Class I areas caused by regional haze. The statutory language is a clear and succinct indicator of the legislative intent behind Section 169A, 42 U.S.C. §7491. All aspects of the RHR and the final BART guidelines, including the determination and implementation of BART, must advance the national goal or be in contravention of Congress's purposes.[40]

A. BART Must Apply if the Cumulative Visibility Analysis Demonstrates that *Any* Existing Visibility Impairment will be Remedied or *Any* Deterioration is Prevented.

[38] RAVI K. SRIVASTAVA, CONTROLLING SO_2 EMISSIONS: A REVIEW OF TECHNOLOGIES EPA/600/R-00/093 (November 2000) (*prepared for* U.S. EPA Office of Research and Development). A similar case for NO_x can and should be made by ORD.

[39] 42 U.S.C. § 7491(a)(1).

[40] *See Central Arizona*, 990 F.2d at 1534.

In Section V of the proposed BART guidelines, EPA describes states' obligations under the RHR to conduct Cumulative Air Quality Analyses – modelling the total cumulative regional visibility improvement that would result if all sources subject to BART were to install the BART controls selected in the engineering determination of BART.[41] Section V of the guidelines also proposes that the results of those analyses might be used to determine whether BART must be applied in a region.[42] We are opposed to any suggestion that the cumulative visibility analysis could be used to exempt a state or region from the BART requirements or to create exemptions for specific sources on *de minimis* contribution grounds.

More specifically, EPA proposes that the cumulative impact assessment should be used to determine whether the BART controls identified in the BART engineering determination, if applied to all sources in a region, would "provide a sufficient visibility

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[41] It should be noted that references to Cumulative Air Quality Analysis in the BART guidelines proposal do not reopen that aspect of the RHR for comment. In the BART guidelines proposal, EPA simply describes the relationship between the BART determination process outlined in the current rulemaking and the cumulative analysis requirement established in the statute and the RHR. The reopener doctrine "is not a license for bootstrap procedures by which petitioners can comment on matters other than those actually at issue, goad an agency into a reply, and then sue on the grounds that the agency had re-opened the issue." *American Iron & Steel Inst. v. EPA*, 885 F.2d 390, 398 (D.C. Cir. 1989).

The statutory basis and requirement of a cumulative analysis of air quality furthermore was a central feature of the final RHR. *See* 64 Fed. Reg. 35,714, 35, 741. The requirement was also at issue in two unsuccessful petitions for administrative reconsideration filed by industry. *See* Letters from Carol M. Browner, EPA Administrator, to Michael L. Teague, Counsel for the Utility Air Regulatory Group and the National Mining Association, and Paul M. Seby, Counsel for the Center for Energy and Economic Development, etc. 15-16 (January 10, 2001). Furthermore, the validity of the RHR is now being contested in the U.S. Court of Appeals for the D.C. Circuit. *See American Corn Growers Ass'n v. EPA*, No. 99-1348 (D.C. Cir. filed Aug. 30, 1999). Any attempt to assert the reopener doctrine of *Ohio v. EPA*, 838 F.2d 1325 (D.C. Cir. 1988), in this case must fail. Given the inordinate attention the RHR and the Cumulative Air Quality Analysis have received thus far, it would be disingenuous to suggest that consideration of the issue was previously deferred to the BART rulemaking. Finally, it would be an enormous waste of administrative and judicial resources to allow that aspect of the RHR to be rehashed in this rulemaking.

[42] *See* 66 Fed. Reg. 38,108, 38,131.

improvement to justify their installation."[43] The Agency further defines "sufficient improvement to justify installation" as either a demonstration that the resulting achievable visibility improvement from the application of BART to all sources subject to BART is a "substantial fraction" either of "the achievable visibility improvement from all measures included in the SIP"or "the visibility goal for any Class I area," or alternatively, is necessary to prevent any degradation from current conditions on best visibility days.[44]

We believe that this complicated formulation is not only unnecessary, but will yield results contrary to the statute's purposes. The statute requires that modeling results from a Cumulative Air Quality Analysis justify the application of BART on all sources subject to BART in a region if they demonstrate, in the associated Class I area, that *any* existing visibility impairment will be remedied or *any* future deterioration in visibility will be prevented. The final BART guidelines should reflect that requirement.

B. EPA May Not Exclude from the Regional Haze Program Any State Containing a Class I Area or Any State the Emissions from which May Reasonably Be Anticipated to Cause or Contribute to *Any* Visibility Impairment in a Class I Area.

EPA also hypothesizes that a State may demonstrate that it makes only a "trivial" contribution to visibility impairment in Class I areas.[45] While the implications of a state asserting that it makes a trivial contribution are not expressly stated, from the context it appears that this would functionally operate as an exclusion to the BART requirement,

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[43] *Id*.

[44] *Id*.

[45] *Id*. at 38,121.

either by exempting a state from the obligation to adopt a regional haze SIP as a threshold matter, or by exempting major stationary sources from the BART requirement through the implementation of a state's regional haze SIP. Neither of those outcomes is legally permissible: the statute does not admit of a *de minimis* exception for states from the BART requirements.

First, Section 169A(b)(2) of the Clean Air Act expressly requires that every state with a protected Class I area must adopt a visibility SIP to address regional haze visibility impairment containing, at a minimum, two core elements: (1) BART, and (2) a long-term strategy for making reasonable progress toward the national visibility protection goal.[46] Thus, it is contrary to law for EPA to allow a state containing a Class I area to decline to implement the BART requirement. This must be clearly stated in the final rule.

Second, the statute provides that a state that does not contain a protected Class I area within its borders must adopt a visibility SIP to address regional haze that contains BART and a long-term strategy if "the emissions from [the state] may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area.[47] This language is expressly expansive in its reach. The language plainly requires implementation of the BART requirement in states that contribute to "any" visibility impairment in a Class I area located elsewhere. Thus, this language forecloses *de minimis* loopholes to the BART requirement.

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[46] 42 U.S.C. § 7491(b)(2).

[47] 42 U.S.C. § 7491(b)(2).

Further, Congress deliberately employed precautionary language that does not require certainty in establishing the relationship between emissions in a state and visibility impairment in a Class I area located elsewhere. The phrase "reasonably anticipated to cause or contribute" on its face only requires a reasonable likelihood. This language was the subject of considerable congressional discussion in the 1977 amendments to the Clean Air Act that established the visibility program. It originated from Judge Skelly Wright's landmark opinion affirming EPA's regulations removing the lead from gasoline which propounded the "precautionary principle" in interpreting the Clean Air Act:

> Where a statute is precautionary in nature, the evidence difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific knowledge, the regulations designed to protect the public health, and the decision that of an expert administrator, we will not demand rigorous step-by-step proof of cause and effect. Such proof may be impossible to obtain if the precautionary purpose of the statute is to be served. . . . The Administrator may apply his expertise to draw conclusions from suspected, but not completely substantiated, relationships between facts, from trends among facts, from theoretical projections from imperfect data, from probative preliminary data not yet certifiable as "fact," and the like.

Ethyl Corp. v. EPA, 541 F.2d 1, 28 (D.C. Cir. 1976) (*en banc*).

Congress was fully aware of this decision when it enacted the 1977 Clean Air Act Amendments,[48] and codified the precautionary principle in the visibility protection

[48] Congress explicitly revised the statutory language governing the regulation of fuels in 1977 to graph upon the statute the precautionary principle enunciated by the *Ethyl* court:

> In order to emphasize the precautionary or preventive purpose of the act (and, therefore, the Administrator's duty to assess risks rather than wait for proof of actual harm), the committee not only retained the concept of endangerment of health; the committee also added the words "may reasonably be anticipated". In evaluating what "may reasonably be anticipated", the limitations and difficulties inherent in environmental medical research referred to above must be considered.

provisions. This interpretation has been affirmed by the U.S. Court of Appeals for the Ninth Circuit, in a case construing the 1980 reasonably attributable BART guidelines:

> Congress mandated an extremely low triggering threshold, requiring the installment of stringent [BART] emission controls when an individual source "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility." 42 U.S.C. §7491(b)(2)(A). The National Academy of Sciences correctly noted that Congress has not required ironclad scientific certainty establishing the precise relationship between a source's emission and resulting visibility impairment.

Central Arizona, 990 F.2d at 1541.

The operative language governing the determination of which states are subject to the visibility program is virtually identical to the language governing BART applicability to a source.[49] By direct analogy, this statutory standard is precautionary and does not require certainty. Indeed, only in circumstances in which emissions from an upwind state are not, in any reasonable way, anticipated to contribute to "any" visibility impairment in a Class I area located in a downwind state may such state be excluded from the BART requirement. We urge EPA to bring its final rules in line with these statutory standards.

C. It is Unlawful for EPA to Adopt Rules that Exempt "Any" Major Stationary Source from the BART Requirement Unless the Statutory BART Exemption Requirements Have Been Satisfied, Including the Concurrence of the Appropriate Federal Land Manager.

> By its use of the words "cause or contribute to air pollution", the committee intends to require the Administrator to consider all sources of the contaminant – food, water, air, etc. – in determining health risk.

H.R. Rep. No. 95-294, at 51 (1977).

[49] *Compare* 42 U.S.C. § 7491(b)(2) (haze SIPs are required from all "State[s] the emissions from which may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area) *with* 42 U.S.C. § 7491(b)(2)(A) (Sources subject to BART are those of a certain vintage and which "emit[] any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility").

To the extent EPA's proposal regarding the applicability of the program functions not as a basis for excluding states from submitting regional haze SIPs but as a basis for establishing a specific exclusion from the BART requirement under the ambit of a visibility SIP, it is at odds with the statutory BART exemption requirements. Section 169A(c) of the Clean Air Act delineates very specific statutory substantive and procedural obligations that must be satisfied in exempting a major stationary source from the BART requirement.[50] In addition to the duties of the Administrator to make specific findings of fact and follow particular procedures, by law the Administrator's decision to grant an exemption may only become effective upon the concurrence of the Federal Land Manager.[51]

D. EPA Must Clarify that the Reductions Required by BART, Whether Achieved Through the Imposition of Source-Specific Emission Limitations or an Alternative Emissions Cap-and-Trade Program, Must be In Addition to Emissions Reductions to be Generated Under Programs Established as of the Regional Haze SIP Due Dates.

To fulfill the Agency's statutory duty in establishing BART guidelines, EPA must clarify, in the final rule, the interface between the BART program, the Title IV acid deposition control program for SO_2, the "NO_x SIP Call," and other emission reduction programs. In particular, EPA should explain that to ensure reasonable progress in protecting visibility and to lawfully carry out the BART requirement, the SO_2 and NO_x reductions required by BART are "in addition" to those required by the Title IV SO_2 control program, the NO_x SIP Call, and any other established emission control program.[52]

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[50] 42 U.S.C. § 7491(c); *see infra* Section IV.B. for a discussion of the statutory exemptions.

[51] 42 U.S.C. § 7491(c)(3).

[52] The National Association of Manufacturers (NAM) has asserted in a letter dated October 11, 2000, and their August 21, 2001 public hearing testimony that since the enactment of the BART

As examined in section III.B. above, the applicability of the regional haze program and the BART requirement were deliberately designed to be broad as a precaution to protect the scenic vistas in Class I areas and ensure progress toward the national visibility protection goal. Thus, the program is inclusive in the states that are required to submit regional haze SIPs and plainly requires that all affected states must adopt plans containing the BART requirement.[53]

Further, Section 169A(b)(2)(A) provides that all "major stationary sources" in an affected state "which may reasonably be anticipated to cause or contribute to any impairment of visibilility" in a Class I area, and meeting the applicable age and size criteria are required to procure, install and operate BART as expeditiously as practicable.[54] The operative applicability language for BART already has been interpreted by the federal court of appeals to establish "an extremely low triggering

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legislation, many Charcoal Production Facilities (CPFs) have purportedly reduced emissions and thus should not be subject to the BART requirement. This claim not only misreads the statute, but erroneously confuses the issues of applicability and implementation of the BART requirement.

NAM presents this argument utilizing CPFs as an example. NAM notes the legislative history relating to the establishment of the 26 source categories highlights a study listing the pollutants of concern for 190 potential sources. Since the enactment of the BART rule, NAM asserts that many of these facilities have reportedly implemented pollution control measures. Thus, NAM contends, Congress' goal of encouraging pollution reductions has been met and CPFs should therefore be exempt from the BART requirement.

Although any such reductions are noteworthy, they clearly do not provide a legal basis to exclude CPFs – or any other "major stationary sources" – from the BART requirement. The fact that sources have installed pollution controls is one of the statutory factors that must be considered in determining what constitutes BART for a particular source. In other words, existing controls on a BART-eligible source are relevant to the implementation of the BART requirement, not its applicability. Accordingly, the law is clear that such controls are not a basis for determining what sources are subject to the BART requirement.

[53] 42 U.S.C. § 7491(b)(2).

[54] 42 U.S.C. § 7491(b)(2)(A).

threshold."[55] This statutorily-mandated low triggering threshold taken together with EPA's determination in the final regional haze rule that "a State should find that a BART-eligible source is 'reasonably anticipated to cause or contribute' to regional haze if it can be shown that the source emits pollutants within a geographic area from which pollutants can be emitted and transported downwind to a Class I area,"[56] subjects all BART-eligible sources in states required to submit regional haze SIPs to the BART requirement.

The only permissible exception is for sources that meet the rigorous statutory standards governing BART exemptions.[57] Indeed, EPA itself has stated that the extraordinary narrowness of the BART exemption criteria affirms, by negative inference, the breadth of the program.[58] Accordingly, there is no statutory basis for excluding sources from the BART requirement because they are subject to the SO_2 acid deposition control program, NO_x SIP Call, or other emission control measures. Rather, the relevance of existing pollution control requirements in place at a particular major stationary source is in determining what constitutes BART for the source based on the BART statutory factors, but is not a basis for declining to apply the BART requirement. Thus, the legal analysis for evaluating existing pollution control requirements at a BART-eligible source is straightforward. Whether required by the Title IV acid deposition

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[55] *Central Arizona,* 990 F.2d at 1541 (installment of stringent BART emission controls is required "when an individual source emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility").

[56] 64 Fed. Reg. 35,714, 35,740.

[57] 42 U.S.C. § 7491(c).

[58] 56 Fed. Reg. 50,172, 50,177-78, n. 16 (Oct. 3, 1991).

control program, the NO_x SIP Call, or any other air pollution abatement program, existing controls inform BART determination but may not be a basis for excusing incremental reductions to meet BART-level emissions limits.

It would also turn logic on its head if EPA determined that emission reductions achieved through programs other than emission rates established at an individual source, such as market-based emissions cap-and-trade programs, should become a basis for rendering BART inapplicable. Like control requirements at individual sources, other emission reduction measures cannot lawfully preclude the application of BART. This necessarily means that BART reduction measures must be "surplus to" or "in addition to" strategies that achieve reductions through other means.

This "surplus" or "additionality" requirement flows directly from the BART requirement of the visibility protection program and, in the words of EPA's own General Counsel, the "overarching" statutory requirement to achieve reasonable progress.[59] Our principal concern is that sources that lower emissions as a result of the BART requirement could create tradable emissions allowances for purposes of other SO_2 or NO_x pollution abatement programs that negate the emissions progress generated by the application of the BART requirement. If this were to be permitted, the reductions achieved from a BART emission limitation applied at one source could be offset by emission increases at another source or group of sources. Under this scenario, visibility would not be improved and the bedrock statutory requirement of achieving reasonable progress toward the national visibility goal would be seriously undermined.

Likewise, if only some but not all RPOs implement "alternative measures" to BART in the form of an emissions cap-and-trade program, the discontinuous regional

caps would allow impermissible leakage into those regions employing emissions rates rather than firm caps.

The final regional haze rule contains provisions that appear to address this concern, but ultimately fall short of providing the necessary regulatory guidance. For example, 40 C.F.R. 51.308(e)(2)(iv) calls for states to demonstrate that the "emission reductions resulting from the emissions trading program or other alternative measure will be surplus to those reductions resulting from measures adopted to meet requirements of the CAA as of the baseline date of the SIP." There are several central questions presented by this provision. First, the phrase "resulting from measures adopted to meet requirements of the CAA as of the baseline date of the SIP" is ambiguous. To ensure that the visibility SIPs in fact assure reasonable progress, EPA must clarify – in the final regional haze BART guidelines – that the "surplus" test applies to requirements that are *established* or *adopted* as of the baseline date of the SIP regardless of whether they have in fact been implemented. Similarly, EPA must clarify in the final BART guidelines that the additionality test applies to the date the requirement is established, rather than when actually adopted by the state, to ensure that states that have failed to timely adopt control measures may not include such measures in the baseline for the purposes of BART determinations.

Moreover, it must be clarified that in states that implement BART through source-by-source emission limitations but that are subject to emissions caps or other requirements under other programs, sources subject to BART may not convert their emission reductions under the BART program to tradable allowances to be emitted elsewhere.

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[59] 56 Fed. Reg. 38,399, 38,403 (Aug.13, 1991).

The problem created if the interface between BART and existing programs is not clarified is powerfully illustrated by the eastern NO_x SIP Call – which by its nature is a summertime NO_x and ozone pollution abatement program. But long-term IMPROVE monitoring data indicates that the NO_x contribution to visibility-impairing fine particle mass in the East is greatest in the winter. For example, an urban monitor located in Washington, D.C. indicates that nitrates comprised 17 percent of the wintertime fine particle mass.[60] Nitrates comprised an average of 15 percent of the wintertime fine particle mass at southern monitors in Mississippi, Arkansas and Kentucky.[61] At a monitor located in the Edwin B. Forsythe National Wildlife Refuge located west of Atlantic City, nitrates comprised about 12 percent of wintertime fine particle mass.[62] Similarly, nitrates were 11 percent of the fine particle mass during the wintertime at three sites in New England.[63] Thus, relying on the NO_x SIP Call to remedy regional haze visibility impairment – in lieu of BART or an alternative measure designed to assure reasonable progress – will seriously miss the mark in carrying out the visibility protection program's statutory mandates and purposes.

The bottom line is that so long as emission reductions may be offset by emission increases in a manner that states cannot meaningfully account for, then states cannot in fact assess the net emissions decrease in a Class I area and therefore cannot assure

[60] CIRA, *supra* note 6.

[61] *Id*.

[62] *Id*.

[63] *Id*.

reasonable progress in protecting visibility.[64] We strongly urge EPA to finalize the current BART guidelines for the states to make clear that BART emissions reductions must be surplus of those achieved by other Clean Air Act programs.

IV. BART Is Applicable to All 26 Source Categories Listed In the Statute, Whether or Not They Have Previously Been Modified.

EPA has clear authority and indeed is obligated under the Clean Air Act to establish regional haze BART guidelines, by rulemaking, for all 26 categories of major stationary sources set forth in the Act.[65] For power plants of over 750 MW of generating capacity, the statute goes further, making the BART guidelines mandatory requirements.[66] We agree with EPA that these requirements must apply irrespective of whether a source has been modified.[67]

A. We Support EPA's Proposal to Establish BART Guidelines for All 26 BART Source Categories, Not Only Large Power Plants

EPA proposes new regulatory text requiring states to follow the BART guidelines in making BART determinations for sources in all 26 major stationary source categories. We strongly support this aspect of EPA's proposal. Any attempt by industry or others to

[64] There are a number of potential public policy responses to ensure that emission reductions are in fact surplus and reasonable progress is achieved. For example, if all RPOs adopted firm and well-designed regional emissions caps as an alternative measure to BART, the net emission reductions expected would be realized. We urge EPA to explore these and the panoply of other policy responses that can be employed to effectively carry out the "surplus" requirement as part of the forthcoming guidelines to states and RPOs on developing alternatives to BART.

[65] *See* 42 U.S.C. §§ 7491(b)(2), (g)(7).

[66] *See* 42 U.S.C. § 7491(b)(2).

[67] EPA's decision to extend the applicability of the guidelines to all 26 source categories is consistent with the approach EPA has taken for over twenty years. *See 1980 BART Guidelines*, *supra* note 8.

rely on legislative history to support an alternative perspective is misplaced; legislative history cannot be dispositive on this point, in light of the clear statutory language supporting EPA's approach.

Section 169A plainly makes BART-eligible "*each* major stationary source which [was] in existence on August 7, 1977 but which [had] not been in operation [before August 7, 1962]."[68] The term "major stationary source" is further defined by the express language of the statute to include emissions sources in 26 source categories, and which have the potential to emit 250 tons or more of any pollutant.[69]

In the visibility provisions of the Act, Congress commanded EPA to guide states in the revision of their SIPs in order to meet the Congressionally mandated visibility goal, described above. First, the statute directs EPA to provide states with "techniques and methods" for assessing visibility impairment, determining the extent to which manmade air pollution contributes to visibility impairment, and preventing and remedying visibility impairment.[70] Second, per Section 169A(b)(2), EPA "shall," by regulation, require that each relevant SIP contains "emission limits, schedules of compliance and other measures as may be necessary to make reasonable progress toward meeting the national goal . . . ."[71] Further, Section 169A(b)(1) expressly directs that EPA's visibility regulations must include guidelines to the states and appropriate techniques and methods for remedying

[68] 42 U.S.C. § 7491(b)(2)(A) (emphasis added).

[69] 42 U.S.C. § 7491(g)(7).

[70] *See* 42 U.S.C. § 7491(b)(1) (referencing the requirements listed at 42 U.S.C. 7491(a)(3)(A-C)).

[71] 42 U.S.C. § 7491(b)(2).

haze air pollution. The plain language of the text is broad in scope and clearly delegates to EPA the authority to establish regulatory guidelines for all source categories.[72]

While Congress expressed particular concern, in the final (addendum) paragraph of Section 169A(b)(2), about large and dirty powerplants built between 1962 and 1977, this added emphasis on one severely polluting industry sector does not change the clear straightforward requirements established in Section 169A(b) for all BART-eligible sources. The addendum paragraph reads: "In the case of a fossil-fuel fired generating powerplant having a total generating capacity in excess of 750 megawatts, the emission limitations required under this paragraph shall be determined pursuant to guidelines, promulgated by the Administrator . . . ."[73]

Furthermore, while there is another reference to 750MW power plants in Section 169A, it is found in the exemptions provisions of subsection (c). These large sources are declared *ineligible* for exemptions from the BART requirement, unless certain specific additional hurdles are surmounted.[74] Read together, the focus on large fossil-fuel fired powerplants in the last part of Section 169A(b)(2) and in the exemption process at Section 169A(c) suggest that Congress was more than aware of the disproportionate contribution of those plants' emissions to haze-producing pollutants. That awareness does not, however, render meaningless those portions of Sections 169A(b)(2)(A) and

[72] 42 U.S.C. § 7491(b)(1).

[73] 42 U.S.C. § 7491(b)(2).

[74] Specifically, the owner or operator of a source must demonstrate to the satisfaction of the EPA Administrator and the Federal Land Managers for downwind class I areas that the "powerplant does not or will not, by itself or in combination with other sources, emit any air pollutant which may reasonably be anticipated to cause or contribute to significant impairment of visibility in any such area." 42 U.S.C. § 7491(c)(2).

169A(g)(7) which clearly demonstrate that Section 169A applies to a wide range of sources and not just powerplants.

The plain language of Section 169A(g)(7) expressly describes the 26 source categories that are "major stationary sources" for the purpose of the BART requirement. There should be no confusion on this point. But NAM and others have argued in oral testimony that legislative history supports another view. Assuming *arguendo* that it is appropriate to look beyond the clear language of the statute,[75] it is notable that the smattering of legislative history that directly concerns BART is confusing at best. The comments of several senators, for example, that "[f]ederal guidelines apply only to fossil-fuel fired generating plants in excess of 750 megawatts" are in conflict with any reasonable reading of Section 169A.[76] The senators' misleading comments reveal why "[i]nquiries into congressional motives or purposes are a hazardous matter."[77] Statements made on the floor of the legislature, even by those closely involved in a bill's consideration, are not infallible indications of the will of Congress. "What motivates one

[75] It is a "familiar canon of statutory construction that the starting point for interpreting a statute is the language of the statute itself. Absent a clearly expressed legislative intention to the contrary, that language must ordinarily be expressed as conclusive." *See Consumer Safety Product Comission v. GTE Sylvania*, 447 U.S. 102, 108 (1980); *see also TVA v. Hill*, 437 U.S. 153, 184 n.29 (1978) ("When confronted with a statute which is plain and unambiguous on its face, we ordinarily do not look to legislative history as a guide to its meaning."); *Gemsco v. Walling*, 324 U.S. 244, 260 (1945) ("The plain words and meaning of a statute cannot be overcome by a legislative history which, through strained processes of deduction from events of wholly ambiguous significance, may furnish dubious bases for inference in every direction.") Given the lack of ambiguity in Section 169A, there is little need to reach beyond the language of the statute to interpret the intent of Congress.

[76] *See*, *e.g.*, 123 CONG. REC. S. 26,854-56 (daily ed. Aug. 4, 1977) (remarks of Senators McClure, Muskie, and Domenici).

[77] *United States v. O'Brien*, 391 U.S. 367, 383 (1968).

legislator to make a speech about a statute is not necessarily what motivates scores of others to enact it."[78]

B. The Applicability of BART for Fossil-Fuel Plants of More Than 250 Million BTU/Hr Heat Input Must be Determined by Aggregating Boiler Capacities at a Source.

EPA requests comment on two proposals for interpreting the statutory source category titled "fossil-fuel boilers of more than 250 million BTU/hour heat input." We support using the approach currently in place in the regulations implementing the Clean Air Act's Prevention of Significant Deterioration requirements, which requires the aggregation of boiler capacities at an industrial power source to determine whether or not the 250 million BTU/hour threshold is met.

The language of section 169A(g)(7) supports this interpretation for use in implementing BART. A "major stationary source" is defined in that section as a "stationary source with the potential to emit 250 tons per more of any pollutant," in any of a list of enumerated source categories. Among the source categories are "fossil-fuel fired steam electric plants of more than 250 million [BTUs] per hour heat input" and the category in question, "fossil-fuel boilers of more than 250 million [BTUs] per hour heat input."[79] Both "fossil-fuel fired steam electric plants of more than 250 million BTUs per hour heat input" and "fossil-fuel boilers of more than 250 million BTUs per hour heat input" refer to power plants – either utility generation units or the electric generating facilities directly supporting industrial processes, and which may or may not offer electricity for sale to the grid. Congress clearly intended, by the use of the word "plant"

[78] *Id.* at 384.

[79] 42 U.S.C. § 7491(g)(7).

in the former source definition, to require the aggregation of all units at a utility plant in determining whether the 250 million BTUs per hour threshold is met. The presence of the term "boilers" in describing power plant facilities at industrial sites distinguishes the power plant portion of an industrial facility from the emissions sources directly associated with the industrial processes itself. Furthermore, Congress's use of the plural "boilers" rather than the singular "any boiler" strongly suggests it is the aggregated collection of power production units that must be considered. Congress arguably wanted to clarify that the aggregate of all "boilers" at a large industrial facility (*i.e.*, where power is produced at a rate equal to or greater than 250 million BTUs heat input per hour) are covered by the BART requirements. In order to be consistent across all types of power plant sources, the heat input of all power plant units at an industrial facility should be aggregated to determine whether the 250 million BTU per hour heat input threshold is satisfied, just as is done at utility power plant facilities.

This approach is also supported by the general structure of the clean air provisions of the Act. As EPA notes, the aggregation of all units or boilers at power plants supporting industrial facilities is a requirement under the PSD rules. The BART requirement and the PSD BACT requirement are brothers in arms, as described further in section V. herein – PSD being aimed at new sources and BART at retrofitting existing sources as of 1977, but toward the same general goal of preserving and protecting clean air areas. It is therefore appropriate that they include consistent source definition interpretations.

C. BART Must Apply to Every Emissions Unit at a Source if the Potential Total Emissions of All Visibility-Impairing Pollutant from the Source Exceeds 250 Tons Per Year.

At Section II, Step 4, of the proposed BART guidelines, EPA states: "If the emissions from the list of the emissions units at a stationary source exceeds a potential to emit of 250 tons per year for any visibility-impairing pollutant, then that collection of emission units is a BART eligible source. A BART analysis is required for each visibility impairing pollutant emitted."[80] While we generally support EPA's approach, we believe that the Clean Air Act mandates a more stringent approach. The final BART guidelines should require that each emissions unit at a source is subject to BART if the emissions from all of the units at a source exceed a potential to emit of 250 tons per year for *all* visibility-impairing pollutants. In other words, if the cumulative source-wide potential to emit for all haze-causing pollutants exceeds 250 tons per year, then each individual unit at that source should be subject to BART.

EPA's decision to subject each unit to a BART analysis if the total emissions of visibility-impairing pollutants exceeds 250 tons per year is part of the Agency's coherent, logical focus on source-wide, multiple-pollutant applicability evidenced throughout the proposed guidelines. In accordance with this consistent approach, EPA writes at Section III, Part C, that once a source has been determined to be subject to BART, "a BART review is required for each visibility-impairing pollutant emitted . . . Consequently, the BART determination must address the air pollution control measures for each emissions unit or pollutant emitting activity subject to review."[81]

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[80] 66 Fed. Reg. 38,108, 38,120.

[81] *Id*. at 38,122.

EPA's requirement that the operator of a source that is subject to BART analyze each emissions unit at the source corresponds to what is known about haze-causing pollutants. As discussed above in section I.A. of these comments, sulfates, nitrates, particulate matter, and other pollutants all contribute to light extinction and visibility impairment. Although sulfates have traditionally been the dominant cause behind haze in Class I areas, other pollutants, especially nitrates, are playing an increasingly significant role. The contributions of such a variety of pollutants to visibility impairment necessitates that EPA require deep reductions in SO_2, NO_x, and PM emissions if we are to achieve the national goal outlined in Section 169A.

The source-wide approach is also supported by the plain language of Section 169A, which clearly anticipates that the application of BART will occur on a source-wide scale. In its description of the factors EPA must take into consideration in determining BART, the Act refers to "any existing pollution control technology in use *at the source*" and "the remaining useful life *of the source*."[82] If Congress had intended BART to apply only on a unit-by-unit basis, it would have required BART analyses on that scale. Because the Act instead conceives of BART on a source-wide scale, EPA's approach is both logical and consistent with the aims of the Clean Air Act. However, as stated above, the final BART guidelines should require that each emissions unit at a source is subject to BART if the emissions from all of the units at a source exceed a potential to emit of 250 tons per year for *all* visibility-impairing pollutants.

D. Modifications to a Source do not Render it BART-Ineligible.

[82] 42 U.S.C. § 7491(g)(2) (emphasis added).

We agree with EPA's position that every BART-eligible source is subject to Section 169A of the Clean Air Act, including those sources that have been modified and are regulated under other statutory schemes such as the closely analogous BACT provision of the PSD program and the LAER provision of the nonattainment program.[83]

EPA asserts in the proposed guidelines that:

> . . . the best interpretation for the purposes of the visibility provisions is that modified emissions units are still "existing." The BART requirements in the CAA do not appear to provide any exemption for sources which were modified since 1977 . . . [A]n emissions unit which began operation within the 1962-1977 time window, but was modified after August 7, 1977, is BART-eligible.

66 Fed. Reg. 38108, 38119.

The Agency's interpretation that a subsequent modification to an BART-eligible existing source does not in itself exempt that source from the BART review process or from the application of the BART requirements is supported by the plain language of Section 169A and the clearly discernable intent of Congress evidenced throughout the Clean Air Act.

In considerable detail, and in plain straightforward language, the Act positively describes which sources are subject to regulation under Section 169A, and then provides for exemptions only in limited, clearly defined circumstances. The statute carefully identifies the types of emission sources that are subject to regulation under Section 169A.[84] First, a source must meet the statutory definition of a "major stationary source." According to Section 169A(g)(7), a facility is a "major stationary source" if it is capable

[83] 66 Fed. Reg. 38,108, 38,119.

[84] These sources would be "subject to BART," as defined by the RHR, and therefore required to apply BART, if their emissions are found to reasonably cause or contribute to any impairment of visibility in a class I area. *See* 64 Fed. Reg. 35,714, 35,737.

of emitting 250 tons or more of any pollutant and if it is of a type that falls within one of twenty-six categories of stationary sources listed in the Act.[85] Second, the source must be an "existing" source, *i.e.*, it must have begun actual operations on or after August 7, 1962, but before August 7, 1977.[86] The three step process set out in the proposed BART guidelines for determining whether a source is BART-eligible[87] directly reflects the statutory language. If a source (1) contains emissions units in one or more of the twenty-six source categories, (2) came into existence between August 7, 1962 and August 7, 1977, and (3) has the potential to emit more than 250 tons per year of any visibility-impairing pollutant, then under Section 169A and the proposed BART guidelines that source is BART-eligible.

According to the Act, if a BART-eligible source is found to cause or contribute to any impairment of visibility in any Class I area, it must install BART "as expeditiously as practicable" unless exempted by the Administrator by rule, after notice and comment, and with the concurrence of the appropriate federal land manager.[88] A subsequent modification to an existing source is not among the factors delineated in the statute as justifying an exemption, and therefore is not *prima facie* evidence in support of an exemption. To receive an exemption from the requirement to apply BART, a BART-eligible source which has been modified and had its emissions controls updated must demonstrate, *like any other source seeking an exemption,* "that [it] does not or will not,

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[85] 42 U.S.C. § 7491(g)(7).

[86] 42 U.S.C. § 7491(b)(2)(A).

[87] *See* 66 Fed. Reg. 38108, 38117

[88] 42 U.S.C. §§ 7491 (b)(2)(A), (c).

by itself or in combination with other sources, emit any air pollutant which may reasonably be anticipated to cause or contribute to a significant impairment of visibility in any mandatory Class I Federal area."[89]

The statute's language does not support any contrary assertion that an otherwise eligible source can avoid a BART determination analysis simply because the source has been modified, and has therefore become subject to more stringent emissions limits. Nor is it determinative that a modified existing source must comply with stringent statutory schemes such as PSD/BACT or nonattainment/LAER that are not typically applicable to sources built before 1977. Congress considered the possibility that some BART-eligible sources might not emit pollutants that "cause or contribute to significant impairment of visibility" in any mandatory Class I region, and crafted the exemption provisions of Section 169A(c) – which do not exempt sources which have been "modified" or sources which, by virtue of a modification, have become subject to BACT or LAER requirements.

V. Regional Haze BART Must Be Determined In Accordance with a Top-Down Methodology, Which Includes Presumptive Targets.

We strongly support a top-down methodology for states' use in making BART engineering determinations, the approach preferred by the Agency.[90] For BART-eligible sources that also have been identified as subject to BART, the engineering analysis supporting the determination of BART should involve a process under which all available

[89] 42 U.S.C. § 7491(c)(1).

[90] 66 Fed. Reg at 38,108, 38,121.

control technologies would be identified and ranked in descending order of control effectiveness, with the most stringent alternative examined first. That alternative would be selected as the "best" unless the applicant can document why it is technically infeasible.[91] This "top-down" approach to the analysis is very similar to the way BACT is determined for new sources located in clean air areas. The top-down approach satisfies Congress's intent and purpose to preserve and enhance air quality in clean air and Class I areas, as set forward in the structure and language of the Clean Air Act, which the bottom-up approach (also described in the proposed BART guidelines) does not.

Title I, Part C of the Clean Air Act sets out Congressional purposes and goals for clean air areas (both Class I areas and other areas classified as in attainment of the NAAQS), including, *inter alia*, "preserv(ing), protect(ing) and enhanc(ing) the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value," and insuring "that economic growth will occur in a manner consistent with the preservation of existing clean air resources. . . ."[92] To achieve these goals, Part C further includes emissions limitation requirements for major new sources in clean air areas and for certain existing sources which, as of 1977, already had caused visibility impairment in Class I areas. Each of these requirements, for new sources and for exiting source

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[91] *Id*. at 38,123-124. We generally support EPA's proposal to define technical feasibility as availability plus applicability to the source type under consideration, and that the burden of proving infeasibility is on the state or applicant. We would expand the notion of availability to include technologies that are still pilot tested as of the close of the state public comment period, which will be approximately five years before sources must actually achieve the BART emissions limits.

[92] 42 U.S.C. §§ 7470(2) and (3).

retrofits, are based on the selection of emissions limits based on the "best" "available" technologies for the job.[93]

BACT and BART therefore are brothers-in-arms – both aimed at the national goal of maintaining and improving air quality in clean air areas. Put into play together, the nondegradation (BACT) requirements on new sources constructed and brought into operation after 1977 were "concerned with imposing stringent requirements on new sources" in all clean air areas while the BART requirements were aimed at retrofitting facilities which already had caused visibility impairment in Class I areas.[94] Because BART and BACT are aimed at the same national goal, and are defined by the same statutory requirement that they be based on the "Best" technology "Available," they should be determined using the same analytical approach.

The determination of the "best available" technology (BACT) for new sources in clean air areas has long been made using a top-down analysis, in which the most stringent emissions reduction technology "available" is analyzed against a list of statutory BART factors to determine the best technology "achievable." For BACT, "best" is defined by the statute as the "maximum degree of emissions reduction" achievable, based on an analysis of specified factors.[95] For BART, the statute simply sets out a different set of factors, not a different definition of either the terms "Best" or "Available,"[96] and it is

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[93] *See* 42 U.S.C. § 7475(a)(4) ("best available control technology" or "BACT" required on new sources), § 7491(b)(2) ("best available retrofit technology or "BART" required on certain existing sources).

[94] 123 CONG. REC. S. 26,856 (daily ed. Aug. 4, 1977) (remarks of Sen. McClure).

[95] 42 U.S.C. § 7479(3).

[96] *See* 42 U.S.C. § 7491(g)(2).

more than reasonable to assume that the drafters meant those terms to have the same meaning throughout Part C – that is for both BACT and BART. Thus, a BART analysis also should begin with the "best" technology – *i.e*., the one that would yield the maximum degree of emissions reductions – and analyze it against the statutory BART factors to determine whether it is "achievable."

The question whether a technology is "available" has been given a "straightforward practical meaning" in the BACT context.[97] Availability involves a "practical, factual determination, using conventional notions of whether the technology can be put into use" at the time it would be applied.[98] Technology that is existing and operating is "available" under this view, no matter for what purpose it was applied elsewhere.[99] In the proposed BART guidelines, EPA adopts this general view of what technologies are "available."[100] We would argue, however, that because these guidelines are being considered almost a decade before the emissions controls requirements must be in place, the concept of "availability" of a technology for regional haze BART purposes should be expanded to include those that are in the pilot scale testing phase, not simply those that have been licensed and demonstrated as EPA proposes.[101]

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[97] *See* Memorandum from John Calcagni, Director of EPA Air Quality Management Division, *Transmittal of Background Statement on "Top-Down" Best Available Control Technology (BACT)* 6 (June 13, 1989).

[98] *Pennsauken County N.J. Recovery Facility*, PSD Appeal No. 88-8, at 8 (EPA 1988) (remand order).

[99] *Id*.

[100] 66 Fed. Reg. 38,108, 38,122.

[101] *Id*. at 38,124.

The top-down approach is likely to result in the application of more stringent controls – or emissions limitations reflecting those controls – on sources subject to BART than would be the case if a bottom-up analysis were done. That is an appropriate response to the statutory goal of preventing any future and remedying any existing impairment of visibility (regional haze) in our nation's Class I areas – areas where pristine air is a paramount value. The alternative bottom-up approach was found in the context of early BACT determinations to provide too little incentive to a state or applicant to set BACT reflecting the most stringent controls, or even to provide analysis of more stringent control options beyond the NSPS.[102] As described above, because BART is based on the same statutory requirements that the "best" "available" technology be selected, BART determinations also must be made by a method that promotes thorough consideration of more stringent control options.[103]

Adopting the top-down approach to BART engineering analyses also should lessen the administrative burden of BART determinations. A top-down BART determination method likely will not require the analysis of the full range of available control technologies, as would the alternative bottom-up analysis.[104] For example, in a properly done bottom-up analysis, a state or applicant would propose the full range of

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[102] *See* Calcagni Memo, *supra* note 97, at 2-3.

[103] The BART guidelines proposal required the NSPS level of control for each visibility-causing pollutant to be included as one of the analyzed control options. EPA correctly notes that the NSPS do not require the most stringent or "best available" controls in some situations – SO_2 is an example of a pollutant for which the NSPS does not require best available controls. We believe that for those situations, a properly done top-down BART analysis will never reach the NSPS levels of control, and therefore that requiring its inclusion will prove unnecessarily burdensome. Furthermore the Agency should make clear in the final rule that compliance with an NSPS level of control does not satisfy the BART requirement.

[104] This can be seen from the BACT experience. *See* Calcagni Memo, *supra* note 97, at 3-4.

alternatives from least to most stringent, and analyze all of them against the statutory BART factors until the most stringent achievable technology is determined. Recent experience with reasonably attributable BART determinations suggests that the best controls already in use are likely to be among the more stringent alternatives.[105] Therefore, as a purely practical matter the bottom-up option is likely to involve a great deal more work than starting with the most stringent available technology.

A. Presumptive "Best Available" Emissions Reductions Levels Should be Established for Regional Haze BART Determinations

Presumptively available emissions reductions levels are one of the most essential components of the BART guidelines, as they establish a starting point representing the "best available technology" in the required engineering analysis. The proposed BART guidelines invite comment on whether "a 90-95 percent presumption [for achievable sulfur dioxide removal efficiencies] is appropriate for utility boilers or whether another presumption should be established instead."[106] We would argue that the presumptively available sulfur dioxide removal efficiencies of 95 percent should be set in the final rule, for all BART-eligible industrial boilers in the 26 source categories, and that the Agency also should establish presumptively available removal efficiencies for NO_x, at 90-95 percent.

[105] *See Central Arizona*, 990 F.2d. at 1536.

[106] 66 Fed. Reg. 38,108, 38,130.

1. A 95 percent control level for sulfur dioxide gas should be presumed in BART engineering analyses based on demonstrated and technologies for both controlled and under controlled utility boilers. Moreover, a 95 percent removal efficiency should also be presumed for all fossil fuel boilers that generate electricity for industrial processes in all source categories.

The availability of pollution control technology achieving reductions levels of 95 percent or greater for sulfur dioxide from electric utility boilers is clearly well-documented as described below. Further, because of the extended SIP timeline, BART retrofits will not be applied until the end of the decade or later and therefore, it is expected that the "best" available sulfur removal technologies will routinely be able to achieve in excess of 95 percent removal efficiencies by that time. Therefore, we believe that the presumptive level of 90-95 percent that is stipulated in the proposal should be strengthened, and modified to read "an SO_2 control level of 95 percent or better is presumed to be achievable."

An EPA ORD Report issued November 2000[107] documents that retrofits of electric utility boilers burning coal over the past decade or more have systematically achieved 90 percent or greater reductions in sulfur dioxide using flue gas desulfurization (FGD) techniques, as demonstrated by both dry and wet scrubbers. The report concludes that limestone spray drying (LSD) technology installed between 1999 and 1995 – a form of wet FGD and the most common existing technology adopted by low to medium sulfur content coal sources – has removal efficiencies of 90-95 percent.[108]

[107] SRIVASTAVA, *supra* note 38.

[108] *Id*.

We do not, however, believe that the technology of the 1980s or 1990s should be established as the presumptively "best available" where it would not be applied to boilers until late in this decade or beyond 2010. According to the EPA ORD report, advanced state-of-the-art wet scrubbers are now capable of achieving over 95 percent removal efficiency. For example, high velocity limestone forced oxidation (LSFO) technology is reportedly capable of removing more than 99.6 percent of SO_2 under test conditions.[109] Advances in technology have also demonstrated the effectiveness of ammonia scrubbing,[110] which is promising for high-sulfur coal, and which is capable of removing over 95 percent of sulfur. As a co-benefit, this technique also reduces acid gases such as hydrochloric acid and sulfur trioxide. While these technologies are under development today, by the beginning of the next decade, the earliest point when BART would be applied, they will be readily "available."

Technologies to remove sulfur from boilers that have previously been retrofit to previously to meet the 1979 New Source Performance Standard (NSPS) of 70 percent but, as such, are currently under-controlled, can also meet removal efficiencies of levels of 95 percent or more according to the EPA report.[111] The performance of boilers already using the wet limestone process can be improved through the application of "once-through wet FGD technology," such as increasing sorbent, reactivity and other upgrades.

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[109] *Id*.

[110] *Id*. at 39. Ammonia scrubbing, however, may create ammonia aerosol by-products if not precisely controlled. This process also produces ammonium sulfate that can then be utilized as fertilizer to reduce waste and improve cost/economics, as opposed to the standard wet FDG process which produces gypsum, typically used in manufacturing wall board. Gypsum is in oversupply and thus commands a low price in the United States.

[111] *Id*.

2. A 90 Percent NO_x Control Level for Uncontrolled and Undercontrolled Power Plants Also is Presumptively Available.

Because power plants account for about one-quarter of the nitrogen oxide emissions nationally, and because the Agency also has and will have considerable "experience in evaluating NO_x control options for utility boilers,"[112] we believe a presumptive control level for nitrogen oxides should be presumed as "best available" at the outset of the required top-down BART analysis for both controlled and uncontrolled power plants. In order to provide support for such a presumption, we request that EPA undertake a similar analysis of NO_x removal technologies as was done by ORD for sulfur dioxide.

NO_x contributes significantly to the formation of regional haze, and therefore to visibility impairment in many Class I areas, particularly in the Northern Great Plains and western United States.[113] Once released, NO_x gases oxidize in the atmosphere to form ammonium nitrate aerosols. In some Class I areas, light scattering due to nitrate is increasing, contributing to deteriorating visual air quality. For example, trends in increasing nitrate-related haze have been documented in Badlands, Big Bend and Mesa Verde National Parks and Chiracahua National Monument.[114]

Selective Catalytic Reduction (SCR) techniques currently represent the best available technology for removal of NO_x.[115] Recent installations suggest that removal

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[112] *See* 66 Fed. Reg. 38,108, 38,130.

[113] CIRA, *supra* note 6.

[114] *Id*.

[115] Many technologies are available for the control of NO_x emissions. They can be divided into two major categories: (1) those that minimize the formation of NO_x during the combustion process (*e.g.*, smaller quantities of NO_x are formed); and (2) those that reduce the amount of NO_x

efficiencies of over 90 percent are proven using SCR. We anticipate that the removal efficiencies of these technologies – and newer innovations – will only improve between now and the implementation of BART starting in the latter part of this decade. The following is brief review of the present capabilities of SCR to support our proposal that a 90 to 95 percent presumptive removal efficiency for NO_x be included in the BART rule.

SCR is a post combustion NO_x control technology widely used worldwide, and rapidly gaining market penetration in the United States.[116] SCR is capable of reductions of NO_x in the 90-95 percent range. The technology was first deployed in Japan and Germany in the late 1970's and 1980's, having reached over 40,000 MW of capacity at present.[117] Advances in the technology have continued over the years, mostly focused on the improvement of catalysts as well as process conditions (*e.g.*, better systems for maintaining uniform gas velocities, uniform ammonia-to-NO_x distribution).[118]

While some of the earlier deployment of SCR in coal-fired applications in the US required reductions of 60-79 percent,[119] the more recent wave of installations have both

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formed during combustion prior to exiting the stack into the atmosphere. It is common to refer to the first approach as "Combustion Modifications" (*e.g.*, low NO_x burners) whereas technologies in the second category are termed "Post-Combustion Controls."
Within each of these categories, several technologies and variations of the same technology exist. Most often combinations of some of these technologies are desirable as they may produce more effective NO_x control than the application of a stand-alone technology.

[116] *See* The McIlvaine Company, *Market Reports* (visited Oct. 2, 2001) <http://www.McIlvainecompany.com.>

[117] IEA COAL RESEARCH, NO_x INSTALLATION ON COAL-FIRED PLANTS (March 1999).

[118] G. Bielawski, How Low Can We Go? (2001) (*presented at* EPA/DOE/EPRI MEGA Symposium, Chicago, August 2001); J. Cichaniwicz, Twenty-Five Years of SCR Evolution: Implications for US Application and Operation (2001) (*presented at* EPA/DOE/EPRI MEGA Symposium, Chicago, August 2001).

[119] D. Bullock, Long-Term SCR Operating Experience at PG&E Generating Coal-Fueled Power Plants (2000) (*presented at* ICAC Forum, March 2000).

required and demonstrated 90 - 93 percent reductions.[120] Based on this data, as well as the cumulative experience expected from new SCR installations in the next few years in the US, NO_X reductions from coal-fired plants, using SCR technology, can reasonably be expected in the 90-95 percent range.

VI. The Six Statutory BART Factors Must Be Considered, Not Weighed – a Cost-Benefit Approach May Not Become the Basis for BART Determinations.

Congress established the BART requirement in Section 169A of the Clean Air Act, including an outline of how BART shall be determined by the states and EPA. Nothing in the Act, or in its legislative history, requires the use of a cost-benefit analysis in BART determinations. Under relevant case law, any attempt by the Agency or a state to create a cost-benefit approach to BART is prohibited.

Section 169A establishes the requirement that each BART-eligible major stationary source which has been found to emit "any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area, "shall procure, install, and operate, as expeditiously as practicable (and maintain thereafter), the best available retrofit technology . . . ."[121] Section 169A(g)(2) requires that BART shall be determined by the states or the Administrator, "tak[ing] into consideration" six factors: "the costs of compliance, the energy and nonair quality

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[120] R. Glaser, The SCR Retrofit at the Montour Steam Electric Station (2001) (*presented at* EPA/DOE/EPRI MEGA Symposium, Chicago, August 2001); K. Robinsons, Selective Catalytic Reduction of a 645 MW Boiler at AES Somerset (2000) (*presented at* ICAC Forum, March 2000); J. Cochran, "Design and initial start-up results fro the New Madrid SCR retrofit project," *presented at* ICAC Forum 2000 (March 2000).

[121] 42 U.S.C. § 7491(b)(2)(A).

environmental impacts of compliance, any existing pollution control technology in use at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology."[122]

Given the nature and the structure of the list of factors, EPA and the states are free to exercise their considered judgment and discretion when assigning such factors their appropriate importance. While construing similar language related to determinations of Best Practicable Control Technology under the Clean Water Act, courts have distinguished "comparison factors" – those factors requiring a balancing analysis – from "consideration factors" – the analysis of which does not require any specific structure.[123]

Where, as in Section 169A, a statute simply requires that specified factors must be "taken into consideration," or "taken into account," without specifying that they be analyzed "in relation to" one another, or "compared," EPA and the states have discretion

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[122] 42 U.S.C. § 7491(g)(2).

[123] *See, e.g., Weyerhaeuser v. Costle*, 590 F.2d 1011, 1045, 1049 (D.C. Cir. 1978). In *Weyerhaeuser*, industry challenged EPA's approach to effluent limitations issued under Sections 301(b) and 304(b) of the Clean Water Act. Industry claimed, *inter alia*, that the Agency should have undertaken a cost-benefit analysis as part of the process of reaching effluent limitations for the pulp and paper industry.

Section 304(b)(1)(B) of the Clean Water Act requires EPA to engage in a two-pronged analysis when "specify[ing] factors to be taken into account in determining the control measures and practices to be applicable to point sources." 33 U.S.C. § 1314(b)(1)(B). First, the statute requires certain factors to be weighed "*in relation to*" each other. *Id*. (emphasis added). These "comparison factors" were contrasted by the *Weyerhaeuser* court with a second group of "consideration factors," which the statute simply required the agency to *"take into account." Id*. (emphasis added). *Weyerhaeuser*, 590 F.2d at 1045.

While the comparison factors required a limited balancing test of costs and benefits, the court found that the consideration factors were simply listed in the statute as independent reference points, which EPA, with the benefit of its institutional expertise and "its express and considered" judgment in such matters, had discretion to assign appropriate relative importance. *Weyerhaeuser*, 590 F.2d at 1045. EPA was not required "to use any specific structure such as a balancing test in assessing the consideration factors, nor [was the Agency] required to give each consideration factor any specific weight." *Id*.

in deciding how that analysis will be done.[124] The six BART factors are simply listed as those Congress directs EPA and the states to consider in determining BART. Congress has delegated to EPA and the states the responsibility for developing a process by which the BART factors are considered. Congress has not, however, required EPA or the states to use any specific method such as a balancing test in assessing the consideration factors listed at Section 169A(g)(2), nor are EPA and the states required to give each consideration factor any specific weight.[125]

At the same time, however, the discretion granted EPA and the states does not extend to changing the Congressionally-mandated "consideration factors" approach – that is, the discretion afforded the states and EPA does not permit a rewriting of the Act to create a cost-benefit analysis requirement where one does not exist in the statute. Indeed the U.S. Court of Appeals for the Ninth Circuit has held that "Congress has not required 'cost-benefit' analysis [for BART determinations] in the Act."[126] Furthermore, when Congress intends an agency to engage in a cost-benefit analysis, it clearly indicates such intent on the face of the statute.[127] EPA, therefore, should clarify, in the final rule, that a cost-benefit analysis cannot be used to define BART, nor should the cost-effectiveness

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[124] *See id.* at 1049.

[125] In *New York v. Reilly*, 969 F.2d 1147, 1150 (1992), the court stated that "[b]ecause Congress did not assign the specific weight the Administrator should accord each of the [consideration factors], the Administrator is free to exercise his discretion. . . ."

[126] *Central Arizona*, 990 F.2d at 1542, n.10.

[127] *Id*. (citing *American Textile Mfrs. Inst. Inc. v. Donovan*, 452 U.S. 490, 510 (1981)).

analysis (either average or incremental cost-effectiveness[128]) become the fulcrum of the analysis, effectively emasculating the other BART consideration factors.

A. If the Remaining Useful Life is the Basis, in Any Respect, for a BART Decision, it Must be Legally Binding and Enforceable.

The proposed BART guidelines include consideration of one of the statutory BART factors, "remaining useful life of the source," as an element in the economic costs analysis.[129] If the remaining useful life of a source is estimated to be shorter than the time period over which the required controls would be amortized, EPA proposes to allow the use of the shorter time period in the cost calculations. The proposal also includes a requirement that declarations of remaining useful life be supported by and based on

[128] EPA gives a great deal of emphasis in the proposal to notions of average cost effectiveness and incremental cost effectiveness as part of the consideration of the costs impacts factor. 66 Fed. Reg. 38,108, 38,126, 38,127-128. One element of the proposed average cost-effectiveness calculation is a baseline annual emissions figure from the BART-eligible source. *Id*. at 38,126. EPA proposes that this the average annual emissions from the two most recent years, unless another period is more representative – the same way this concept is quantified under the new source review regulations. *Id*. at 38,127. EPA then perfunctorily suggests, in a footnote, that it may change the definition when it revises the new source review program rules, and that if it does so it will like wise revise the approach in the BART guidelines.

We are concerned about this apparently cavalier treatment of a significant public policy issue. EPA's proposal to revise the method for calculating baseline emissions under the new source review program is more than 5 years old. Further, although the 1996 new source review proposal examines the implications of the baseline change in the specific context of the new source review program, there is no similar examination of the implications of this policy change for the BART program in the current notice. Because the public must receive adequate notice of such a potentially consequential action, we urge EPA to clearly limit its final BART guidance rule to the two year baseline approach, and to provide meaningful notice and opportunity for comment in the event the Agency decides to change this approach based on any future changes to the new source review program.

[129] 66 Fed. Reg. at 38,108, 38,126.

federally-enforceable restriction preventing operation past the end of that time period.[130] We strongly support that concept.

But EPA also requests comment on whether this requirement should somehow be loosened to allow a source operator "flexibility to continue operating beyond [the end of remaining useful life] in the event . . . that market conditions change."[131] That concept is unacceptable. If a source is deemed to have a short remaining useful life, its operator should not be permitted under any circumstances to speed up the amortization of BART controls or avoid fully applying BART at the end of that agreed upon time period. If an operator wants flexibility, the operator must pay for it. Similarly, the suggested option of requiring a BART-eligible source that continues in operation beyond its declared useful life to install full BART controls at the point of life extension makes no environmental or economic sense – but simply creates a loophole for older sources to avoid BART for a period of years.

Furthermore, should EPA decide to allow BART-eligible sources with limited remaining useful lives to be partially exempted from the requirement that they install BART,[132] the retirement date must be included as an operating condition in the sources' Title V permits. Because the statute requires that BART-eligible sources install BART controls within five years of the issuance of the relevant SIP,[133] we support EPA's proposal to set compulsory retirement dates five years after the date of the SIP

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[130] *Id*.

[131] *Id*.

[132] *See id*. at 38,126.

[133] *See* 42 U.S.C. §§ 7491(b)(2)(A) and (g)(4).

revision.[134] If the source has not been permanently retired by the specified retirement date, the owner or operator of that source must either (a) shut down temporarily, make changes to ensure that BART emissions levels can be achieved, without taking remaining useful life into consideration, and pay a preset fine; or (b) immediately and permanently shut down. These requirements largely conform to the scheme EPA proposed in the BART guidelines.[135] We strongly agree that EPA must take all necessary precautions to ensure that the retirement date is specific and enforceable.

B. Consideration of Nonair Quality Environmental Impacts in the BART Determination Must Include the Benefits of Sulfur, NOx and PM Emissions Decreases, Including Lowered Deposition to Forests, Soils, Lakes, Streams, and Coastal Waters.

The statutory BART factors include an assessment of the "non-air quality environmental impacts of compliance."[136] In the proposed BART guidelines, EPA asks states to consider environmental impacts of applying BART control technologies – including increased hazardous waste discharges, solid waste increases, or increased discharges of polluted water.[137] Indeed, the majority of the discussion of this BART factor focuses on the potential *adverse* environmental impacts of applying BART. Although a short paragraph is included suggesting that it will be "important to consider relative differences between options regarding their beneficial impacts to non-air quality

[134] *See* 66 Fed. Reg. 38,108, 38,126.

[135] *See id*.

[136] 42 U.S.C. § 7491(g)(2).

[137] 66 Fed. Reg. 38,108, 38,129.

media," only one example is provided – whether a control technology will result in less deposition of pollutants to nearby sensitive water bodies.[138]

The final BART guidelines should explicitly require, as part of the BART determination process, an assessment of the positive non-air quality environmental impacts – *i.e.*, an estimate of the environmental benefits – that will result from applying BART. It is possible to estimate the ecosystem benefits in Class I areas associated with certain levels of lowered emissions of sulfur dioxide, nitrogen oxides, and particulate matter in upwind regions. Such an estimate, prepared as a qualitative assessment, must be included in the BART determination process.

1. Positive Environmental Impacts Would Result From Lowered Emissions of SO_2, NO_x and PM Near Our Nation's Class I Areas.

Acid deposition, nitrogen saturation in forests and coastal waters, and declines in forest growth due to ozone exposure are all well documented environmental impacts of air pollutant emissions from industrial facilities, including facilities in the 26 BART source categories. Appendix 6 describes these impacts, including references that can be helpful to states undertaking assessments of the ecosystem benefits that would result from the application of BART emissions limits to sources near Class I areas.

Implementation of the BART requirement, particularly with the preferred top-down approach and presumptive stringent control targets, will yield significant ecological benefits in Class I area. Recent work by scientists with the Hubbard Brook Research Foundation found that an additional 80 percent reduction in sulfur beyond that required under the 1990 Clean Air Act Amendments would begin to allow biological recovery to

[138] *Id*. at 38,130.

begin mid century in the northeastern United States.[139] Model simulations in the Shenandoah National Park project that greater than 70 percent reduction in sulfate deposition (from 1991 levels) would begin to benefit stream chemistry such that the number of streams suitable for brook trout viability would increase. A 70 percent reduction would simply prevent further increase in Virginia stream acidification.[140] In the Great Smoky Mountains National Park, two separate ecosystem models have concluded that sulfate reductions of 70 percent are necessary to prevent acidification impacts from increasing. Deposition reductions above and beyond these amounts are necessary to improve currently degraded aquatic and terrestrial ecosystems.[141, 142] To reverse and recover from acidic deposition impacts, Canadians in the Acidifying Emissions Task Group have recommended a 75 percent reduction in US sulfur emissions, post Phase II of Title IV of the CAAA.[143]

If the final BART guidelines include a top-down engineering analysis for the determination of BART and stringent presumptive control targets, they will make a serious dent in the reductions needed to reverse the damage caused by 150 years of acid deposition, nitrification, and ozone episode in our nation's most pristine areas. The

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[139] C.T. Driscoll, et al., Acidic Deposition in the Northeastern United States: Sources, Inputs, Ecosystem Effects and Management Strategies, BIOSCIENCE 2001, at 51(3).

[140] *Id*.

[141] B.J. COSBY AND T.J. SULLIVAN, FINAL REPORT: APPLICATION OF THE MAGIC MODEL TO SELECTED CATCHMENTS: PHASE I, SOUTHERN APPALACHIAN MOUNTAIN INITIATIVE (SAMI) (1998).

[142] R.K. MUNSON, FINAL REPORT: APPLICATION OF THE NUCM MODEL TO NOLAND DIVIDE, WHITE OAK RUN AND SHAVER HOLLOW FOR SAMI PHASE I (1998).

[143] THE ACIDIFYING EMISSIONS TASK GROUP, TOWARDS A NATIONAL ACID RAIN STRATEGY (1997) (submitted to the National Air Issues Coordinating Committee).

lowered emissions levels and associated and reductions in deposition of sulfur and nitrogen that will occur as a result of applying BART will benefit the freshwater, estuarine and terrestrial environments in many places in this country.

VII. The 1980 BART Guidelines Plainly Do Not Preclude The Establishment of A BART Emissions Limit More Stringent Than the NSPS Level of Control, for Purposes of Remedying Reasonably Attributable Visibility Impairment.

In addition to proposing BART guidelines for regional haze, EPA proposes limited revisions to regulations governing the 1980 BART guidelines for conducting BART analyses to remedy reasonably attributable visibility impairment. In particular, the Agency proposes to clarify that "options more stringent than NSPS must be considered" in reasonably attributable BART reviews."[144] The Agency explains that the purpose of the proposed revisions is to clarify confusion arising in light of statements in the 1980 reasonably attributable BART guidelines "that could be read to indicate that the new source performance standards (NSPS) may be considered to represent the maximum achievable control for existing sources."[145] The Agency asserts that the proposed regulatory change is intended to recognize the advances in SO_2 control technologies over the past 20 years, the lower costs of control, and to require consideration of control levels more stringent than NSPS.[146] We agree that this clarification is much needed. At the same time, we vigorously disagree that the 1980 guidelines have ever provided that

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[144] 66 Fed. Reg. 38,108, 38,135 (proposed amendment to 40 C.F.R. § 51.302).

[145] *Id*. at 38,109.

[146] *Id*. at 38,109-10.

meeting NSPS levels of control could have permitted a state or source to avoid the detailed analysis of control options required by the guidelines.

A review of the passages cited by the Agency, along with other pertinent passages in the BART guidelines, reveals that while the NSPS level of control generally was considered, in 1980, to be the maximum achievable, other more stringent control options were and continue to be permissible under the guidelines. As the Agency points out in the preamble to the currently proposed guidelines, the 1980 guidelines do state that "[m]aximum achievable control is generally represented by New Source Performance Standards."[147] But at the same time, in a section expressly governing the consideration of "alternative levels of control," the 1980 guidelines provide the full context for that reference to the NSPS level of control:

> As previously stated, for fossil fuel fired power plants with a generating capacity in excess of 750 megawatts, the Agency believes that the NSPS level of control can be met with technology that is *generally* available to these sources, and that this level of control *generally* represents the best these sources can install as BART.
>
> In determining BART, and for inclusion in its SIP, the State must explain in detail how it weighed the various BART factors required by the Act (§169A(g)(2)), the regulations (§51.301(c)), and this guideline. This explanation must demonstrate that the emission limitation chosen (*if one other than the NSPS*) reflects a reasonable balance of the various BART factors. This explanation must set forth the visibility, energy, economic, and other impacts associated with application of an NSPS level of control, and compare those impacts to *alternative levels of control* including the level of control selected by the State as BART. Because EPA believes that NSPS control generally represents the best these sources can install as BART, if the State sets for a pollutant emitted by a fossil fuel fired power plant with a generating capacity in excess of 750 megawatts a BART emission limitation equivalent to the NSPS level of control, this detailed demonstration will not be required for the purposes of EPA review.

Id. at 20-21 (emphasis added).

[147] *See 1980 BART Guidelines*, *supra* note 8, at 11.

This more comprehensive explanation of the process for determining reasonably attributable BART under the 1980 guidelines illuminates that at the time they were issued – more than 20 years ago – EPA believed the NSPS level of control was generally "available."[148] According to the express language set out in the 1980 guidelines, the effect of the Agency's general belief was that a determination by the state to require the NSPS level of control relieved the state of the burden of conducting a "detailed demonstration" of its decision based on the relevant statutory BART factors. At the same time, EPA specifically provided that a state could require an "alternative level of control." Thus, EPA did not in any way foreclose a state from requiring an alternative level of control more stringent than NSPS. Rather, EPA recognized that an alternative level of control may be appropriate. In such circumstances, EPA constrained the state's determination by requiring the state to provide an explanation that the emission limitation it selected reflects a reasonable consideration of the BART factors.

Accordingly, we support EPA's initiative to modernize the seriously outdated 1980 BART guidelines. However, we fundamentally disagree that those guidelines ever precluded a state from establishing as BART for purposes of remedying reasonably attributable impairment, an emission limitation that is more stringent than the NSPS level of control.[149] Indeed, EPA itself previously has advanced this interpretation of the 1980 BART guidelines when it was acting in the shoes of the state of Arizona in proposing a BART emission limitation to remedy reasonably attributable impairment at the Grand

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[148] *See* section V. above for a discussion of the meaning of the term "available" in this context.

[149] As discussed above in section V., BART determinations must use a method that promotes thorough consideration of more stringent control options.

Canyon National Park under a visibility FIP and presented, among other alternatives, an option requiring a 90 percent reduction in SO_2.[150]

VIII. This Rulemaking Action Will Not Have a Significant Adverse Impact on the Supply, Distribution or Use of Energy Under Executive Order 13,211.

We support and agree with EPA's conclusion that the proposed BART guidelines "[are] not likely to have a significant adverse effect on the supply, distribution, or use of energy,"[151] and therefore is not a "significant energy action" requiring a detailed Statement of Energy Effects under Executive Order 13,211. We concur with the Agency's reasoning on this point, and add some specific further comments below.

First, because BART level emissions limits are not required to be in place until after 2008 at the earliest, significant reductions in SO_2 and NO_x emissions already will be in place by that point at BART-eligible sources. Key vehicles for achieving such reductions will be some combination of $PM_{2.5}$ and ozone NAAQS attainment actions and possibly multi-pollutant power plant emissions reduction legislation. Therefore, the incremental effects of applying BART or requiring BART-level emission limits on these sources will be smaller than if BART were required, for example, in 2002.

Large reductions in sulfur dioxide emissions will be required by 2015 (the reference year chosen by the Agency in the RIA for the Regional Haze Rule) as a result of the implementation of the $PM_{2.5}$ NAAQS. Contrary to the suggestions made by commenters at the public hearings on the proposed BART guidelines,[152] the Supreme

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[150] *See, e.g.*, 56 Fed. Reg. 5173, 5177-78 (Feb. 8, 1991).

[151] 66 Fed. Reg. 38,108, 38,113.

[152] *See* Jeffrey Marks, Statement on behalf of the National Association of Manufacturers, at Public Hearing on EPA Docket No. A-2000-28, Arlington, VA 3 (August 21, 2001).

Court has upheld EPA's major conclusion that a fine particle standard is necessary,[153] and it is quite likely that implementation will be well underway by 2015. Implementation will require deep sulfur reductions from existing sources. Such reductions were estimated by EPA in preparing the Regional Haze Rule RIA, which served as the basis for EPA's Executive Order 13,211 analysis.

Furthermore, as DOE's Energy Information Administration has recognized in analyses of potential costs of various multi-pollutant legislative strategies, by 2015, the marginal price will be set in most (if not all) US power markets by natural gas and oil-fired power plant units.[154] Thus, costs of meeting BART-level emissions limits for sulfur and NOx may reduce earnings at sources subject to BART, but these costs will not be passed through into market prices. For this reason, even if EPA's annual estimate of the regional haze BART guideline costs ($72 million per year) were low, annual costs of several times this amount would still not be passed through to market prices, and would still be very small relative to projected generation revenues, as EPA points out. For example, if actual costs were three times those estimated by EPA, or $216 million per year, they would represent only a trivial fraction (0.04 percent) of projected 2010 revenues (of $282 billion per year).[155]

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[153] *Whitman v. American Trucking Assn's, Inc.*, 121 S. Ct. 903, 912 (2001).

[154] ENERGY INFORMATION ADMINISTRATION, ANALYSIS OF STRATEGIES FOR REDUCING MULTIPLE EMISSIONS FROM ELECTRIC POWER PLANTS: SULFUR DIOXIDE, NITROGEN OXIDES, CARBON DIOXIDE, AND MERCURY AND A RENEWABLE PORTFOLIO STANDARD (SR/OIA/2001-3) 13-14 (July 21, 2001).

[155] *Id*. at 29.

IX. Conclusions

We generally support the BART guidelines as proposed. Four conditions are critical to our support, however. First, EPA must adopt its "preferred" top-down method for BART engineering analysis, and reject the suggested alternative "bottom up" approach.[156] The top-down approach should include a rebuttable best available technology presumption, set at a 90 to 95 percent removal efficiency for nitrogen oxides and a 95 percent level for sulfur dioxide, on both controlled and uncontrolled power plants. Second, the Agency must make clear that BART emission reductions must be in excess of the emission cuts required under other CAA programs (*e.g.*, Title IV and the NO_x SIP Call). Third, the final BART guidelines must clarify that the Cumulative Visibility Analysis may not be used to create an extra-statutory, *de minimis* exemption from the BART requirements. And fourth, if determinations regarding a source's remaining useful life are made the basis of any BART decision, those determinations must be legally binding and enforceable.

Thank you for your consideration of our views.

Respectfully submitted,

Ann Brewster Weeks
L. Bruce Hill
Jonathan F. Lewis
Clean Air Task Force
77 Summer Street, 8th Floor
Boston, MA 02110

Vickie L. Patton
Environmental Defense
1405 Arapahoe Avenue
Boulder, CO 80302

[156] *See* 66 Fed. Reg. 38108, 38121-22.

For:

Clean Air Task Force
Armond Cohen, Executive Director
77 Summer Street, 8th Floor
Boston, MA 02110

Environmental Defense
Vickie L. Patton, Senior Attorney
1405 Arapahoe Avenue
Boulder, CO 80302
(303) 440-4901

Southern Alliance for Clean Energy
Stephen A. Smith, Executive Director
Ulla-Britt Reeves, Clean Air Regional Coordinator
PO Box 1842, Knoxville, TN 37901-1842
(423) 637-6055

Clear the Air
Angela Ledford, Campaign Director
1200 18th Street, NW, 5th Floor
Washington, DC 20036
(202) 887-1341

National Environmental Trust
John M. Stanton, Vice President
1200 18th street, NW
Washington, DC 20035
(202) 887-8821

Natural Resources Defense Council
Patricio Silva, Midwest Activities Coordinator
1200 New York Avenue, NW, Suite 400
Washington, D.C. 20005-3928
(202) 289-6868

Natural Resources Council of Maine
Sue Jones
3 Wade Street
Augusta, ME 04330
(207) 622-3101 x215

The Illinois Environmental Council
Brian P. Urbaszewski, Co-Chair of the Legislative and Policy Committee
107 W. Cook, Suite 15
Springfield, IL 62704
(217) 544-5954

The Ohio Environmental Council
Kurt Waltzer, Clean Air Program Manager
1207 Grandview Avenue
Columbus, Ohio 43212
(614) 487-7506

Izaak Walton League of America
Jonathan Birdsong, Senior Conservation Associate
707 Conservation Lane
Gaithersburg, MD 20878-2983
(800) 453-5463 x235

American Lung Association of Metropolitan Chicago
Brian P. Urbaszewski, Director of Environmental Health Programs
1440 W. Washington
Chicago, IL 60607
(312) 243-2000

New Mexico Citizens for Clean Air & Water
John Bartlit, Chairman
Los Alamos, NM
(505) 672-9792

Utahns for an Energy-Efficient Economy (UE3)
Sarah Wright, Chair
917 2nd Ave.
Salt Lake City, Utah 84103
(801) 673-7156

Grand Canyon Trust
Rick Moore, Program Officer
2601 North Fork Valley Road
Flagstaff AZ 86001
(520) 774-7488

Land & Water Fund of the Rockies
John Nielsen, Energy Program Co-Director
2260 Baseline Road
Boulder, CO 80302
(303) 444-1188

Center for Energy Efficiency and Renewable Technologies
John White, Executive Director
1100 Eleventh Street, Suite 311
Sacramento, California 95814
(916) 442-7785

Appendix XX: Photographs of class I airsheds representing the clearest and most hazy days (source: IMPROVE). Airsheds with deterioration noted.

Big Bend National Park, TX (deteriorating)

Great Gulf Wilderness, NH

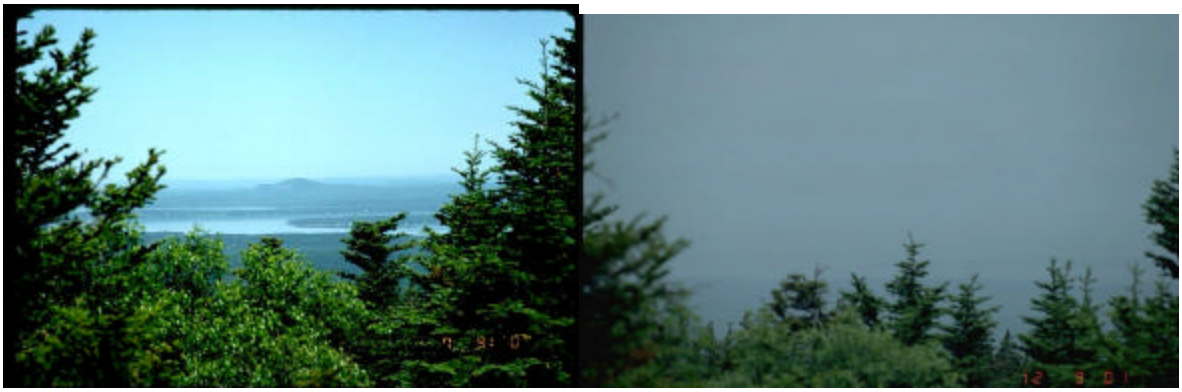
Voyageurs National Park, MN

Boundary Waters Canoe Area, MN

Badlands, National Park, SD (deteriorating)

Great Smoky Mountains National Park, NC and TN (deteriorating)

Washington Monument, DC



Acadia National Park, ME

Yosemite National Park, CA (deteriorating)

Yellowstone National Park, WY

Grand Canyon National Park, AZ

Glacier National Park, MT

Bridger Wilderness, WY

Mesa Verde National Park, CO

Canyonlands National Park, UT

Chiracahua National Monument, AZ (deteriorating)

Regional Haze Summary: Selected Class I Airsheds
Source: 4/22/99 V.P. Gore Fact Sheet on Announcement of Final Haze Rule; EPA data

Park or Wilderness	Worst Day	Best Day	Visibility Lost
Acadia National Park (ME)	19 miles	74 miles	74%
Badlands National Park (SD)	37 miles	102 miles	64%
Bandalier Wilderness Area (NM)	65 miles	114 miles	43%
Big Bend National Park (TX)	42 miles	104 miles	60%
Bryce Canyon National Park (UT)	66 miles	138 miles	52%
Boundary Waters Wilderness Area (MN)	28 miles	108 miles	74%
Bridger Wilderness Area (WA)	78 miles	156 miles	50%
Brigantine Wilderness Area (NJ)	13 miles	42 miles	70%
Canyonlands National Park (UT)	70 miles	125 miles	44%
Chiricahua Wilderness Area (AZ)	61 miles	120 miles	50%
Crater Lake National Park (OR)	59 miles	136 miles	56%
Denali National Park (AK)	76 miles	139 miles	45%
Dolly Sods Wilderness Area (WV)	10 miles	46 miles	79%
Glacier National Park (MT)	35 miles	84 miles	58%
Grand Canyon National Park (AZ)	68 miles	128 miles	47%
Great Basin National Park (NV)	83 miles	153 miles	46%
Great Sand Dunes Wilderness Area (CO)	66 miles	124 miles	47
Great Smoky Mountains National Park (TN/NC)	15 miles	55 miles	74%
Guadalupe Mountains National Park (TX)	47 miles	99 miles	52%
Lassen Volcanic National Park (CA)	62 miles	145 miles	57%
Lye Brook Wilderness Area (VT)	17 miles	87 miles	81%
Mammoth Cave National Park (KY)	12 miles	38 miles	68%
Mesa Verde National Park (CO)	72 miles	127 miles	43%
Mount Rainier National Park (WA)	21 miles	10 miles	80%
Okefenoke Wilderness Area (GA)	16 miles	46 miles	64%
Petrified Forest National Park (AZ)	62 miles	112 miles	45%
Pinnacles Wilderness Area (CA)	35 miles	81 miles	57%
Point Reyes Wilderness Area (CA)	23 miles	73 miles	70%
Redwood National Park (CA)	30 miles	99 miles	70%
Rocky Mountain National Park (CO)	64 miles	142 miles	55%
San Gorgonio Wilderness Area (CA)	24 miles	112 miles	79%
Sequoia National Park (CA)	25 miles	94 miles	73%
Shenandoah National Park (VA)	11 miles	48 miles	77%
Simeonof Wilderness Area (AL)	10 miles	34 miles	70%
Upper Buffalo Wilderness Area (AR)	14 miles	53 miles	75%
Weminuche Wilderness Area (CO)	68 miles	142 miles	52%
Yellowstone National Park (WY/ID/MT)	72 miles	127 miles	44%
Yosemite National Park (CA)	41 miles	131 miles	69%

Clean Air Task Force/ B. Hill

Preliminary Update of Source Apportionment at Three National Parks in the Eastern United States

Kristi Gebhart, National Park Service, Air Resources Division, CIRA, Colorado State University, Fort Collins, CO 80523, 970-491-3684, gebhart@cira.colostate.edu

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Introduction

Several years ago we used a simple back trajectory technique to apportion measured sulfate at Shenandoah, Great Smoky Mountains, and Acadia National Parks to known source areas in the eastern half of the United States and Canada[1]. There are several reasons to revisit these analyses including changes in emissions and in fine particle measurement methods and advancement of the science. We anticipate doing a full re-assessment in the future. This quick analysis, however, attempts only to address the question of how the apportionment of sulfur may have changed in the last decade if the same analysis were repeated with more recent data.

Updates of Data and Methodology

As much as possible, all techniques and data are the same or similar to those used in the 1989 paper. There are two minor modifications. First, 24-hour average IMPROVE[2] data are used rather than the 72-hour average data from the old NPS/SFU. Secondly, rather than performing the analysis for each separate year, 5-year time periods were analyzed. The longer time periods provide more data for each regression, should give a more robust result, and help dampen fluctuations due to inter-annual variability in meteorology.

Measurements of fine particulate sulfur and sulfate ion have undergone several modifications over the years. For this analysis the sulfur concentrations are based on the IMPROVE sulfate ion concentrations before May 1995 and IMPROVE elemental sulfur for later dates. A full discussion of this issue is on the IMPROVE web site[3].

Results

Results are summarized in Tables 1-3. Maps of the source areas are shown in Figures 1 and 2. The uncertainties in the tables are based on the standard errors of the regression coefficients only and do not reflect measurement or model uncertainties. Our original paper[1] has a lengthy discussion of uncertainties that is still valid. Attributions within a factor of 2 of their standard errors are not statistically significant, but are included in the table for completeness and for comparison with the older results. Many of the attributions are fairly stable over the years. Some fluctuations from year to year are expected from meteorology alone. A change in the percent of sulfur attributed to a source does not necessarily imply a corresponding change in their emissions. For example, if all sources had emissions reductions, but the reductions were non-uniform across different areas, the fractional attributions to the various source regions would likely change, with some increasing while others decreased.

Great Smoky Mountains

In 1984-1987, Columbus-Dayton-Cincinnati (No. 13) was, on average, the largest source of sulfur at Great Smoky Mountains. While this is also true in later years, the average percent of sulfur attributed to Western TVA (No. 1) has more than doubled, so that in later years it's fractional contribution is approximately the same as Columbus-Dayton-Cincinnati. These two sources together are estimated to have contributed approximately half of the measured sulfur in the 1990s. The fractions attributed to South MS (No. 6) and Toledo-Central Michigan (No. 14) have also increased, though their contributions are still relatively small. Sources with large decreases in their average percent attributions include Memphis-TVA (No. 9), Florida (No. 4), Birmingham (No. 2), West MO (No. 10), and Northern NY (No. 16). Results for all sources are shown in Table 1.

Shenandoah

The Pittsburgh-Cleveland (No. 6) source area is still predicted to be by far the largest source of sulfur at Shenandoah on average. The percent of sulfur attributed to Piedmont-North TN (No. 11), the second largest source in 1983-1987, has dropped by a factor of 2, making Columbus-Dayton-Cincinnati (No. 14) now the second largest contributor. The model attributes approximately half the sulfur at Shenandoah during the 1990s to these two sources combined. There are notable increases in the average percent of sulfur attributed to Tenn. River – Birmingham (No. 7), NYC-Philadelphia (No. 9), and Minneapolis-St. Paul (No. 12) and a large decrease in the average percent attributed to Toledo (No. 8). Complete results are shown in Table 2.

Acadia

In 1986-1987 the three largest sources of sulfur at Acadia were estimated to be Sudbury (No. 15), Northern NY (No. 19), and NYC-Philadelphia (No. 9). The largest source of sulfur at Acadia during the 1990s was Northern NY. The model attributes 1/4 to 1/3 of the sulfur on average to this source. The percents attributed to Northern NY and NYC-Philadelphia have remained relatively constant, while the percent attributed to Sudbury has fallen by a factor of 2. It is known that the INCO smelter in Sudbury planned dramatic reductions in their emissions between 1985 and 1994 though the exact dates and magnitude of the reductions are unknown. Sources with large increases in their average percentage attributions include St. Louis-East MO (No. 5) and Pittsburgh-Cleveland (No. 6). No other sources besides Sudbury had notable reductions. All results for Acadia are shown in Table 3.

Disclaimer

The assumptions, findings, conclusions, judgments, and views presented herein are those of the author and should not be interpreted as necessarily representing official National Park Service policies. This document is a progress report of ongoing research and has not been peer-reviewed.

References

1. Gebhart, K.A. and W.C. Malm (1990) "Source Apportionment of Particulate Sulfate Concentrations at Three National Parks in the Eastern United States" in *Visibility and Fine Particles*, Transactions of the A&WMA/EPA International Specialty Conference, Estes Park, CO, Oct. 1989, C.V. Mathai, Ed., 898-913.

2. IMPROVE web site. http://vista.cira.colostate.edu/improve/

3. Discussion of sulfur vs sulfate issues in the IMPROVE network. http://vista.cira.colostate.edu/improve/Data/QA_QC/issues.htm

Table 1. Great Smoky Mountains National Park. Percent of fine sulfur attributed to each of several source areas for three time periods and summary statistics of the sulfur concentrations. See Figure 1 for source locations.

Source Number	Source Area	1984-1987 percent	1990-1994 percent	1995-1999 percent
1	Western TVA	8.7	23.0 ± 2.8	23.1 ± 2.6
2	Piedmont-East TN	5.9	10.5 ± 1.4	6.6 ± 1.4
3	Atlanta-Chattanooga	6.8	8.0 ± 2.0	8.2 ± 1.7
4	Florida	6.3	3.8 ± 1.4	3.3 ± 1.1
5	Birmingham	3.1	1.0 ± 1.6	-2.3 ± 1.7
6	South MS	0.3	4.1 ± 1.6	3.9 ± 1.4
7	South LA	3.2	2.6 ± 1.5	4.2 ± 1.5
8	West TX	4.3	3.9 ± 1.2	2.2 ± 1.2
9	Memphis (TVA)	7.8	4.1 ± 1.3	0.8 ± 1.5
10	West MO	3.2	-1.1 ± 2.2	1.3 ± 2.4
11	St. Louis Area	5.9	3.7 ± 2.4	8.3 ± 2.3
12	Chicago	2.4	2.2 ± 1.5	2.0 ± 1.3
13	Columbus-Dayton-Cincinnati	28.1	24.5 ± 2.7	24.8 ± 2.5
14	Toledo-Central MI	0.8	3.3 ± 1.5	4.2 ± 1.3
15	Pittsburgh-Cleveland	8.9	4.5 ± 1.5	6.1 ± 1.3
16	Northern NY	3.2	1.9 ± 0.9	1.6 ± 0.9
17	NYC-Philadelphia	1.4	0.1 ± 1.4	1.8 ± 1.3
		SFU	IMPROVE	IMPROVE
	Mean Sulfur (ng/m^3)	1547	1744	1670
	Standard Deviation	998	1356	1266
	No. of Obs.	361	485	513
	Maximum	6928	7848	7048
	Minimum	27	77	97
	Median	1343	1280	1231

Table 2. Shenandoah National Park. Percent of fine sulfur attributed to each of several source areas for three time periods and summary statistics of the sulfur concentrations. See Figure 2 for source locations.

Source Number	Source Area	1983-1987 percent	1990-1994 percent	1995-1999 percent
1	East Texas	0.9	-0.2 ± 1.0	1.8 ± 1.5
2	Austin-Houston	3.3	2.2 ± 0.9	1.7 ± 2.3
3	South LA & MS	2.3	2.1 ± 1.2	1.9 ± 1.4
4	Chicago	5.4	5.7 ± 2.0	5.6 ± 2.4
5	St. Louis-East MO	0.2	0.3 ± 2.4	1.2 ± 2.8
6	Pittsburgh-Cleveland	29.5	40.0 ± 3.4	29.6 ± 4.2
7	Tenn. River – Birmingham	2.0	4.2 ± 2.1	4.1 ± 2.3
8	Toledo	6.4	-2.2 ± 1.8	1.6 ± 2.8
9	NYC-Philadelphia	2.2	6.7 ± 1.3	7.5 ± 1.5
10	Atlanta – Chattanooga	1.8	4.4 ± 1.5	2.7 ± 1.8
11	Piedmont – North TN	16.3	9.5 ± 1.8	8.0 ± 2.2
12	Minneapolis – St. Paul	1.6	-1.1 ± 1.4	3.2 ± 1.6
13	Kansas City – West MO	1.3	0.7 ± 1.7	4.3 ± 2.2
14	Columbus – Dayton – Cincinnati	11.6	17.0 ± 2.3	15.7 ± 3.3
15	Sudbury	2.0	0.6 ± 1.2	2.1 ± 1.7
16	Central Michigan	4.0	2.8 ± 1.8	3.9 ± 2.0
17	Memphis	2.4	2.3 ± 1.1	-0.6 ± 1.3
18	Louisville – Mid Ohio River	2.6	3.1 ± 2.1	3.5 ± 2.5
19	Northern NY	2.9	0.4 ± 1.5	1.1 ± 1.7
20	North Florida	1.4	1.7 ± 1.0	0.9 ± 1.4
		SFU	IMPROVE	IMPROVE
	Mean Sulfur (ng/m^3)	1426	1849	1491
	Standard Deviation	961	1643	1257
	No. of Obs	457	510	477
	Maximum	6819	12977	4686
	Minimum	11	17	27
	Median	1203	1305	1031

Table 3. Acadia National Park. Percent of fine sulfur attributed to each of several source areas for three time periods and summary statistics of the sulfur concentrations. See Figure 2 for source locations.

Source Number	Source Area	1986-1987 percent	1990-1994 percent	1995-1999 percent
3	South LA & MS	1.2	1.5 ± 0.9	1.2 ± 1.6
4	Chicago	4.9	4.3 ± 2.3	5.8 ± 2.8
5	St. Louis-East MO	0.0	5.9 ± 2.2	7.8 ± 2.4
6	Pittsburgh-Cleveland	0.1	11.5 ± 2.8	3.7 ± 3.2
7	Tenn. River – Birmingham	0.8	2.8 ± 1.8	-0.4 ± 2.2
8	Toledo	4.7	1.1 ± 1.9	6.5 ± 1.9
9	NYC-Philadelphia	14.5	9.6 ± 2.6	14.5 ± 2.8
10	Atlanta – Chattanooga	1.0	-0.1 ± 1.5	1.6 ± 1.0
11	Piedmont – North TN	1.6	2.3 ± 1.4	3.3 ± 1.7
12	Minneapolis – St. Paul	0.8	4.5 ± 1.3	-2.3 ± 1.6
13	Kansas City – West MO	3.5	2.9 ± 1.4	4.0 ± 2.1
14	Columbus – Dayton – Cincinnati	3.5	4.7 ± 2.4	2.3 ± 2.9
15	Sudbury	29.0	16.9 ± 2.1	13.8 ± 2.5
16	Central Michigan	8.8	7.9 ± 2.6	4.8 ± 2.9
17	Memphis	1.3	0.1 ± 0.9	-0.1 ± 1.1
18	Louisville – Mid Ohio River	0.0	-0.6 ± 1.7	-1.4 ± 2.1
19	Northern NY	24.3	24.3 ± 3.4	32.8 ± 4.2
		SFU	IMPROVE	IMPROVE
	Mean Sulfur (ng/m^3)	606	907	705
	Standard Deviation	448	886	694
	No. of Obs.	170	513	509
	Maximum	2373	6660	6877
	Minimum	45	53	44
	Median	482	632	519

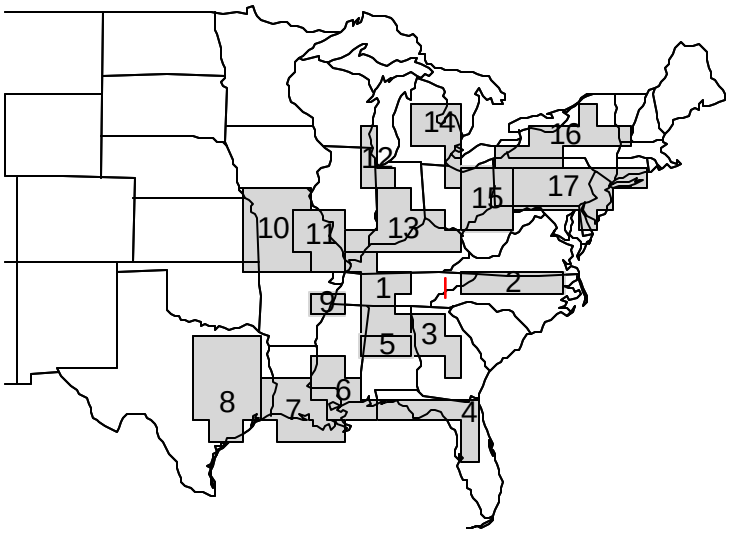


Figure 1. Source areas used for Great Smoky Mountains National Park. Refer to Table 1 for names. The diamond is the park location.

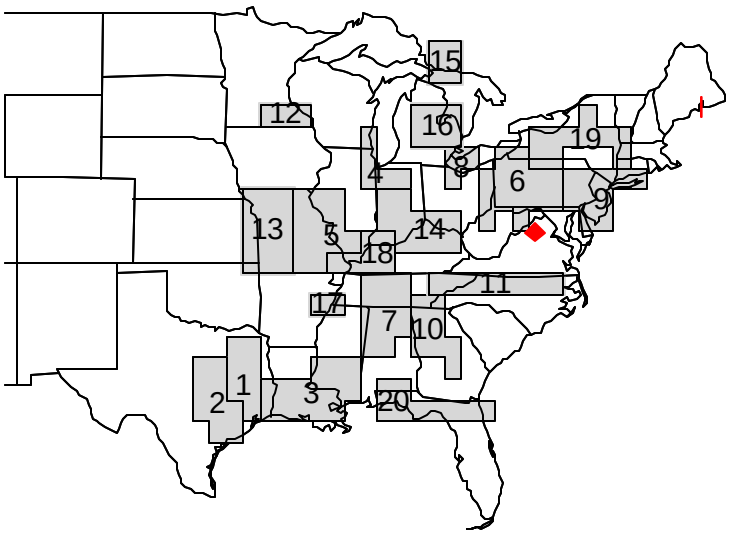


Figure 2. Source areas used for Shenandoah and Acadia National Parks. Refer to Table 2 for names. Sources 1, 2, and 20 were not used for Acadia. Diamonds indicate the park locations.

Sources of Sulfate Trends in the Eastern United States, 1982-1998

David Pyles and Thomas A. Cahill
Atmospheric Sciences, Department of Land, Air, and Water Resources,
Jessica Utz
Department of Statistics,
University of California, Davis 95616

Fine ($PM_{2.5}$) sulfate concentrations have been measured at national parks in the eastern United States since 1982 as part of the National Park Service and Interagency Monitoring of Protected Visual Environments (IMPROVE) programs designed to understand and protect visibility (Malm et al, 1994). When the IMPROVE data were combined with the NPS data (Eldred et al, 1994) the result showed a sharp increase of sulfates, 30% or more, at the two eastern sites, Shenandoah NP and Great Smoky Mountains NP for the summer season (Eldred at Cahill, 1994). This result was unexpected since the national SO_2 emissions had dropped about 7% in the same period, and caused some (including White, 1998) to question whether the effect was a result of a changed in sampling protocols in 1998 at the start of the IMPROVE network. To find the sources of the rise in sulfates, we have performed trajectory and statistical analyses of air pollution in the southern Appalachian Mountains around Great Smoky Mountains NP. For the summer of 1995, the time of the SEAVS visibility study, we used SO_2 source data from 11 utility and industrial boilers in the region. Wind field data from NMC/NCEP re-analysis fields were used to develop pollutant trajectories. Specifically, winds at 850 millibars (adjusted to sea level) were used in the study area 75^o to 100^o West Longitude and 25^o to 40^o North latitude to follow parcels every 2 hours. The pollutant concentrations were based on the monthly mean average values broken into 2 hr parcels, and weighted versus distance by a 1/r factor. Impacts on great Smoky Mountains NP were then correlated with data taken during the SEAVS period for SO_2, SO_4, and selenium, a tracer of coal combustion. Statistical analyses were then made of the data from the model and the receptor site, leading to source by source attributions. The two closest sources contributed 77% of all the sulfates seen during the SEAVS period. With this association, we then returned to the trend data to show that the rise in sulfates, 1982-1992, was associated with a rise in emissions from the two closest power plants confirming an association reported in 1996 (Cahill et al, 1996).

Eldred, Robert A. and Thomas A. Cahill. Trends in elemental concentrations of fine particles at remote sites in the United States. 1994 *Atmospheric Environment*, Vol. 28, No. 5, pp. 1009-1019.

Malm, W.C., Sisler, J.F., Huffman, D., Eldred, R.A. and Cahill, T.A.. Spatial and seasonal trends in particle concentration and optical extinction in the United States. 1994 *Journal of Geophysical Research,* VOL. 99, No. D1, 1347-1370, January 20.

An Overview of the Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study

Mark C. Green and Hampden Kuhns
Desert Research Institute
755 E. Flamingo Road
Las Vegas, NV 89119

Marc L. Pitchford
National Oceanic and Atmospheric Administration
755 E. Flamingo Road
Las Vegas, NV 89119

ABSTRACT

As a result of concern over visual air quality at Big Bend National Park, a large study is being conducted to consider sources of visibility impairment at Big Bend. The primary goals of the Big Bend Regional Aerosol and Visibility Observational (BRAVO) study are to understand the long-range, trans-boundary transport of visibility-reducing particles from regional sources in the U.S. and Mexico and to quantify the contributions of specific U.S. and Mexican sources (or source regions) responsible for poor visibility at Big Bend NP. The field study was conducted from July 1999 through October 1999. While it is acknowledged that sources in both the U.S. and Mexico contribute to visibility impairment at Big Bend[1], due to an inability to reach agreement on study design, the field study was conducted solely in the U.S. Analyses conducted during the study design phase identified several sources of particular interest: the Carbon I and Carbon II coal-fired power plants located about 270 km east-southeast of Big Bend National Park, other urban and industrial sources in northern Mexico, coal-fired power plants along the lignite belt in Texas, and other urban and industrial sources in east Texas.

The study included release of perfluorocarbon tracers at 4 locations. The field study included a network of 37 $PM_{2.5}$ samplers and 24 tracer sampling sites collocated with aerosol sites. At Big Bend, additional measurements were made for high time resolution sulfate, SO_2, and tracer. Also at Big Bend were size resolved aerosol measurements, and specialized optical measurements. Radar wind profilers were deployed at 4 sites in southern Texas. Stack samples were collected for chemical characterization from a variety of industrial source types in Texas. Multiple attribution analyses methods including source and receptor oriented modeling approaches will be applied for BRAVO.

INTRODUCTION

A preliminary regional visibility study was conducted in Texas and northern Mexico in September and October 1996. A brief overview of the study and consensus results are presented here. A more detailed description of the preliminary study is contained elsewhere[1].

The primary objective of the preliminary study was to obtain information that would allow for the identification of possible source regions in both countries and source types responsible for visibility degradation at Big Bend National Park. The study was not intended to quantify impacts of specific sources on Big Bend air quality. The study was intended to obtain information on pollutant gradients over a broad area of Texas and northeast Mexico to assist in the design of a future study to identify the causes of visibility impairment at Big Bend . The

study was conducted at 19 monitoring stations (10 in Texas, 9 in Mexico) from September 9 through October 13, 1996. The sites sampled $PM_{2.5}$ at all sites and PM_{10} at Big Bend and Guadelupe Mountains national parks. The $PM_{2.5}$ filters were analyzed for chemical composition.

It was noted that care should be taken in interpreting the results of the study due to its' limited duration and geographical coverage. Consensus was not reached by the work group on all issues. Key consensus results are paraphrased below:

- To the northeast of Big Bend are large sources of sulfur statistically associated with selenium, likely from coal-fired power plants at distances that can exceed 700 km. These sources sometimes cause high concentrations of fine particulate and fine particulate sulfur through much of Texas, including Big Bend National Park.
- On some occasions with southerly flow, Mexican emissions appear to be associated with significant sulfur concentrations at Big Bend.
- During periods with southeasterly winds, emissions from both Mexico and the United States may contribute to $PM_{2.5}$ mass and fine particulate sulfur at Big Bend. Also, because of the lack of correlation of selenium and vanadium (power plant endemic tracers) with sulfur for these wind directions, sources in addition to power plants are contributing to these concentrations.
- Transport from areas to the northwest of Big Bend is associated with relatively low concentrations of fine particulate mass and fine particulate sulfur.
- Relative humidity plays a large role in visibility impairment at Big Bend.
- Fine particulate sulfur plays a large role in visibility impairment at Big Bend and most of the particulate sulfur is in the form of sulfate.

The primary goals of the Big Bend Regional Aerosol and Visibility Observational (BRAVO) study are to understand the long-range, trans-boundary transport of visibility-reducing particles from regional sources in the U.S. and Mexico and to quantify the contributions of specific U.S. and Mexican sources (or source regions) responsible for poor visibility at BBNP.

Previous air quality studies in the desert southwest (including SCENES, VIEW, VISTA, WRAQ, RESOLVE, WHITEX, and Project MOHAVE) and the U.S.-Mexico Preliminary Study provide a great deal of background information useful to the planning of this project. In addition to determining impacts from individual sources, simultaneous assessment of all the important sources of haze for BBNP is desirable. This would allow for the formulation of more effective emissions control strategies in both countries that would ultimately result in the improvement of air quality in BBNP and throughout the region.

Other goals that are relevant to the BRAVO Study include:

- Determination of the chemical constituents of fine particles responsible for regional hazes along the U.S.-Mexico border, inclusive of Big Bend;
- Determination of the effects of meteorology including moisture from the Gulf of Mexico on visibility-reducing particles.
- Evaluate and improve the accuracy of atmospheric models and source attribution methods through the use of atmospheric tracers and updated source emissions profiles.

Overall direction of the BRAVO study is the responsibility of the BRAVO steering committee. The steering committee has representatives of the United States Environmental Protection Agency (USEPA), the National Park Service (NPS),and the Texas Natural Resources Conservation Commission (TNRCC). A sub-committee of the steering committee is comprised

of representatives of non-governmental organizations (NGOs), such as industry and environmental groups.

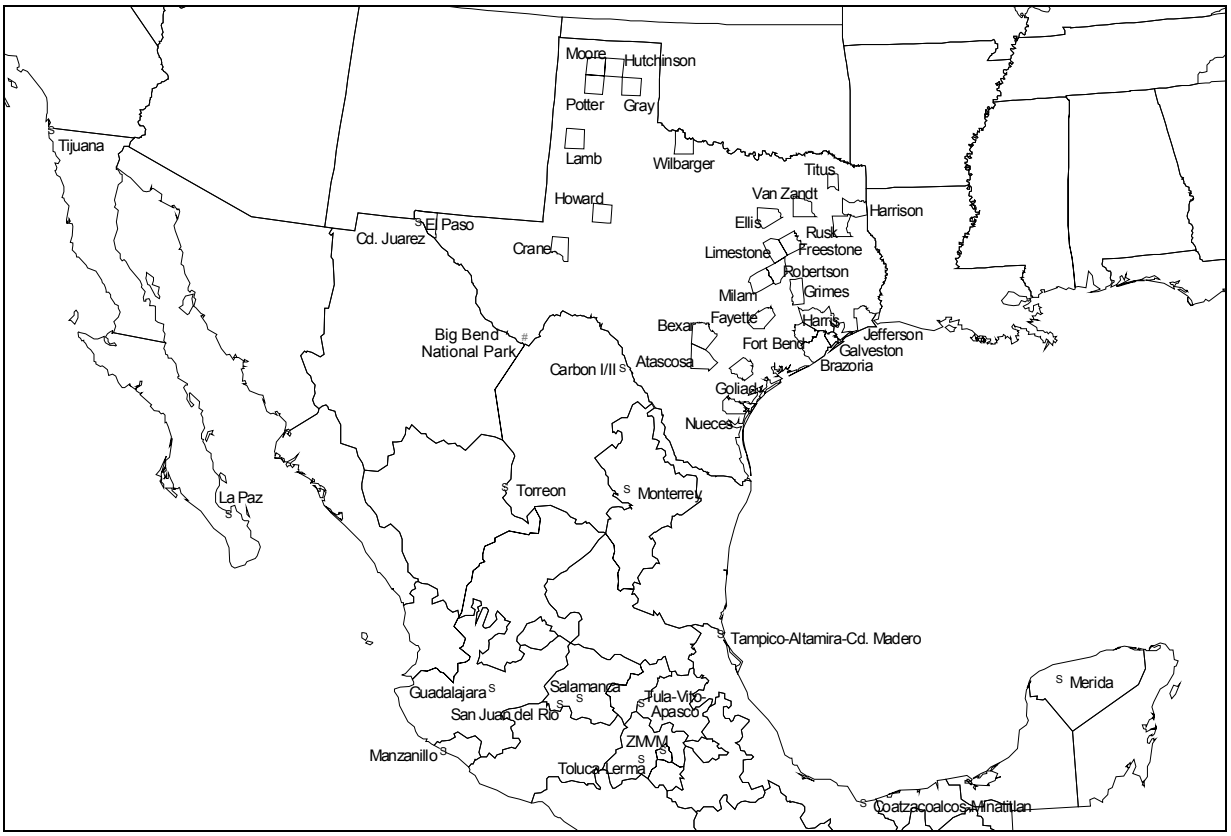
BACKGROUND

In this section, information regarding SO_2 emissions distributions, transport climatology, seasonal air quality patterns at Big Bend at presented. This information was used to help design the BRAVO study. Readers mainly interested in the field program for BRAVO may skip to the section titled "field study".

SO_2 emissions

According to the preliminary study and long-term monitoring at Big Bend, sulfate is an important component of haze at Big Bend National Park and results from atmospheric conversion of SO_2. Thus, emissions of SO_2 are of particular concern to the BRAVO study. Figure 1 is a map of the region that shows BBNP and the locations of SO_2 source areas of importance in Mexico and in Texas (other states in the region have much lower SO_2 emissions).

Figure 1: Site map of Mexican cities and Texas counties with SO_2 emissions greater than 5000 tons SO_2/yr. The location of Big Bend National Park is also shown.



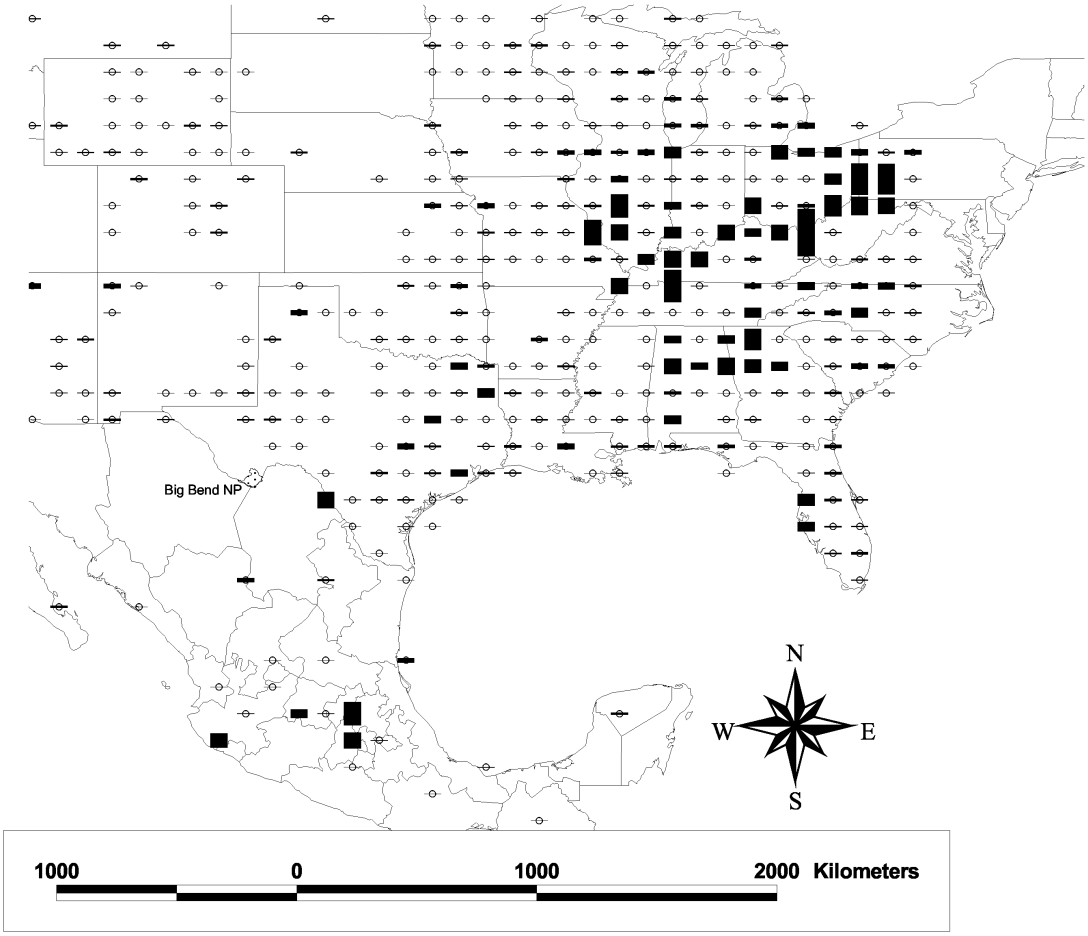
Major SO_2 sources in Texas include oil refineries, coal fired power plants, and carbon black producers. The majority of the Texas refineries are located along the eastern shore of Texas on the Gulf of Mexico. Historically, coal fired power plants were built along the lignite belt which runs from the northeast corner of Texas southwest toward the Carbon I/II facilities in Mexico.

Carbon black manufacturers are distributed along the east coast of Texas and near the oil fields in the Texas panhandle.

Major SO_2 emissions in Mexico are due largely to fuel oil refining and combustion and coal combustion. The Carbon I/II power plants are the largest coal combustion facilities in Mexico. Major refineries and industrial centers are located in Tampico on the east coast, Manzanillo on the west coast, Tula-Vito-Apasco north of Mexico City, and Toluca-Lerma south of Mexico City.

Figure 2 shows point source SO_2 emissions by 1 degree longitude by 1 degree latitude grid cells. The data is based upon information from Instituto Nacional de Ecologia (base year 1994) for Mexican cities with emissions greater than 5000 tons/year and the USEPA AIRS database. Figure 2 shows the greatest concentration of SO_2 emissions in the Ohio River Valley, although the numbers may not fully reflect recent reductions in SO_2 emissions in that area. Closer to Big Bend are significant sources in northern and central Mexico and eastern Texas.

Figure 2. Point sources of SO_2 by 1 degree longitude by 1 degree latitude grid cells. The bar at Carbon I/II (see Figure 1) corresponds to 240,000 tons per year.



Transport Patterns

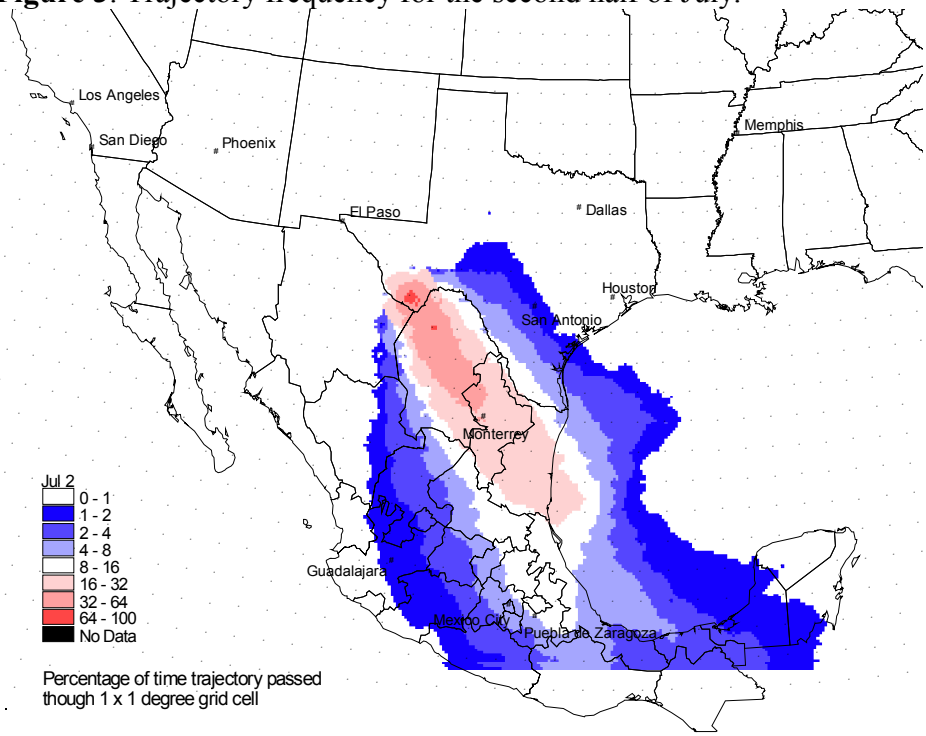
Transport patterns used to help plan BRAVO are based upon results of the Atmospheric Transport and Dispersion model (ATAD)[2]. The analysis used 18,264 ATAD backtrajectories for Big Bend National Park for the period 1982-1994. A series of analyses were run that provided

the frequency with which ATAD backtrajectories passed over 1 degree latitude by 1 degree longitude (1°x 1°) grid cells. Frequencies were calculated for annual and one-half month periods to determine the seasonal variations in transport paths. Using light extinction and aerosol data at Big Bend, the probability of high light extinction and high chemical components of haze was determined for periods when backtrajectories went through each 1°x 1° grid cell. This type of analysis, in conjunction with emission density maps can give an *idea* of the regions and sources that are contributing to haze at Big Bend.

Because a 1°x 1° grid cell subtends a smaller angle as distance increases from Big Bend and the backtrajectories have no dispersion, cells at greater distances from Big Bend tend to have lower percentages of backtrajectories passing through them than cells nearer to Big Bend. However, the relative frequency of flows from different directions can be noted by considering the shape of the contoured frequency plot.

The most frequent annual flow direction for Big Bend is from the southeast. However, substantial variations in average frequency of flow directions occur during the year. In late January backtrajectories from the west and northwest are at their annual peak, while few backtrajectories come from cells far to the south of Big Bend. From late February through late April bimodal distribution occurs with flows mainly from the west and the southeast, with the westerly mode shifting from west-northwest to west-southwest from February to April. From May through July, the flow becomes progressively more southeast and nearly all backtrajectories are from the southeast in July (Figure 3).

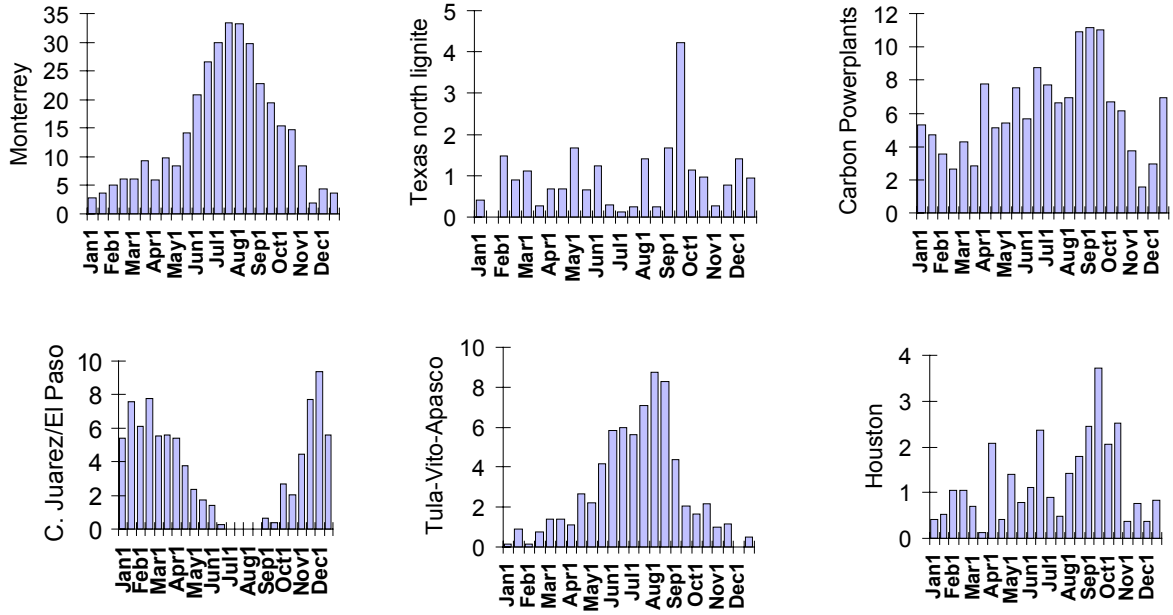
Figure 3. Trajectory frequency for the second half of July.



In the late summer, flows are still dominated by southeasterly backtrajectories, but backtrajectories from the east or northeast increase and reach their annual peak frequency. By early November, a tri-modal distribution of backtrajectories from the north, west, and southeast occurs. The pattern gradually evolves back to the west & northwest backtrajectories being most frequent in January, completing the annual cycle.

Figure 4 shows the frequency of flow by half-month period from selected source areas to BBNP using the 12 years of ATAD backtrajectories. With the exception of locations to the west and north), all of the areas are most frequently transported to BBNP during the period from the beginning of July through the end of October. During the early part of this period emissions from sources in Mexico to the southeast of BBNP are almost exclusively transported to BBNP. At the end of this period, the sources to the northeast (Houston, and the Texas lignite belt power plants) are also transported to BBNP.

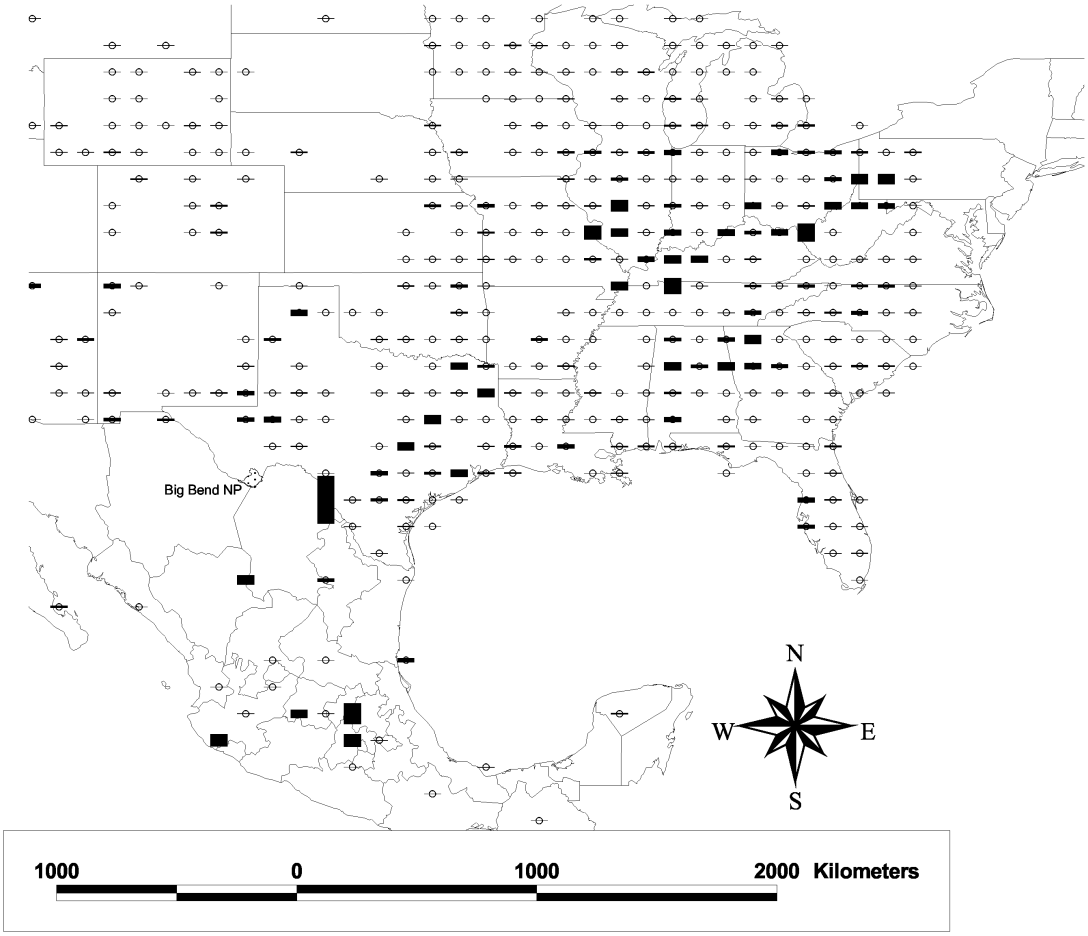
Figure 4. Frequency of flow by ½ month periods to Big Bend from selected source areas. Frequency is the percentage of backward trajectories from Big Bend that passed over the 1° latitude by 1° longitude cell containing the source area. The relative frequency by time of year is the parameter of interest. The absolute magnitude is an artifact of the grid size (1°x 1°) used.



Relative effects of transport from specific source areas

Next we consider relative effects of transport from some specific source areas considering distance from Big Bend and frequency of transport. This assessment was not expected to accurately model the impacts from different source areas; rather it was used for study planning purposes. Figure 2 showed estimated SO_2 emissions from 1° latitude by 1° longitude cells. Emissions from sources at a greater distance from BBNP disperse more before reaching BBNP than emissions from more nearby sources. Emissions were weighted by distance (emission rate divided by distance) to account for this effect; the results are shown in Figure 5. The inverse distance weighted analysis shows less weighting of the Ohio River Valley sources and much greater weighting for the Carbon I/II powerplants. Other sources in northern and central Mexico and eastern Texas appear to be potentially significant as well. This analysis may give an indication of potential maximum impacts from an area, but does not consider how frequently there is transport and hence total potential impact from the various source areas.

Figure 5. Emissions weighted inversely by distance from BBNP for 1° latitude by 1° longitude grid cells.



SO_2 emissions were also weighted by the frequency of transport from the source areas to BBNP (Figure 6). Due to most frequent transport from the south and southeast and infrequent transport from the northeast, the Mexican sources (especially Carbon I/II, Tula-Vito-Apasco, and the Mexico City area) predominant using this method.

Sisler, *et al.*[3] used IMPROVE aerosol data to estimate the percent of aerosol light extinction from each of the major components for the period March 1992- February 1995. Their results showed that sulfate is the most important contributor to particle-caused light extinction at Big Bend (41%), with organic compounds (19%), light absorbing compounds (21%), and crustal material (17%) also important.

Seasonality of light extinction and aerosol components

Figure 7 summarizes the tenth, fiftieth, and nintieth percentile levels of light extinction coefficient (b_{ext}) as measured by a transmissometer at Big Bend, by month, averaged over the period December 1988 – August 1998. Periods with relative humidity greater than 90% are not included. Data flagged for having hourly changes of $b_{ext} > 10$ Mm^{-1}, but not > 90% RH were included (this data represents about 20% of the observations). The average pattern shows highest median extinction in May. Light extinction levels are lowest in winter (November-March), and highest in summer (May-September), with transition periods in the spring and fall. May 1998 had particularly high light extinction due to large fires in Mexico.

Figure 6. Emissions weighted by transport frequency for 1° latitude by 1° longitude grid cells.

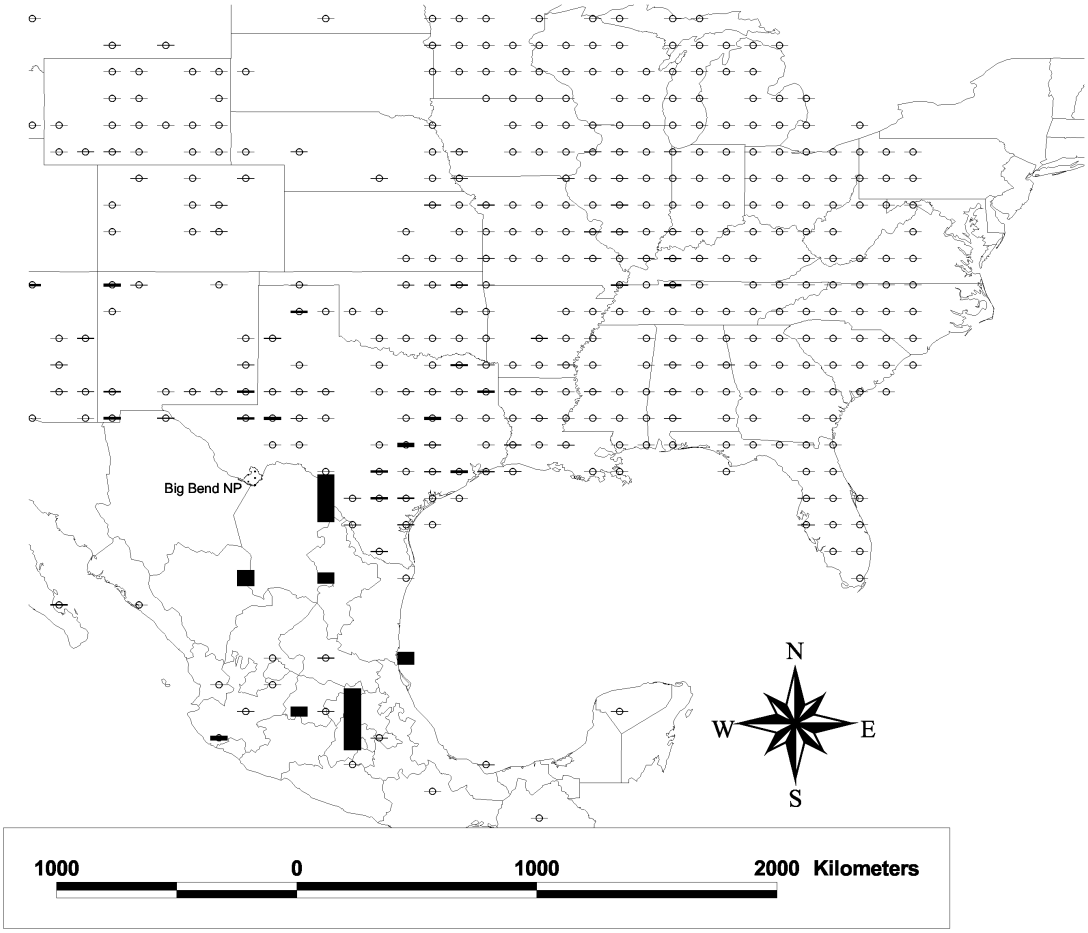
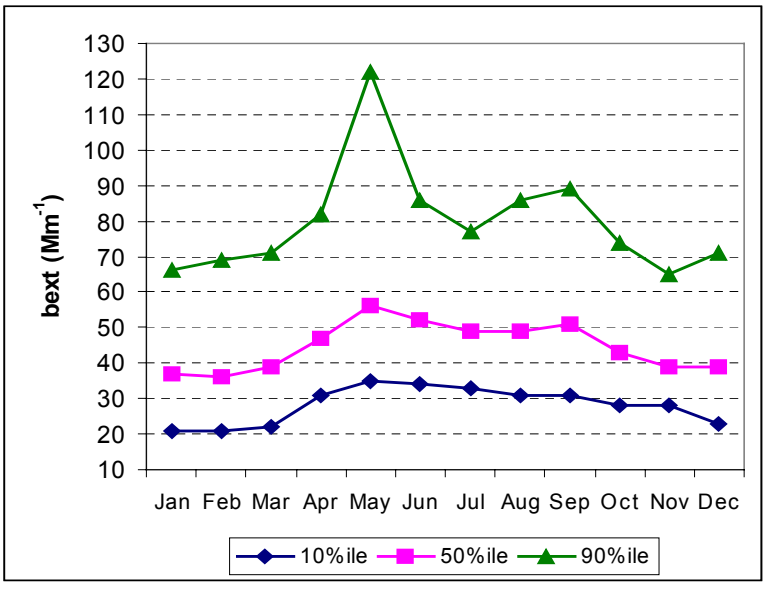
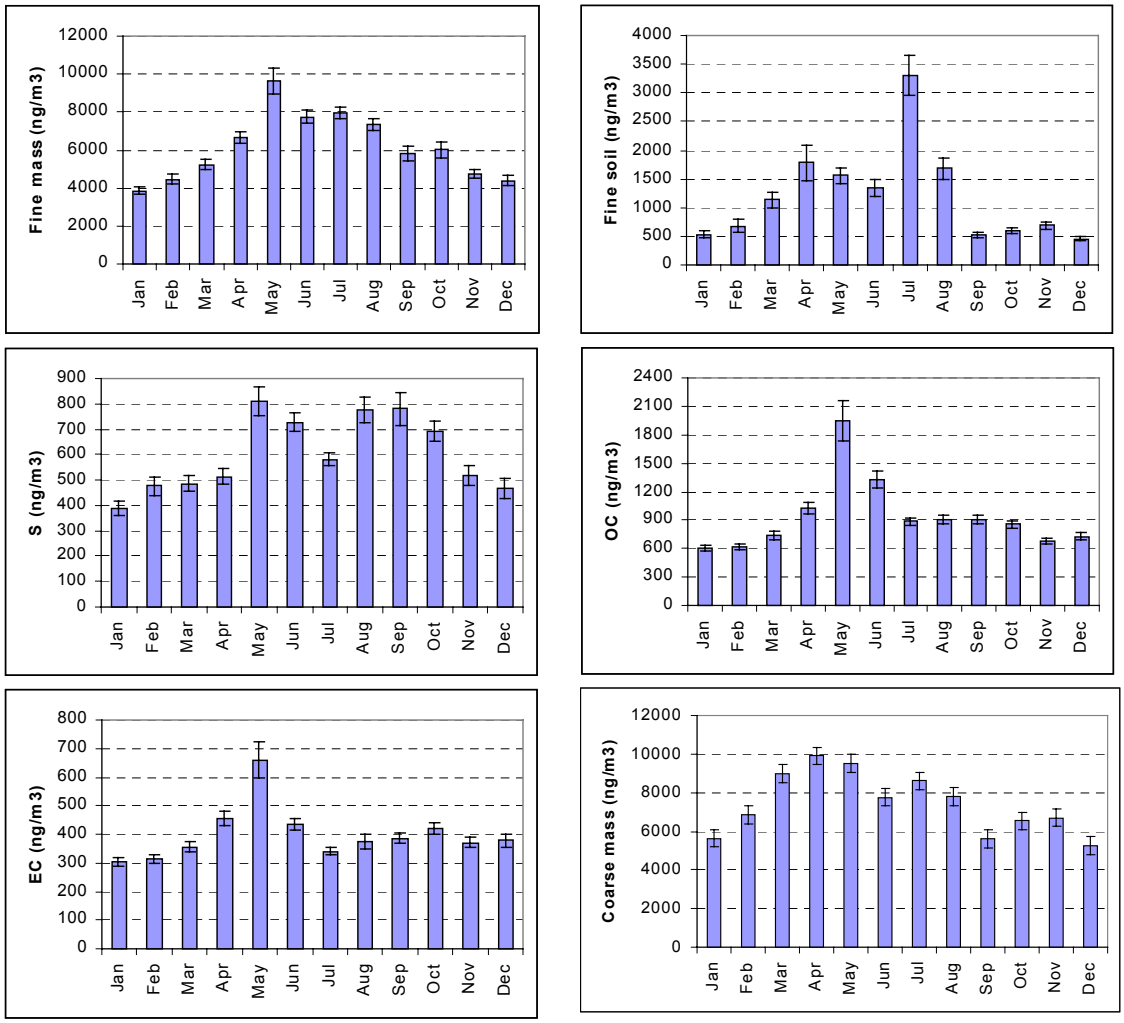


Figure 7. 10, 50, and 90 percentile b_{ext} values at Big Bend. (Dec 1988—August 1998). Periods with relative humidity greater than 90% are not included. Data flagged for having hourly changes of $b_{ext} > 10$ Mm^{-1}, but not > 90% RH were included (20% of observations).



Monthly variability in aerosol component concentrations are shown in Figure 8. Elemental carbon (EC), organic carbon (OC) and fine mass all peak in May. This is the same month as the peak in b_{ext}. A few very high values of EC and OC in May suggest that fires (agricultural and wildfires) may be particularly important during this time of year (especially for May 1998). Average monthly particulate sulfur is similarly high for May through October, except for a dip in concentrations in July. Fine soil is lowest in winter and shows a pronounced peak in July. The July peak is expected to result from transport of Saharan dust. Perry, et. al, (1977) demonstrated transport of Saharan dust into the southern and eastern United States, including Big Bend National Park. The Saharan dust is characterized by a deficit of calcium, leading to a higher ratio of aluminum to calcium and silicon to calcium for periods with significant concentrations of Saharan dust present.

Figure 8. Monthly averaged concentration of aerosol components. Error bars show the standard error of the mean. Time period is from March 1988 – February 1999.



Relationship between light extinction, chemical components, and backtrajectories

The analyses presented here relate backtrajectories from Big Bend passing through each grid cell to bext and chemical components measured at Big Bend. These are presented in the form of conditional probability maps which show the probability that a specified condition is met

for the backtrajectories passing through each grid cell. For light extinction coefficient (b_{ext}), particulate sulfur, organics, fine soil, organic carbon, and elemental carbon, the condition was that high (80 percentile or higher) concentrations occurred. Note that these maps show the probability that high concentrations occurred when backtrajectories passed over an area; it should be noted that some areas have much more frequent transport to Big Bend than other areas.

Figure 9 shows the frequency of backtrajectories passing through each grid cell for which b_{ext} at Big Bend was at the 80 percentile (57 Mm^{-1}) or higher. Twenty percent of all backtrajectories meet this criteria; thus areas with values of greater than 20 percent more often than average contribute to high light extinction conditions when backtrajectories pass over those areas, while areas with values less than 20 percent are less likely than average to contribute to high extinction. Figure 9 shows that areas to the northeast through south are relatively likely to be associated with high extinction when the air passes over these areas. Areas from the southwest through north are relatively less likely to be associated with high b_{ext} when the air passes through these areas.

Figure 9. Frequency of trajectories passing over each grid cell in which the air arriving at BBNP was above the 80 percentile b_{ext} value (57 Mm^{-1}).

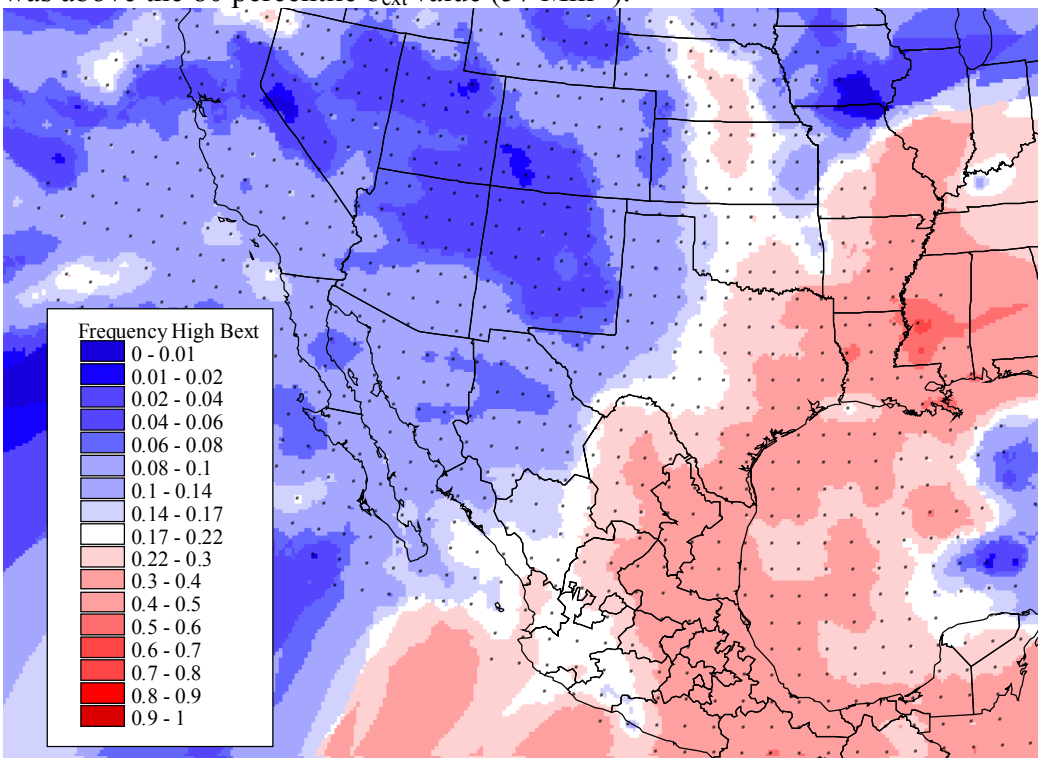
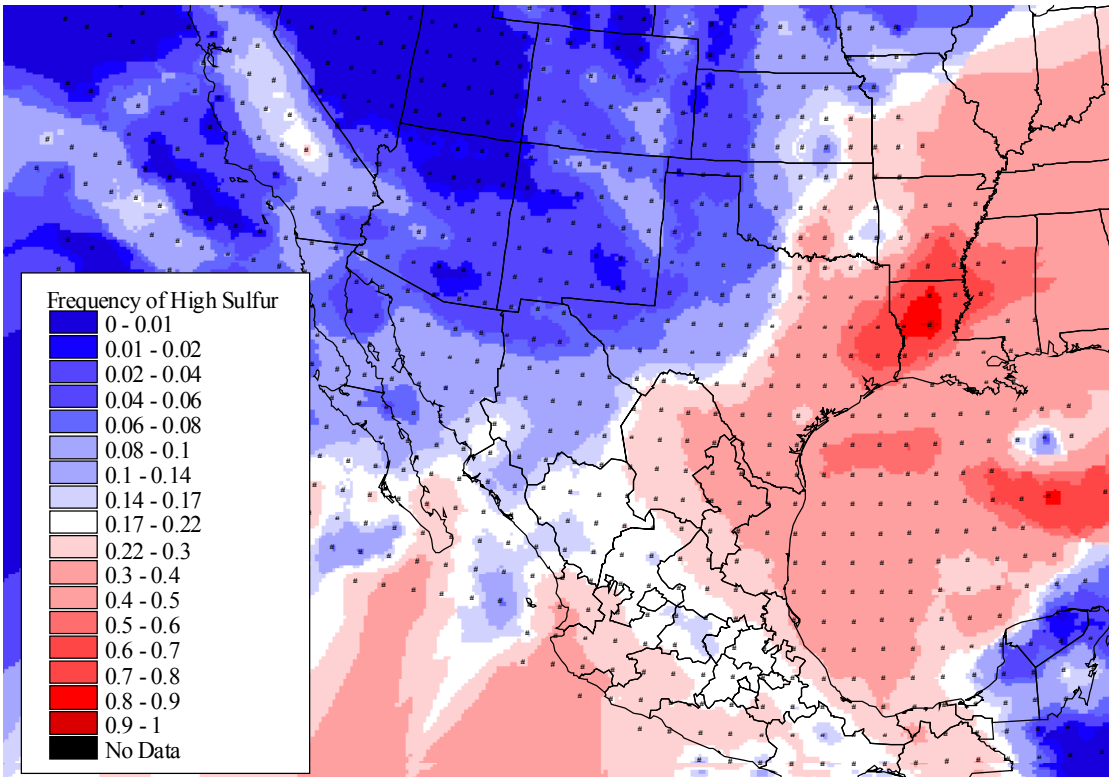


Figure 10 shows the conditional probability for high particulate sulfur concentrations (80 percentile = 929 ng/m^3). High sulfur concentrations are relatively likely for areas northeast through south of Big Bend, with high concentrations unlikely to be associated with backtrajectories from the west-southwest through the north. Backtrajectories passing over east Texas and Louisiana were the most likely to be associated with high sulfur at Big Bend.

High levels of light absorption are most likely for backtrajectories from the northeast clockwise through the west-southwest. The highest probability is associated with backtrajectories passing through east Texas and Louisiana. Backtrajectories from the north-northeast clockwise through the west are relatively likely to be associated with high elemental

carbon at Big Bend, especially backtrajectories passing over east Texas. High concentrations of organic carbon are most likely for backtrajectories passing over the coastal or near- coastal Gulf of Mexico in Mexico, Texas and Louisiana. High organic carbon concentrations are unlikely for backtrajectories from the northwest.

Figure 10. Frequency of trajectories passing over each grid cell in which the air arriving at BBNP was above the 80 percentile particulate sulfur concentration (929 ng/m^3).



Because high humidity is required for water growth of hygroscopic aerosols, such as ammonium sulfate, and high humidity is often accompanied by clouds that can accelerate conversion of SO_2 to sulfate, it is informative to examine backtrajectory and relative humidity relationships. Backtrajectories with an easterly component which were likely to be associated with high relative humidity, and backtrajectories with a westerly component, which were unlikely to be associated with high relative humidity. Backtrajectories passing through the Gulf of Mexico to the east to southeast of Big Bend were especially likely to be associated with high RH at Big Bend.

FIELD STUDY

Tracer Release

The tracer study included release of unique tracers from multiple locations and coincident tracer monitoring at many locations. The tracer release program is described here. The tracer monitoring network is shown in the next section. The objectives of the tracer study were to:

1) Tag (track emissions transport from) large individual sources with the potential for significant visibility impairment at Big Bend National Park.

2) Tag source areas with the potential for significant visibility impairment at Big Bend National Park.
3) Evaluate and improve performance of air quality models used for BRAVO.

The tracer release program is described here. The tracer monitoring network is shown in the next section. For objective 1, tagging large individual point sources can be used in direct attribution analysis methods, such as TAGIT[5], which looks for gradients in particulate sulfur between source affected areas and areas outside the influence of emissions from the tagged source. The tracer can also be used to determine periods when the tagged source did not affect Big Bend National Park. In objective 2, the tracer is used to give the general transport pattern and dispersion for emissions from a given source area. Because tracer is released from a point within an area of multiple sources, direct source attribution is not possible. The results are a qualitative demonstration of transport from the source region as well as information useful for objective 3. Meeting objective 3 is useful for modeling the effects of tagged and non-tagged sources alike. This includes obtaining transport and dispersion measurements, against which model results can be evaluated.

The tracer study was subject to constraints that affected the study design. The most significant constraint was that tracer release and sampling was not possible in Mexico. The conceptual study plan proposed tracer releases from the Carbon power plants in Mexico, about 20 km south of Eagle Pass, Texas, from Tula-Vito-Apasco, a large Mexican area source for SO_2, and from 2 U.S. sources. The inability of the United States and Mexico to reach an agreement regarding the study is a significant constraint on the ability to fully meet study objectives. The resulting tracer study design reflects an attempt to address the effects of this constraint.
A physicochemical constraint was the availability of only four different perfluorocarbon tracers. This limits to four the number of sources or source areas that can be concurrently tagged.

Emissions of SO_2 from the Carbon I and Carbon II power plants are estimated to be on the order of 240,000 tons per year. The power plants are located 1 km apart at a distance of 270 km east-southeast of Big Bend National Park. Because of the size of these plants and the closeness of the plants to Big Bend relative to other large emission sources, tracking the emissions from these plants is the highest priority. Other sources of substantial emissions of SO_2 and other compounds which may lead to visibility impairment are located in eastern Texas. These include many power plants along the lignite belt, along with the cities of Houston, Dallas-Fort Worth and San Antonio. The Houston area contains numerous industrial sources and the Parish power plant is nearby. The San Antonio area is nearby to power plants in the southern lignite belt. As a result of these emission patterns, the transport patterns described earlier, and the constraints listed above, the tracer study is designed to track emissions from the Carbon power plants and sources in eastern Texas.

Because of the inability to gain access to the Carbon stacks, tracer was released from Eagle Pass, Texas, approximately 20 km north-east of the Carbon plants. An elevated (90 meters) release from a television tower was done at Eagle Pass to better simulate stack releases than would be possible with a near ground-level release. Tracer was also released from the Big Brown power plant stack in northeastern Texas to represent elevated emissions from sources in that area, the Houston area to represent urban and industrial emissions from east-central Texas, and San Antonio to represent power plants and urban sources in the southern lignite area. Because flow from eastern Texas is uncommon in the first two months of the study (July and August), tracer releases from multiple Texas locations during these months would not have been the best use of resources. Providing information about the adequacy of the Eagle Pass tracer

release to represent emissions from the Carbon plants is a more effective use of resources. Concern over the Eagle Pass releases arises from the facts that there is a horizontal separation of 20 km between Eagle Pass and Carbon I/II and a vertical separation of varying amount between any release location and the effective stack heights from Carbon I/II. The vertical separation is of concern especially at nighttime and early morning hours when the atmosphere is stable and significant vertical wind shear may occur. Radiosonde data from Del Rio (90 km northwest of Carbon I/II) indicates substantial vertical wind shear during the morning sounding.

It might be expected that for tracer releases during periods of well-mixed atmospheric conditions Eagle Pass is a suitable surrogate for Carbon I/II emissions. Well-mixed conditions are likely to occur during daytime from about 1-2 hours after sunrise until approximately sunset. The tracer release program included continuous release of one tracer compound plus a separate tracer released during the daytime so that the concentrations measured at receptors can be separated into daytime, nighttime, or a known mixture of daytime and nighttime. A third tracer was released on alternate days to provide information on which day the tracers were released and to help resolve ambiguities over the release time of the tracer. If the Eagle Pass releases are representing transport from Carbon I/II there should be significant relationships between SO_2 and tracer concentrations. Two months of release using 3 tracers should be sufficient to understand the conditions during which tracer releases at Eagle Pass are representative of emissions from the Carbon plants.

During the second two months of the study, only one tracer was released at Eagle Pass. The two tracers previously used for timing were moved to Houston and San Antonio. September-October is the time of year with most frequent transport from these source areas toward Big Bend National Park.

The four perfluorocarbon tracers used were oPDCH, PDCB, PTCH, and i-PPCH. Criteria for selection of the tracer compounds included background concentration, cost, and ability to separate the compounds during chromatographic analysis. Release rates were determined using estimated dispersion factors from the release locations to Big Bend (extrapolated from Project MOHAVE tracer data[6,7]), and estimated precision for the new chromatographic system developed for BRAVO. Concentration uncertainty for 6 hour and 24 hour samples was estimated to be in all cases less than 10% of maximum concentration expected at Big Bend. Sample volume was the same for the 6 and the 24-hour samples because the 6-hour sampler pumped at 4 times the rate as the 24-hour sampler. Concentration uncertainty for the 1-hour samples at Big Bend is higher due to the lower sample volume. The sampling network is described later in this section.

Release rates for the first period of the study are shown in the Table 1. oPDCH and i-PPCH were released continuously. PDCB was released on alternate days from 8am to 8am CDT. PTCH was released every day but only from 8am to 8pm CDT.

Table 1. Tracer release schedule first phase of study.

Location	**Eagle Pass**	**Eagle Pass**	**Eagle Pass**	**Big Brown**
Tracer	OPDCH	PDCB	PTCH	i-PPCH
Release period	7/5/99-11/1/99	7/5/99-9/13/99	7/5/99-9/13/99	7/9/99-11/1/99
Release Rate (kg/hr)	0.155	0.525 alternate days (8am-8am) CDT	0.184 8am – 8pm CDT only	0.092

Release rates for the second period of the study are shown in Table 2. There was a hiatus of 4 days (8am to 8am) from terminating PDCB and PTCH at Eagle Pass and initiating release at San Antonio and Houston. oPDCH at Eagle Pass and i-PPCH at Big Brown continued to be released during this interim period. In early September, PDCB and PTCH releases from Eagle Pass were terminated. Note that all tracers were released continuously during the second half of the study.

Table 2. Tracer release schedule for the second half of the study.

Location	Eagle Pass	San Antonio	WA Parish	Big Brown
Tracer	OPDCH	PDCB	PTCH	i-PPCH
Release period	7/5/99-11/1/99	9/17/99-11/01/99	9/17/99-10/25/99	7/9/99-11/1/99
Release Rate (kg/hr)	0.155	0.442	0.115	0.092

There was a hiatus of 4 days (8am to 8am) from terminating PDCB and PTCH at Eagle Pass and initiating release at San Antonio and Houston. oPDCH at Eagle Pass and i-PPCH at Big Brown continued to be released during this interim period. In early September, PDCB and PTCH releases from Eagle Pass were terminated. Release at San Antonio and Houston began 5 days later at 8am and terminated at 8am CDT (7am CST) on November 1 along with the releases from Eagle Pass and the Big Brown power plant. Note that all tracers were released continuously during the second half of the study.

Data Gathering

The data gathering component of the study was from July 1- October 31, 1999.

Aerosol and Gaseous (includes tracer) Data

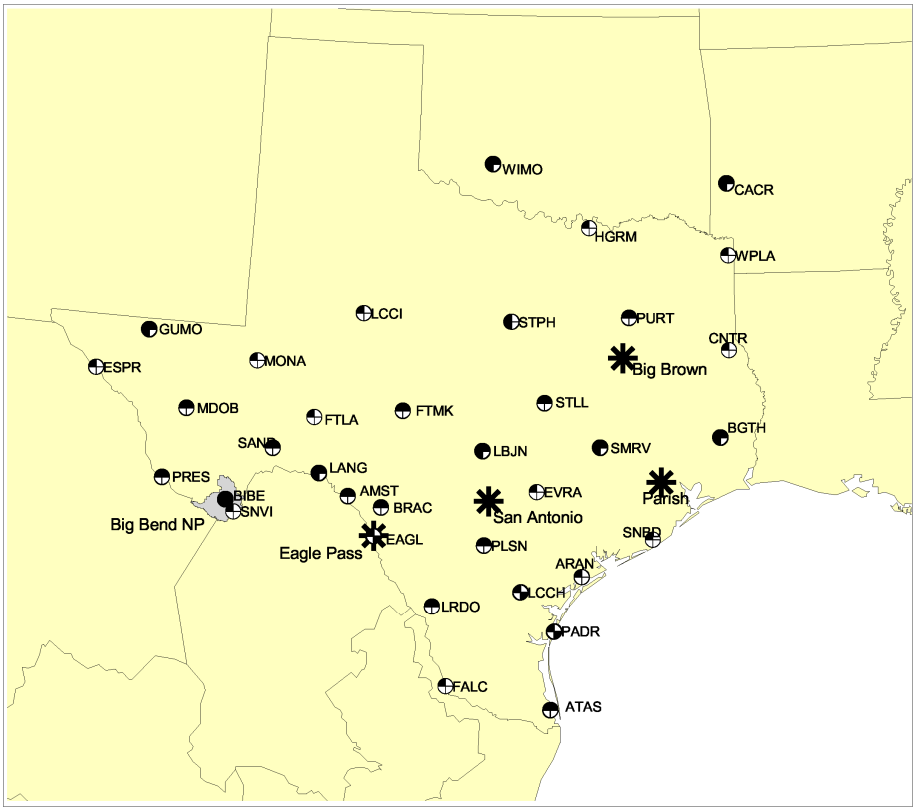
The network for collection of aerosol and gaseous data included 36 sites located throughout Texas, except for the panhandle area, and one site (Witchita Mountains) in Oklahoma. The IMPROVE sampler was used for collecting aerosol and SO_2 samples. All sites collected $PM_{2.5}$ on Teflon filters; many sites had additional measurements. Table 3 summarizes the number of sites for each type of measurement.

Table 3. Number of measurement sites by measurement type.

Measurement Type	Number of Sites
24 hour $PM_{2.5}$ elements (H, Na-Pb, mass, b_{abs}) (Teflon filter)	34
24 hour SO_2 and tracer	18
24 hour $PM_{2.5}$ carbon (quartz filter)	7
24 hour $PM_{2.5}$ ions (nylon filter)	4
6 hour $PM_{2.5}$ elements, SO_2, tracer	6
24 hour PM_{10} elements, ions, carbon	1
12 hour $PM_{2.5}$ elements, ions, carbon	1
Collocated 24 hour $PM_{2.5}$ elements, ions, carbon, SO_2, tracer	1
Collocated 24 hour PM_{10} elements, ions, carbon	1
Collocated 6 hour $PM_{2.5}$ elements, SO_2, tracer	1

Figure 11 shows the locations of the 24-hour monitoring sites and the parameters measured at each site. The purposes of sites included: general gradient sites in Texas (about 100 km apart); border gradient sites at the Texas/Mexico border, Texas/other U.S. states border sites, coastal gradient sites, Big Bend area gradient sites, Class I areas, and sites predominantly downwind of tracer release locations. Six 6-hour sites were located along an arc from the SNVI to MONA sites (see Figure 11). Delays with development of the new capillary column gas chromatography system for tracer analysis caused the shut-down of the 24-hour and 1-hour tracer monitoring network for a significant portion of the study period. The six 6-hour sites continued to collect samples for the entire study.

Figure 11. 24 hour network of gas and aerosol sampling locations.



24 Hour BRAVO Network Configuration

Fine Particles on Teflon Filter
SO2 and Tracer
Ion Balance
Carbon
Tracer Release Sites

100 0 100 200 Kilometers

Additional aerosol and gaseous measurements were made at Big Bend (K-Bar Ranch). These measurements are summarized in Table 4. Many of the specialized aerosol measurements at Big Bend were used for ion balance, carbon apportionment, and size distribution studies. The goals of the ion balance and carbon apportionment studies are briefly summarized below.

Ion balance study goals

- Determine what form(s) aerosol sulfate is found in at Big Bend National Park (BBNP) (e.g., H_2SO_4, NH_4HSO_4, $(NH_4)_2SO_4$, Na_2SO_4, etc…)
- Determine whether previously observed correlations between BBNP sulfate and sodium reflect the presence of sodium sulfate aerosol
- Determine changes in sulfate content and speciation during transport of air from the coast to BBNP

Carbon study goals

- Determine dominant source types contributing to carbonaceous aerosol at Big Bend National Park (BBNP)
- Determine whether dominant source types change with transport conditions or season

Table 4. Specialized aerosol and gaseous measurements at Big Bend.

Measurement	Averaging period
High time resolution, high sensitivity SO_2	1 hour
High time resolution particulate sulfate	12 minutes
High time resolution organic carbon	1 hour
Hourly tracer sampling	1 hour
$PM_{2.5}$ carbonaceous aerosol	24 hours
Carbon speciation by GC/MS for selected periods	24 hours
Gaseous nitric acid	24 hours
Gaseous ammonia	24 hours
MOUDI size resolved aerosol	24 hours
Various particle size measurements- differential mobility analyzer, optical particle counters, aerodynamic particle sizers	Seconds
Gaseous hydroperoxides	1 hour
Scanning electron microscopy (SEM) analysis	24 hours

Optical Data

Optical data collected at Big Bend National Park included a transmissometer and ambient nephelometer data at a site about 5 Km north of the main BRAVO monitoring location at K-Bar Ranch. For the BRAVO study, additional optical data were collected. These included 2 additional transmissometers , 2 open air Optec nephelomters, two ambient $PM_{2.5}$ Optec nephelometers, one ambient PM_{10} Optec nephelometer. The additional transmissometers are located about 0.5 Km southwest of the K-Bar Ranch site. The additional nephelometers were all located at the K-Bar Ranch site. There were also five 35mm cameras and two 8mm time-lapse cameras at the south end of the new transmissometer path. The cameras gave views from the Rio Grande River Basin to the existing transmissometer site path.

Additional optical instruments at the K-Bar Ranch site included two $PM_{2.5}$ Radiance Research nephelometers for which relative humidity was controlled, an aethalometer (operated with no-cut, 2.5 μm cut and 1 μm cut), and a photo-acoustic light absorption instrument.

Meteorological Data

The standard US and Mexican upper air meteorological data sites radiosonde sites collect altitude, pressure, wind speed, wind direction, temperature, and dew point temperature, usually

twice per day at 0 and 1200 Greenwich Mean Time (7 am and 7 pm MDT). These sites were supplemented by radar wind profilers at Big Bend, Brownsville, Eagle Pass, and Llano (about 100 km north of San Antonio). A radar wind profiler is also located at Palestine, near the Big Brown power plant. Radar wind profilers collect wind speed and direction as a function of height and data is generally reported hourly. Radar wind profilers equipped with a radio acoustic sounding system (RASS) also obtain vertical profiles of virtual potential temperature, although usually only to 500-1500 meters AGL.

Source Characterization

The objectives of the BRAVO source characterization program were to: 1) identify and sample $PM_{2.5}$ from representative emitters from within the study domain; 2) analyze these samples for the same chemical components measured at receptor sites; and 3) create chemical source profiles for use in subsequent source apportionment and data analysis activities. Accomplishment of these objectives provides input data to receptor models such as the Chemical Mass Balance, Tracer Mass Balance Linear Regression, and Differential Mass Balance Receptor models. The derived profiles will also assist in the evaluation of meteorological trajectory models that determine relative impacts from different source areas when coupled with an emissions inventory that will be compiled for the BRAVO field study period.

Source samples were subjected to the same chemical analysis procedures as the ambient aerosol data (described earlier). Carbon speciation for sources can be helpful for use in CMB modeling at receptor sites for which carbon speciation of ambient samples is done. Several criteria were set forth to select the source types and specific sources that needed to be tested. Unfortunately, it was not possible to collect samples from sources in Mexico. Data from the preliminary study and measurements made at the numerous border sites during transport from Mexico can be used to help charaterize Mexican sources. The first criterion was source types that are likely to contibute to $PM_{2.5}$ carbon, suspended dust, and sulfate. These are the largest contributors to light extinction at Big Bend National Park. The largest source types with these components are: 1) gasoline vehicle-exhaust for carbon and some sulfate; 2) diesel vehicle exhaust for carbon and some sulfate; 3) vegetative burning for carbon; 4) cooking for carbon; 5) coking for carbon; 6) road dust for suspended dust; 7) windblown dust from deserts and playas for suspended dust; 8) coal combustion in a variety of industries for sulfate; and 9) residual oil combustion from a variety of industries for sulfate. The second criterion was representatives of these source types that allow an average and standard deviation for chemical abundances to be estimated. The third criteria for industrial point sources was source types that have high sulfur dioxide emissions accompanied by high particulate emissions. The fourth criterion was access to effluent streams. The fifth criterion was cost-effectiveness.

The following sources were sampled as part of the BRAVO source characterization program:

- Motor vehicles- Roadside sampling several locations in Laredo, San Antonio
- Prescribed burn – 1 near Big Bend
- Coal combustion- 2 power plants, aluminum smelter
- Oil refineries – 4 across Texas
- Cement kilns – 2 locations
- Food preparation – various types (wood smoke barbeque, Mexican food, etc.)

The coal combustion sources burn a variety of coal types and use multiple types of controls to reduce their emissions of both particulate matter and sulfur dioxide. Cement Kilns

use a variety of fuel sources including coal, hazardous waste, and tires. Oil refineries can be substantial emitters of SO_2, organic and elemental carbon particulates, VOC's, and NO_x. The oil refinery source samples will assisting in distinguishing these sources from motor vehicle and other combustions sources. The cooking source profiles will be added to an existing library of food preparation profiles that already include hamburger, steak, and chicken cooking sources.

Emissions Inventory

A comprehensive emissions inventory (EI) was compiled for air pollution sources within the BRAVO study domain (Texas, New Mexico, Oklahoma, Arkansas, Louisiana, and sources in Mexico north of Mexico City). The emissions inventory database is spatially resolved in order to identify the location and density of sources. The inventory documents emissions of SO_2, NO_X, PM_{10}, and VOC's. Data for the were compiled from the following list of data providers: Texas Natural Resource Conservation Commission (TNRCC); Minerals Management Service: Environmental Protection Agency: AIRS Facility Subsystem, National Emissions Trends Database, Continuous Emissions Monitors, and Atmospheric Modeling Division; Western Governor's Association; Instituto Nacional de Ecologia (INE); National Interagency Fire Center.

All emissions data were be processed into a spatially and (where possible) temporally resolved database. When inventories were redundant (i.e. point sources in Texas are listed in both the TNRCC EI and the AFS EI), a judgment was made to use data from the source that originally collected the data. The database lists each pollution source along with the data provider so that all data may be traced backed to its source. The EI will be in a format that can be gridded for use as input for dispersion models.

Quality Assurance

The major purpose of independent quality assurance in BRAVO is to verify the adequacy of the participants' measurement and quality control procedures, and to identify problems and apprise project management. At the beginning of the study, senior auditors reviewed study design documents to ensure that all measurements were being planned to produce data with known precision and accuracy. The auditors focused on verifying that adequate communications exist between measurement and data analysis groups to ensure that measurements will meet data analysis requirements for precision, accuracy, detection limits, and temporal resolution. Field performance and system audits were conducted at each of the BRAVO monitoring sites. Measurement systems audited at the majority of sites included aerosol sampling using the IMPROVE sampler and tracer sampling using the Brookhaven BATS sampler. Performance audits will include flow rate checks of the IMPROVE sampler and checks of the various settings on the BATS sampler. System audits evaluate the adequacy of project components such as Standard Operating Procedures, measurement documentation, operator training, quality control checks, and sample chain of custody.

In addition to the IMPROVE and BATS sampler audits, system and performance audits of additional special measurements were conducted at the Big Bend K-Bar site. System audits were conducted on the radar profiler/RASS systems at K-Bar and at several other sites in Texas. Field system audits were conducted at each of the BRAVO tracer release sites in Texas. A laboratory system audit was conducted at Brookhaven National Laboratory (tracer analysis), and additional system audits were conducted at UC Davis (elemental analysis) and Desert Research Institute (carbon). A system audit will be conducted on-site at the BRAVO central data management center (DRI- Las Vegas). The audit will evaluate the adequacy of project components such as

communications between the study participants and the data manager, calculation procedures, handling of quality control test data, data archiving procedures, data base security, and data validation procedures.

ASSESSMENT APPROACHES

Assessment includes all systematic uses of data and other information to meet the BRAVO Study objectives. Some of the assessment methods provide results that directly address one or more of the study objectives, while others provide information useful or required as intermediate results in the overall process of assessment. A major product of the BRAVO Study is the development of a conceptual model of the important physical and chemical processes that are responsible for haze conditions in Big Bend National Park. The conceptual model is a plausible descriptive explanation of the causes of impairment that is supported by the measurement data. It includes the identification of the important sources (i.e., individual major sources, source types, and source areas), and a description of the meteorological conditions under which these sources contribute to Big Bend haze.

Assessment approaches for BRAVO can be divided into 5 major categories: descriptive analysis, association analysis, study period representativeness, source attribution, and reconciliation of results. Descriptive analysis includes a summarization of the data collected. Several purposes are served by descriptive analysis including data quality assurance and validation, data familiarity, and a means of testing the plausibility of some aspects of prospective conceptual models. An example of descriptive data analysis is summarizing temporal and spatial patterns of aerosol concentration.

Association analyses are similar to descriptive analyses except that more than one parameter is considered at a time. Like descriptive analysis, association analysis is an important step in data quality assurance and validation, promotes data familiarity, and is a means to test conceptual models. In addition association analysis allows precision (and other quality descriptors) to be directly determined from collocated measurement, permits assessment of aerosol and optical closure at some of the more complete monitoring sites, and may reveal insightful relationships concerning the conditions associated with and causes of haze. The following are the principal closure exercises for the BRAVO Study:

- Fine mass closure – compare the sum major of measured species combined with the mass of the assumed common oxides and other non-measured components (ammonium ion for sulfate and nitrates, etc.) with the gravimetric fine mass;
- Optical closure – compare the sum of the measured light scattering and light absorption with the total measured light extinction; and
- Extinction budget – compare the sum of the calculated extinction for the major aerosol components (component concentration multiplied by an extinction efficiency that may be a function of relative humidity) with the measured total light extinction.

In order to know how applicable BRAVO Study results are to other periods of times (other times of the year and other years), the representativeness of the study period must be determined. The approach used to determine representativeness of the study period starts by comparing meteorological and air quality data during the study period with similar data for other times during the year and for the same period of time in previous years. Simple statistical tests and comparisons of frequency distribution plots for the study period and other periods show the degree of similarity of the study period is to those other period for each parameter.

Attribution analyses are quantitative assessments of the contributions by important sources. Attribution methods are typically divided into two broad categories: predictive air quality models and receptor models. Air quality models use meteorological measurements, pollutant emissions data, and calculated or assumed boundary conditions to calculate the transport, dispersion, deposition and chemical transformation of pollutants emitted into the atmosphere at specific known emission source locations. Receptor models rely on the ambient air quality measurements made at monitoring site and the characteristics of the likely emission sources to infer the contribution of those sources.

One of the design strengths of the BRAVO Study is the planned use of multiple attribution analyses methods. Comparisons of results from various attribution methods that utilize different assumptions and data sets can provide insights not otherwise achievable by any single attribution method. If the results tend to agree, credibility is enhanced. If they are inconsistent, a reconciliation process is applied which may uncover inappropriate model assumptions or questionable input data, or in the worst case be used to determine a suitable range of uncertainty for the study findings.

Of the various attribution methods that will be applied, only regional air quality modeling can be used to address all of the important emission sources in the region for any time period, including times outside of the BRAVO Study period. A major product of the study is the evaluation, and fine-tuning (if needed) of a regional air quality model for uniform application to all of the important emission sources in the region. The reconciliation process will determine if air quality modeling produces results that are consistent with the best of the other methods and if not whether they can be made more consistent by modifying the assumptions within acceptable ranges or changing which input data are utilized. The best of the regional air quality models that are evaluated in the BRAVO Study will be applied to all of the important emission sources as a means to ensure consistent evaluation of each source's contribution to haze at Big Bend.

The following is a list of attribution related techniques that are likely to be used for BRAVO:

- Tracer scaling[8]
- Receptor Model Applied to Pattern in Space (RMAPS)[9]
- Tracer regression[10]
- Differential Mass Balance regression (DMBR)[11]
- Tracer-Aerosol Gradient Interpretive Technique (TAGIT)[12]
- Chemical Mass Balance (CMB)
- Artificial neural networks[13]
- Trajectory analysis
- Meteorological modeling with MM5
- Eulerian grid air quality modeling (specific models not yet determined) using emissions inventory and MM5 meteorological fields

A portion of the perfluorocarbon tracer data will be initially withheld to allow independent development and testing of the attribution models. The models will then be evaluated using the remaining tracer data. This evaluation will be useful in the reconciliation process, which will judge the credibility of the competing attribution analyses. It is likely that multiple attribution techniques will have similarly credible results. In this case, a range of results spanning the high and low attribution among credible models will be presented.

CONCLUSION

BRAVO is a major field and data analysis study being conducted to help determine the causes of visibility impairment in Big Bend National Park in Texas. The field measurement portion of the study was from July through October 1999. The study included tracer release from multiple locations and aerosol sampling at many locations in Texas, including along the border with Mexico. Many intensive specialized measurements were also conducted at Big Bend National Park. Data analysis and modeling efforts are ongoing. A final study report is expected in 2001.

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Appendix Z

Nonair Ecological Impacts of Emissions from BART-Eligible Sources: Acid Deposition, Nitrogen Saturation, and Ozone Exposure.

Emissions from BART-eligible facilities contribute significantly to the problems of acid rain, nitrogen saturation in forests and coastal waters, and declining tree growth due to increased ozone exposure. Appropriately, the BART guidelines, as proposed, will considerably reduce the emission and deposition of sulfur and nitrogen. These reductions will benefit freshwater, estuarine, and terrestrial environments throughout the country, including many in class I areas. Such areas face the following challenges:

1. Acid Rain

It is increasingly well documented that the problem of acid rain has not been solved. Over 150 years of deposition of sulfur and nitrogen has taken a serious toll on ecosystems. Although sulfur emissions have declined in recent years, they remain very high when compared to historic levels, and nitrogen levels have not fallen.

The result of this legacy of deposition is that forests and waters, particularly in the eastern US are still suffering from the negative impacts of deposition of acidic compounds. Without more reductions, sensitive forests and aquatic systems will not recover.

In streams and lakes, through a combination of increasing acidity either permanently or in short bursts, mobilizing aluminum and depleting plant nutrients, acidic deposition has resulted in a loss in fish species and fish species diversity throughout eastern North America. By leaching nutrients from forest soils, releasing toxic aluminum and through direct impact on foliage, acidic deposition causes mortality and growth reductions in red spruce and sugar maple, and there is evidence that other tree species are also being harmed.

Some specific problems that are documented to be associated with acidic deposition are:

> Preliminary work suggests that episodic acid deposition has contributed to the decline of Atlantic salmon in Maine, with this periodic acidification having the greatest impact on smolts and fry.[i]
>
> Forty one percent of lakes in the Adirondack region of New York and 15 percent of lakes in New England are either chronically or periodically acidic. Nearly 25 percent of surveyed lakes in the Adirondacks do not support any fish, and many others have less aquatic life and reduced species diversity when compared to less acidic lakes.[ii] Acid rain is the major cause of red spruce mortality in New York.[iii]
>
> Reduction in fish diversity in northwest Pennsylvania is linked to aluminum leaching from acid rain. Comparison of fish data collected in the Allegheny

Plateau and Ridge and Valley region 40 years ago to data collected in the mid 1990s found an overall decrease in species diversity, with the most dramatic declines occurring in five species of non-game, acid-sensitive fish. Streams that experienced a loss of species had greater increases in acidity and more episodic acidification than streams that either gained or had no change in species.[iv] In the same area, acid rain has been associated with poor sugar maple and red oak regeneration as well as deterioration of tree health and excessive mortality in mature trees of both species.[v]

The West Virginia Department of Natural Resources has identified hundreds of miles of streams that are chronically acidic and is currently liming 60 streams to offset the damage from acidic deposition.

Episodic acidification is “ubiquitous” in Shenandoah National Park streams, and chronic acidification of surface water is also a serious concern. Values of pH as low as 5.0 are common in these streams.[vi] In spring, 2001, Paine Run River was placed on the American River’s Most Endangered list because, without further cuts in air pollution, it will become too acidic to sustain populations of brook trout and other aquatic organisms. Thirty percent of trout streams in Virginia are either chronically (6%) or episodically (24%) acidic and therefore either marginal or unsuitable for acid-tolerant brook trout.[vii] By the time acid-tolerant species are affected, there are many acid-sensitive species that are no longer productive.

Great Smoky Mountains streams are very sensitive to acidic deposition. The sensitivity of these sites has emerged later than was observed in the Northeast, suggesting that it took longer to leach out agents that were able to buffer sensitive sites from acidity. Many high elevation streams are currently acidic.[viii] Acidic deposition is also causing forest soils to experience chemical imbalances that are contributing to tree stress.[ix,x]

Many soils in the Southeast are already nutrient-poor. Human intervention, and in particular the chronic loading of sulfate and nitrate from acidic deposition, has made already calcium-poor soils more calcium deficient. Analyses at forest sites in the southeastern US suggest that within 80 to 150 years, soil calcium reserves will not be adequate to supply the nutrients needed to support the growth of merchantable timber.[xi]

In the Colorada Rockies, the ability of some lakes to neutralize acidity has been diminished since the mid 1980s.[xii]

Because pollutants cross borders, there is documented damage in Canada as well. Atlantic salmon habitat in Nova Scotia rivers has been seriously reduced by increased acidity. A study of 49 rivers that historically supported salmon found populations to be extinct in 14 rivers and severely impacted in 20. Loss of salmon is correlated with increased acidity.[xiii] Sensitive watersheds, located primarily in central Ontario and Quebec, have not responded to reductions in sulfate

deposition as well or as rapidly as those in less-sensitive regions. At the current sulfur deposition levels (20 kg wet sulfate/ha/yr), roughly 95,000 lakes will continue to be damaged by acid deposition. Lakes continue to acidify despite reductions in sulfur deposition.[xiv] Modeling found that after full implementation of CAAA cuts and Air Quality agreements that 76,000 lakes in southeastern Canada will remain damaged, that is have a pH below 6.[xv]

A continuing decline in soil nutrients, due to acidic deposition, is occurring in forest ecosystems in Ontario and Quebec. In Ontario, levels of acidic deposition are accelerating the loss of base cations and essential nutrients from soils that support sugar maple dominated hardwood forests. In Quebec, studies have shown the nutrient status of sugar maple seedlings declined as soil acidification levels and soil base saturation decreased. At current deposition levels, these effects will likely be sustained or increased. With sustained soil nutrient loss, not only will nutrient uptake by tree roots be reduced, but also forest ecosystem productivity will decline.[xvi]

2. Nitrogen Saturation in Forests and in Coastal Waters

While many ecosystems in the United States continue to be nitrogen-limited, there are more and more areas in the country where sites are exhibiting symptoms of nitrogen excess. Too much nitrogen is a serious problem for a number of reasons. It disrupts plant/soil nutrient relationships, promotes soil acidification and toxic aluminum mobility,

alters microbial activity in soils, degrades surface and ground water quality, has a toxic effect on aquatic biota and results in eutrophication of coastal and estuarine waters.[xvii]

In estuarine systems, this over fertilization has resulted in blooms of algae and seaweed that rob the waters and fish of oxygen. Under these conditions, there is a loss of natural habitat and declines in the abundance of commercially and ecologically valuable plants and aquatic species. It is now clear that atmospheric deposition is a major contributor to the nitrogen that is over-fertilizing our coastal waters. Authors of a National Research Council report published last year estimate that atmospheric deposition can be responsible for as much as 40 percent of the nitrogen entering coastal waters.[xviii] Power plants can be a significant contributor to this nitrogen burden. Chesapeake and Pamlico Bays have among the highest power plant nitrogen contributions – accounting for nearly 10 percent of atmospheric nitrogen – of 40 estuaries studied on the East Coast.[xix]

In forests, when trees are unable to use the excess nitrogen, nitrogen saturation occurs. At its worst, nitrogen saturation contributes to tree mortality and degrades surface water quality. In the eastern United States, nitrogen-saturated forests have been documented in the Adirondacks, Catskills, and Whitetop Mountain in Virginia, Fernow Experimental Forest in West Virginia and at a number of sites in the Great Smoky Mountains National Park.[xx]

Nitrogen deposition has almost doubled in the Front Range of the Colorado Rockies in the past 15 years, resulting in nitrogen saturation at some watersheds. This elevated nitrogen appears to be a contributing factor in the changes in lake diatom community composition.[xxi]

3. Ozone Exposure

Unlike humans who are more affected by peaks in ozone, plants are harmed by the cumulative impact of day-to-day ambient exposures. This means the national ambient air quality standards set to protect human health do not protect plants. Recent field work in the United Kingdom has corroborated earlier work by the US National Crop Loss Assessment Network that predicted that ozone is costing the US agricultural industry up to a billion dollars each year is yield reductions from commodity crops.[xxii]

Assessments of the extent and magnitude of the effects of ambient ozone on tree species in the eastern United States are as high as 33 percent annual biomass loss, depending on species and ozone concentrations. Loss is predicted to be greatest and substantial among sensitive species – black cherry, aspen, tulip poplar, loblolly pine, sugar maple and eastern white pine. Research suggests that trees may be more sensitive to cumulative ozone exposure than crops.[xxiii]

Based on ambient levels of ozone measured in the Northeast from 1987 to 1992, models have shown a decline in total growth (wood, leaves, roots) ranging from 17

percent in areas of highest concentration (southern New York and southern New England) to two percent in areas of lowest concentration (northern Maine). Researchers hypothesized that if they only had measured wood growth that the impacts would be even higher, since wood production is a lower priority for ozone-stressed trees.[xxiv]

Ozone-induced foliar injury has been observed on a number of species in Shenandoah and Great Smoky Mountains NPs since the early 1980s. In the Great Smoky Mountains, fumigation studies showed that in addition to foliar injury, ozone concentrations typical of higher elevations in the park are sufficient to cause biomass loss in sensitive species. [xxv] National Park Service data shows ozone concentrations increasing in both parks – but particularly in the Smokies – in the last decade.[xxvi]

The US Forest Service is conducting research on effects of ozone on vegetation in North Carolina. North Carolina has adopted the 0.08 ppm eight hour ozone standard. At this standard, there are high elevation sites in western North Carolina that are in non-attainment for ozone. Preliminary US Forest Service modeling work is showing tree growth reductions of sensitive species of 10 percent in areas of nonattainment.[xxvii]

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APPENDIX B

National Park Service, GPRA 2003 Visibility Dataset

APPENDIX B:

NPS GPRA 2003 Visibility Dataset

10 year period: 1993-2002

site	short_name	dv10beta	dv10prob	dv90beta	dv90prob	NO3beta	NO3prob	SO4beta	SO4prob	o3beta	o3prob	fail	pass	total_pass	percent_pass	gpra_year
ACA2	Acadia									0.32	0.28					2003
ACAD	Acadia	-0.23	0.00	-0.26	0.02	0.12	0.36	-0.34	0.19	0.56	0.30	0	1	1	100.0	2003
BADL	Badlands	-0.08	0.15	-0.14	0.08							0	1	2	100.0	2003
BAND	Bandelier	-0.05	0.15	0.02	0.24	1.01	0.01	0.28	0.18			1	0	2	66.7	2003
BIBE	Big Bend	-0.07	0.45	0.14	0.09	-0.20	0.24	-0.75	0.31	-0.21	0.20	1	0	2	50.0	2003
BRCA	Bryce Canyon	-0.08	0.08	0.03	0.30	0.63	0.07	-0.35	0.28			1	0	2	40.0	2003
BUFF	Buffalo					-0.06	0.36	-0.47	0.04			0	1	3	50.0	2003
CACO	Cape Cod									0.19	0.19	0	1	4	57.1	2003
CANY	Canyonlands	-0.11	0.08	-0.05	0.43					0.39	0.05	1	0	4	50.0	2003
CAVO	Capulin Volcano					0.55	0.28	-0.06	0.50			0	1	5	55.6	2003
CHAM	Chamizal									1.81	0.02	1	0	5	50.0	2003
CHIR	Chiricahua	-0.06	0.05	0.04	0.50					0.05	0.46	0	1	6	54.5	2003
CHIS	Channel Islands									-0.58	0.19	0	1	7	58.3	2003
COSW	Congaree Swamp									1.27	0.04	1	0	7	53.8	2003
COWP	Cowpens									0.45	0.43	0	1	8	57.1	2003
CRLA	Crater Lake	-0.15	0.07	0.24	0.28							0	1	9	60.0	2003
CRMO	Craters of the Moon					0.27	0.24	-0.10	0.50	0.38	0.15	1	0	9	56.3	2003
DENA	Denali	-0.18	0.00	-0.08	0.30	0.09	0.19	0.08	0.50	0.30	0.01	1	0	9	52.9	2003
DEVA	Death Valley									-0.06	0.45	0	1	10	55.6	2003
EVER	Everglades					0.05	0.45	-0.10	0.36	0.10	0.46	0	1	11	57.9	2003
GICL	Gila Cliff	-0.13	0.19	-0.19	0.19	1.00	0.00	0.12	0.38			1	0	11	55.0	2003
GLAC	Glacier	-0.21	0.01	0.03	0.38	0.14	0.15	-0.22	0.04	0.16	0.50	1	0	11	52.4	2003
GRBA	Great Basin	-0.08	0.11	0.09	0.24	0.09	0.39	-0.29	0.19	0.37	0.13	1	0	11	50.0	2003
GRCA	Grand Canyon	-0.13	0.20	0.01	0.27	0.82	0.09	0.20	0.14	0.60	0.05	1	0	11	47.8	2003
GRSA	Great Sand Dunes	0.06	0.08	0.15	0.11							1	0	11	45.8	2003
GRSM	Great Smoky Mtns	-0.04	0.36	-0.17	0.02	-0.07	0.43	-0.07	0.50	0.46	0.31	0	1	12	48.0	2003
GSCC	Great Smoky Mtns									0.78	0.13					2003
GSCD	Great Smoky Mtns									1.49	0.04					2003
GSCM	Great Smoky Mtns									0.75	0.08					2003
GUMO	Guadalupe Mtns	-0.11	0.02	0.31	0.00	0.41	0.04	0.37	0.24			1	0	12	46.2	2003
INDU	Indiana Dunes					-0.44	0.15	-1.75	0.01			0	1	13	48.1	2003
ISRO	Isle Royale					-0.15	0.18	-0.32	0.18			0	1	14	50.0	2003
JOTR	Joshua Tree									-2.48	0.02	0	1	15	51.7	2003

LAVO	Lassen Volcanic	-0.16	0.01	0.29	0.19				0.29	0.30	0	1	16	53.3	2003
LIBI	Little Bighorn					0.41	0.04	-0.17	0.15		1	0	16	51.6	2003
MACA	Mammoth Cave	0.01	0.45	-0.17	0.02				0.44	0.08	1	0	16	50.0	2003
MEVE	Mesa Verde	-0.03	0.38	0.13	0.04	0.81	0.05	-0.18	0.24	0.91	0.01	1	0	16	48.5	2003
MORA	Mount Rainier	-0.21	0.01	-0.31	0.00	0.04	0.27	0.26	0.20	-0.59	0.19	0	1	17	50.0	2003
NOCA	North Cascades					0.09	0.31	-0.06	0.46	1.01	0.39	0	1	18	51.4	2003
OLYM	Olympic					-0.04	0.09	0.04	0.36	-0.25	0.30	0	1	19	52.8	2003
ORPI	Organ Pipe					1.67	0.01	0.67	0.13			1	0	19	51.4	2003
PEFO	Petrified Forest	0.00	0.50	0.14	0.05							1	0	19	50.0	2003
PINN	Pinnacles	-0.01	0.55	0.00	0.55					-0.07	0.50	0	1	20	51.3	2003
PORE	Point Reyes	0.11	0.36	-0.53	0.23							0	1	21	52.5	2003
REDW	Redwood	-0.16	0.01	0.02	0.50							0	1	22	53.7	2003
ROM2	Rocky Mountain					0.44	0.12	-0.23	0.07							2003
ROMO	Rocky Mountain	-0.19	0.01	0.10	0.15	0.63	0.04	-0.12	0.43	0.26	0.36	1	0	22	52.4	2003
SAGU	Saguaro									-0.86	0.00	0	1	23	53.5	2003
SELP	Sequoia									1.36	0.07					2003
SEQU	Sequoia	0.06	0.50	-0.34	0.14	-0.30	0.28	-0.21	0.19	-0.29	0.43	0	1	24	54.5	2003
SHEN	Shenandoah	-0.13	0.31	-0.38	0.04	0.10	0.27	-0.21	0.36	0.22	0.30	0	1	25	55.6	2003
THRO	Theodore Roosevelt									0.16	0.13					2003
TONT	Tonto	-0.04	0.45	0.05	0.27							0	1	26	56.5	2003
VOYA	Voyageurs									0.50	0.15	1	0	26	55.3	2003
WASH	Washington	-0.32	0.09	-0.24	0.04							0	1	27	56.3	2003
YELL	Yellowstone	-0.14	0.02	0.06	0.46	0.31	0.08	-0.10	0.50	0.79	0.01	1	0	27	55.1	2003
YOSE	Yosemite	-0.08	0.11	0.15	0.11	0.13	0.46	0.19	0.24	-0.29	0.38	1	0	27	54.0	2003
												23	27			

APPENDIX C

Class I Areas Not Evaluated by EPA in its "Better than BART" Analysis for the Proposed CAIR

APPENDIX C:

Class I Areas Not Evaluated by EPA in its "Better than BART" Analysis for the Proposed CAIR

Name	CAIR Modeling?	STATE	CATEGORY	CAIR State?	Within 200 km
Boundary Waters Canoe Area	No	MN	USFS	Yes	Yes
Bradwell Bay Wilderness	No	FL	USFS	Yes	Yes
Breton	No	LA	F&WS	Yes	Yes
Caney Creek Wilderness	No	AR	USFS	Yes	Yes
Cohutta Wilderness	No	GA	USFS	Yes	Yes
Edwin B Forsyth NWR	No	NJ	F&WS	Yes	Yes
Everglades NP	No	FL	NPS	Yes	Yes
Hercules-Glades Wilderness	No	MO	USFS	Yes	Yes
Isle Royale NP	No	MI	NPS	Yes	Yes
Joyce-Kilmer-Slickrock Wilderness	No	TN	USFS	Yes	Yes
Linville Gorge Wilderness	No	NC	USFS	Yes	Yes
Mingo	No	MO	F&WS	Yes	Yes
Rainbow Lake Wilderness	No	WI	USFS	Yes	Yes
Seney	No	MI	F&WS	Yes	Yes
St. Marks	No	FL	F&WS	Yes	Yes
Swanquarter	No	NC	F&WS	Yes	Yes
Voyageurs NP	No	MN	NPS	Yes	Yes
Wolf Island	No	GA	F&WS	Yes	Yes
Agua Tibia Wilderness	No	CA	USFS	No	
Alpine Lake Wilderness	No	WA	USFS	No	
Anaconda-Pintler Wilderness	No	MT	USFS	No	
Arches NP	No	UT	NPS	No	
Black Canyon of the Gunnison NM	No	CO	NPS	No	
Bob Marshall Wilderness	No	MT	USFS	No	
Bosque del Apache	No	NM	F&WS	No	Yes/Barely
Cabinet Mountains Wilderness	No	MT	USFS	No	
Capitol Reef NP	No	UT	NPS	No	
Caribou Wilderness	No	CA	USFS	No	
Carlsbad Caverns NP	No	NM	NPS	No	
Craters of the Moon NM	No	ID	NPS	No	
Cucamonga Wilderness	No	CA	USFS	No	
Desolation Wilderness	No	CA	USFS	No	
Diamond Peak Wilderness	No	OR	USFS	No	
Dome Land Wilderness	No	CA	USFS	No	
Eagle Cap Wilderness	No	OR	USFS	No	
Eagles Nest Wilderness	No	CO	USFS	No	
Emigrant Wilderness	No	CA	USFS	No	
Fitzpatrick Wilderness	No	WY	USFS	No	
Flat Tops Wilderness	No	CO	USFS	No	
Galiuro Wilderness	No	AZ	USFS	No	
Gates of the Mountains Wilderness	No	MT	USFS	No	
Gearhart Mountain Wilderness	No	OR	USFS	No	
Glacier NP	No	MT	NPS	No	
Glacier Peak Wilderness	No	WA	USFS	No	
Goat Rocks Wilderness	No	WA	USFS	No	

Grand Teton NP	No	WY	NPS	No	
Great Gulf Wilderness	No	NH	USFS	No	Yes
Hells Canyon Wilderness	No	ID	USFS	No	
Hoover Wilderness	No	CA	USFS	No	
John Muir Wilderness	No	CA	USFS	No	
Joshua Tree NM	No	CA	NPS	No	
Kaiser Wilderness	No	CA	USFS	No	
Kalmiopsis Wilderness	No	OR	USFS	No	
Kings Canyon NP	No	CA	NPS	No	
La Garita Wilderness	No	CO	USFS	No	
Lava Beds NM	No	CA	NPS	No	
Lostwood	No	ND	F&WS	No	
Marble Mountain Wilderness	No	CA	USFS	No	
Maroon Bells-Snowmass Wilderness	No	CO	USFS	No	
Mazatzal Wilderness	No	AZ	USFS	No	
Medicine Lake	No	MT	F&WS	No	
Minarets Wilderness	No	CA	USFS	No	
Mission Mountains Wilderness	No	MT	USFS	No	
Mokelumne Wilderness	No	CA	USFS	No	
Mount Adams Wilderness	No	WA	USFS	No	
Mount Baldy Wilderness	No	AZ	USFS	No	
Mount Hood Wilderness	No	OR	USFS	No	
Mount Jefferson Wilderness	No	OR	USFS	No	
Mount Washington Wilderness	No	OR	USFS	No	
Mountain Lakes Wilderness	No	OR	USFS	No	
North Absaroka Wilderness	No	WY	USFS	No	
North Cascades NP	No	WA	NPS	No	
Olympic NP	No	WA	NPS	No	
Pasayten Wilderness	No	WA	USFS	No	
Pecos Wilderness	No	NM	USFS	No	
Pine Mountain Wilderness	No	AZ	USFS	No	
Presidential Range-Dry River Wilderness	No	NH	USFS	No	Yes
Rawah Wilderness	No	CO	USFS	No	
Red Rock Lakes	No	MT	F&WS	No	
Rocky Mountain NP	No	CO	NPS	No	
Roosevelt Campobello International	No	ME	NPS	No	
Saguaro NM	No	AZ	NPS	No	
Salt Creek	No	NM	F&WS	No	Yes/Barely
San Gabriel Wilderness	No	CA	USFS	No	
San Jacinto Wilderness	No	CA	USFS	No	
San Pedro Parks Wilderness	No	AZ	USFS	No	
San Rafael Wilderness	No	CA	USFS	No	
Sawtooth Wilderness	No	ID	USFS	No	
Scapegoat Wilderness	No	MT	USFS	No	
Selway-Bitterroot Wilderness	No	ID	USFS	No	
Sierra Ancha Wilderness	No	AZ	USFS	No	
South Warner Wilderness	No	CA	USFS	No	
Strawberry Mountain Wilderness	No	OR	USFS	No	
Superstition Wilderness	No	AZ	USFS	No	
Sycamore Canyon Wilderness	No	AZ	USFS	No	
Teton Wilderness	No	WY	USFS	No	
Theodore Roosevelt NP	No	ND	NPS	No	

Thousand Lakes Wilderness	No	CA	USFS	No	
Three Sisters Wilderness	No	OR	USFS	No	
UL Bend	No	MT	F&WS	No	
Ventana Wilderness	No	CA	USFS	No	
Washakie Wilderness	No	WY	USFS	No	
West Elk Wilderness	No	CO	USFS	No	
Wheeler Peak Wilderness	No	NM	USFS	No	
White Mountain Wilderness	No	NM	USFS	No	Yes
Wichita Mountains	No	OK	F&WS	No	Yes
Wind Cave NP	No	ND	NPS	No	
Yellowstone NP	No	WY	NPS	No	
Yolla Bolly Middle Eel Wilderness	No	CA	USFS	No	
Zion NP	No	UT	NPS	No	

APPENDIX D

Emission Reductions Under BART As Compared to CAIR

APPENDIX D

MSB Energy Associates, Incorporated

7507 Hubbard Ave. • Suite 200 • Middleton, WI • 53562-3135
608/831-1127 • Fax 608/836-1290

Emission Reductions Under BART As Compared to CAIR

A. SO2

We compared the projected SO2 reductions forecasted by the EPA for the Clean Air Interstate Rule (CAIR) with the potential SO2 reductions from the additional implementation of the best available retrofit technology (BART) standard. For the CAIR case we used the IPM modeling prepared by EPA to support its interstate air quality proposal.[1] The comparison of the CAIR case and the CAIR/BART case is limited to emissions from electric generating units in the CAIR region.

1. BART-Eligible Units Under CAIR

There are 251 electric generating units in the CAIR region that are BART-eligible. In 2002, these units emitted 5.0 million tons of SO2. Of these units, 54 are currently scrubbed. Under the EPA's modeling of CAIR in 2015, 108 units are scrubbed, 1 unit is repowered, and 142 are left unscrubbed. According to the IPM modeling of CAIR, these BART-eligible units will emit 2.0 million tons of SO2 in 2015 – a reduction of 3 million tons as compared to 2002.

2. BART Eligible Units Under BART

In order to determine the impact of BART implementation, we assumed that under the BART rules the 142 unscrubbed units would be required to add scrubbers which would remove 95% of the SO2. Units which are currently scrubbed would be left unchanged, even if the current level of scrubbing is low. The application of BART controls would result in SO2 emissions in 2015 of 500,000 tons – a reduction of 4.5 million tons as compared to 2002. The full results of these changes are shown in Table 1 below.

[1] When EPA conducted the IPM modeling run, the proposed regulatory program was known by its original name: the "Interstate Air Quality Rule." For the sake of simplicity, we will refer to the program throughout this memo by its new name: the "Clean Air Implementation Rule" or "CAIR."

3. Non-BART Units

Under the CAIR proposal, many of the non-BART units also reduce their emissions. In 2002 the non-BART eligible units emitted about 4.4 million tons of SO2. Under the CAIR modeling, the non-BART plants in the CAIR region would emit 2.8 million tons of SO2. This is a reduction of 1.6 million tons compared to 2002 for non-BART units.

An important question is whether, under a combination of BART and CAIR, the non-BART eligible units would continue to reduce their emissions by 1.6 million tons, or whether instead the reductions at these plants will be less. If full trading between BART and non-BART units is allowed, there is a good chance that the non-BART reductions in SO2 will be much less. If trading of allowances from BART sources is not allowed, then the non-BART reductions may well be the same as modeled under CAIR.

Table 1. SO2 Emissions Under BART and CAIR in the CAIR Region

2002 Emissions – 9.4 million tons
BART-Eligible Units – 5.0 million tons
Non-BART Units – 4.4 million tons

2015 Emissions Under CAIR Modeling – 4.8 million tons
BART-Eligible Units – 2.0 million tons
Non-BART Units – 2.8 million tons

Reductions from 2002 – 4.6 million tons

2015 Emissions Under Both CAIR and BART (CAIR/BART) – 3.3 million tons
BART-Eligible Units – 0.5 million tons
Non-BART Units – 2.8 million tons

Reductions from 2002 – 6.1 million tons
Additional Reductions As Compared to CAIR Only – 1.5 million tons

B. NOx

We compared the projected NOx reductions forecasted by the EPA for the CAIR case with the potential NOx reductions from the additional implementation of BART. For the CAIR case we used the IPM modeling prepared by EPA to support its original interstate air quality proposal. As noted above, the comparison of the CAIR case and the CAIR/BART case is limited to emissions from electric generating units in the CAIR region.

1. BART-Eligible Units Under CAIR

In 2002, the 251 BART-eligible units in the CAIR region emitted 1.8 million tons of NOx. Of these units, 12 currently have SCRs. Under the EPA's modeling of CAIR in 2015, 139 units have SCRs, 1 is repowered, and 111 are left without SCRs. According to the IPM modeling of CAIR, these BART eligible units emit 500,000 tons of NOx in 2015, a reduction of 1.3 million tons compared to 2002.

2. BART Eligible Units Under BART

The appropriate level of NOx emission reduction to use for modeling BART is uncertain. There are several ways in which it can be envisioned. BART could require SCRs on all designated units. That could reduce NOx emissions at those units by 80-85% or more. As an alternative, BART could specify an emission rate. Currently EPA is leaning towards that approach, with the rate specified being 0.20 lbs per MMBTU. We have looked at the implications of using that as the target BART emission rate. We have also looked at the implications of using a BART rate of 0.15 lbs per MMBTU, which is a readily achievable emission rate. Numerous coal plants currently achieve NOx emission rates better than 0.20 lbs per MMBTU, with a number of those achieving better than 0.15, many without using SCRs.

In order to determine the impact of BART implementation, we analyzed two cases. In each case the 111 units without SCRs under CAIR had their NOx emission rate reduced – in one case to 0.20 lbs per MMBTU and in the other case to 0.15 lbs per MMBTU. We did not address the option of requiring SCRs on BART eligible units, though that option could certainly qualify as BART. If the BART eligible units were required to meet a limit of 0.20 MMBTU, emissions of NOx in 2015 would decrease by 1.4 million tons as compared to 2002. If the same units meet a limit of 0.15 MMBTU, NOx emissions would decrease by 1.45 million tons. The full results of the analysis are shown in Table 2 below.

3. Non-BART Units

Under the CAIR proposal, many of the non-BART units will also reduce their emissions. The same question can be asked about NOx as SO2 -- under a combination of BART and CAIR, would the non-BART eligible units continue to reduce their emissions by the same amount, or would reductions at these plants be less? If full trading between BART and non-BART units is allowed, there is a good chance that the non-BART reductions in NOx will be much less. If trading of allowances from BART sources is not allowed, then the non-BART reductions will most likely remain unchanged.

Table 2. NOx Emissions Under BART and CAIR in the CAIR Region

2002 Emissions – 3.7 million tons

BART-Eligible Units – 1.8 million tons
Non-BART Units – 1.9 million tons

2015 Emissions Under CAIR Modeling – 1.5 million tons
BART Eligible Units – 0.5 million tons
Non-BART Units – 1.0 million tons

Reductions from 2002 – 2.2 million tons

2015 Emissions Under Both CAIR and BART (CAIR/BART) –
1.4 million tons at BART of 0.20 lbs per MMBTU
1.35 million tons at BART of 0.15 lbs per MMBTU
BART Eligible Units – 0.40 million tons at BART of 0.20 lbs per MMBTU
0.35 million tons at BART of 0.15 lbs per MMBTU
Non-BART Units – 1.0 million tons

Reductions from 2002 – 2.3 million tons at BART of 0.20 lbs per MMBTU
2.35 million tons at BART of 0.15 lbs per MMBTU
Additional Reductions As Compared to CAIR Only –
0.1 million tons at BART of 0.20 lbs per MMBTU
0.15 million tons at BART of 0.15 lbs per MMBTU