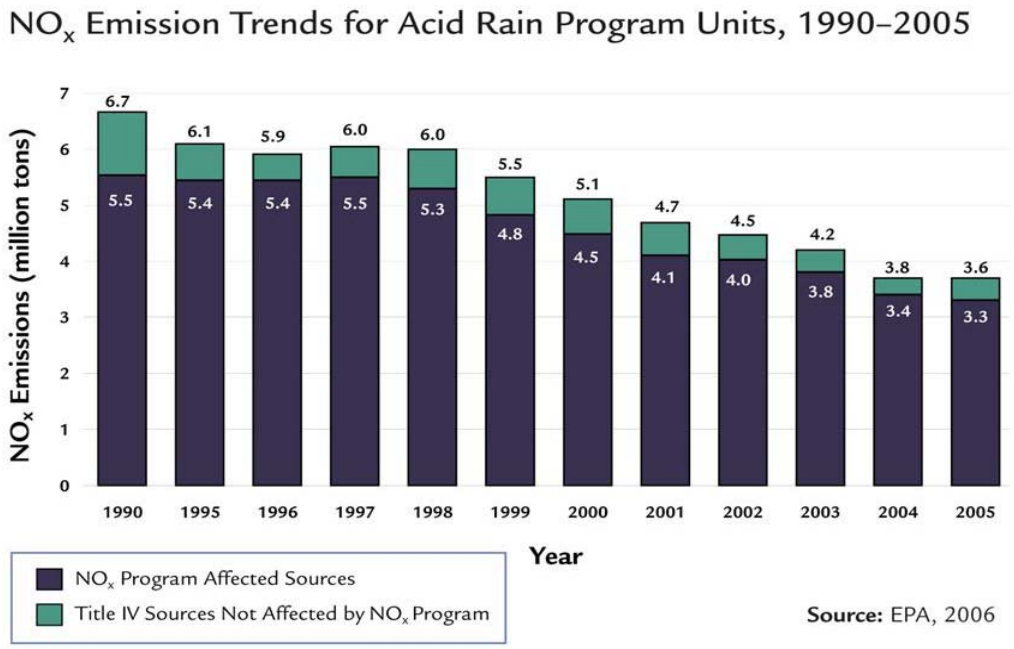
OAR Nitrogen Control and N-Related Programs Summary for SAB Integrated Nitrogen Committee

Office of Atmospheric Programs (OAP)

Acid Rain Program (ARP) — Congress established the ARP as part of the Clean Air Act Amendments of 1990. This annual, national program reduces sulfur dioxide (SO_2) from electric generating units through a cap and trade program. The ARP also reduces NO_x emissions from some of these units, but unlike the SO_2 portion of the ARP, there is no NO_x allowance trading or cap on NO_x emissions. Instead, the ARP NO_x provisions apply boiler-specific NO_x emission limits (lb/mmBtu) on certain coal-fired boilers that are subject to the SO_2 requirements of the ARP. NO_x limits under the ARP applied beginning in 1996 for some of the largest boilers subject to the SO_2 requirements; a second phase to reduce NO_x emissions from additional coal-fired generating units began in 2000. For more information, visit www.epa.gov/airmarkets/arp.



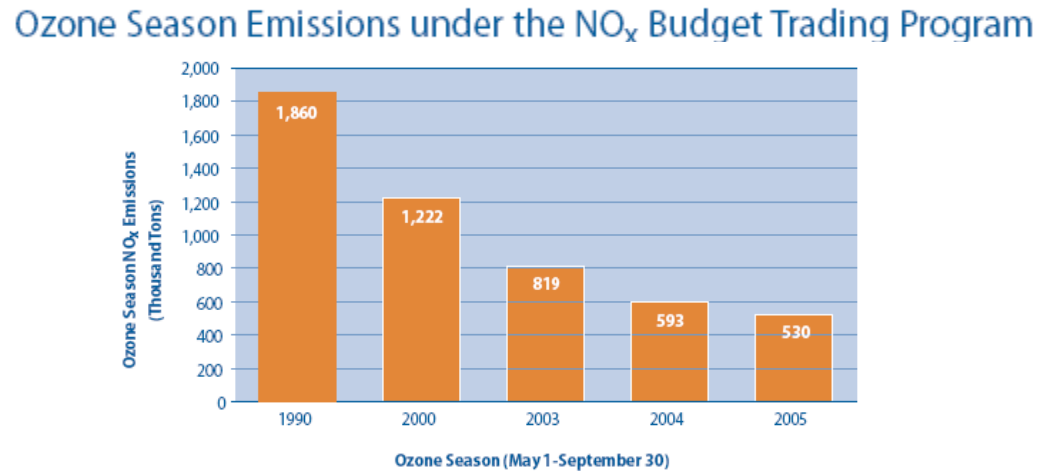
Note: Other programs such as the NOx SIP Call and the OTC NOx Budget Program, described below, as well as state laws also contribute to reductions, especially after 2000.

Ozone Transport Commission (OTC) NO_x Reduction Programs — The OTC was established under the 1990 Clean Air Act Amendments. States in the Northeast collaborated to help reduce summertime ground-level ozone in the region by achieving ozone season NO_x reductions in several phases. In 1995, sources were required to reduce their annual NO_x emission rates to meet Reasonably Available Control Technology (RACT) requirements. From 1999 to 2002, states achieved reductions in NO_x from fossil fuel-fired electric generating units and large industrial boilers and turbines through Phase I of an ozone season cap and trade program, known as the OTC NO_x Budget Program.

The second phase of the OTC NO_x Budget Program was slated to begin on May 1, 2003, but was superseded by EPA's NO_x State Implementation Plan Call (NO_x SIP Call). The OTC states include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Washington, D.C. (Maine, Vermont, and Virginia did not join the OTC trading program. New Hampshire is not subject to requirements of the NOx SIP Call). For more information on the OTC, visit www.epa.gov/airmarkets/otc.

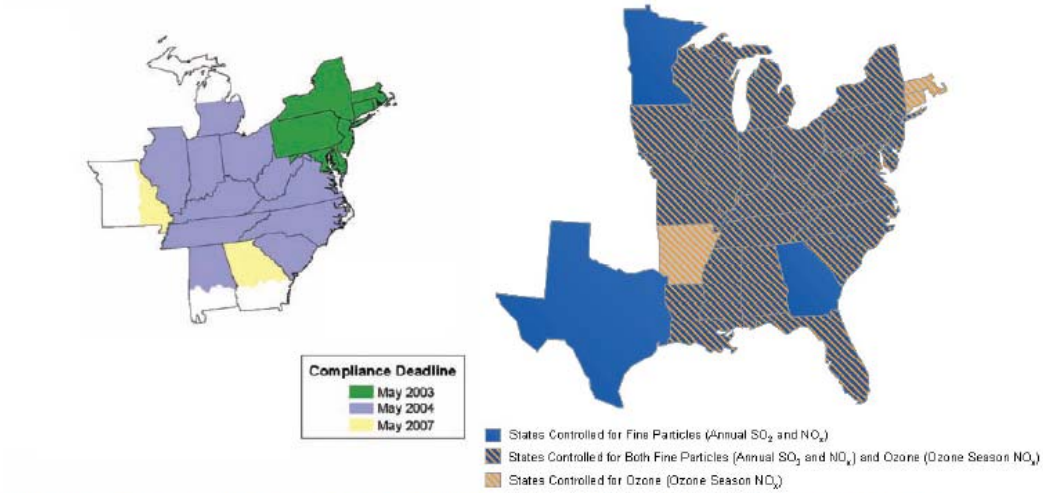
NO_x SIP Call and the NO_x Budget Trading Program (NBP) — In 1995, EPA and the Environmental Council of the States formed the Ozone Transport Assessment Group to begin addressing the problem of ozone transport across the entire eastern United States. Based on the group's findings and other technical analyses, EPA issued a regulation in 1998 to reduce the regional transport of ground-level ozone. This rule, commonly called the NO_x SIP Call, requires states to reduce ozone season NO_x emissions that contribute to ozone nonattainment in other states. The NO_x SIP Call does not mandate which sources must reduce emissions. Rather, it requires states to meet emission budgets and gives them flexibility to develop control strategies to meet those budgets.

Under the NO_x SIP Call, EPA developed the NBP to allow states to meet their emission budgets in a highly cost-effective manner through participation in a region-wide cap and trade program for electric generating units and large industrial boilers and turbines. All 19 affected states and the District of Columbia chose to meet their NO_x SIP Call requirements through participation in the NBP. While EPA administers the trading program, states share responsibility with EPA by allocating allowances, inspecting and auditing sources, and enforcing the program. Compliance with the NO_x SIP Call was scheduled to begin on May 1, 2003 for the full ozone season. However, litigation delayed implementation until May 31, 2004. In 2005, all NBP affected sources were required to comply for the full ozone season, May 1 through September 30.



Source: EPA

Transition from the NO_x Budget Trading Program to the Clean Air Interstate Rule

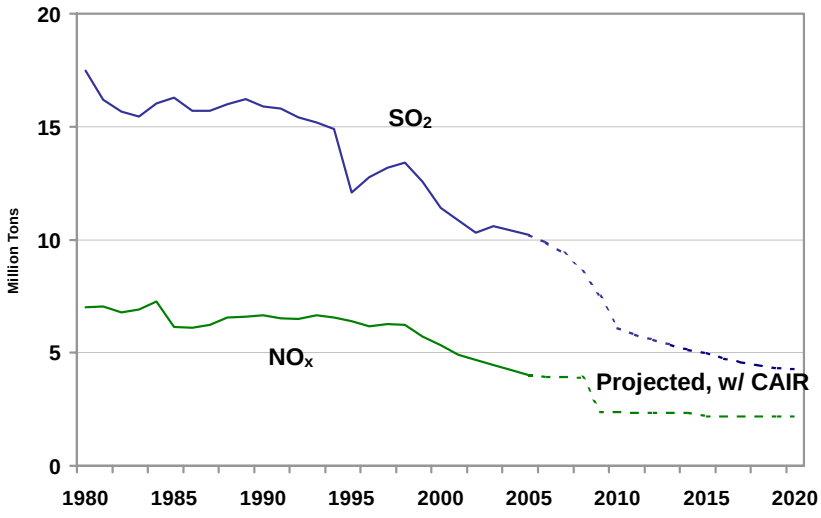


Note: The affected portions of Missouri and Georgia are required to comply with the NO_x SIP Call as of May 1, 2007. However, EPA has stayed the NO_x SIP Call requirements for Georgia while it responds to a petition to reconsider Georgia's inclusion in the NO_x SIP Call.

Source: EPA

Clean Air Interstate Rule (CAIR) — On March 10, 2005, EPA promulgated CAIR, a rule that will achieve the largest reduction in air pollution in more than a decade. In addition to addressing ozone attainment, CAIR assists states in attaining the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) by reducing transported precursors, SO_2 and NO_x. CAIR accomplishes this by creating three separate programs: an ozone season NO_x program and annual NO_x and SO_2 programs. Each of the three programs uses a two-phased approach, with declining emission caps in each phase based on highly cost effective controls on power plants. Similar to the NO_x SIP Call, CAIR gives states the flexibility to reduce emissions using a strategy that best suits their circumstances and provides an EPA-administered, regional cap and trade program as one option. States are now choosing the strategy that best enables them to achieve these mandated reductions and state implementation plans are due to be submitted to EPA for approval by the fall of 2006.

Nationwide SO_2 and NO_x Emissions from the Power Sector



International relationships and activities – In cooperation with OAQPS, the Office of Atmospheric Programs provides staff support for implementing the 1991 US-Canada Air Quality Agreement. The Agreement provides a mechanism for both countries to cooperate in reducing nitrogen and sulfur emissions that contribute to trans-boundary environmental issues, such as acid rain, ozone, and fine particulate matter. In addition, OAP staff work with countries throughout the world in areas such as emissions control technology and monitoring, design and implementation of emissions trading programs, and enhancing capabilities for environmental monitoring and assessment.

Office of Air Quality Planning and Standards (OAQPS)

National Ambient Air Quality Standards (NAAQS) --- The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings. The Clean Air Act requires periodic review of the science upon which the standards are based and the standards themselves. EPA has set NAAQS for six principal "criteria" pollutants. They are ozone (O3), particulate matter (PM), lead (Pb), carbon monoxide (CO), nitrogen oxides (NOx), and sulfur dioxide (SO2). OAR is currently beginning a joint NOx/SOx review for the secondary standard.

Prevention of Significant Deterioration (PSD) --- The CAA (§§ 160-169) requires that each implementation plan contain emissions limitations and other such measures as may be necessary to prevent significant deterioration of air quality in each region designated as attainment or unclassifiable with regard to the national ambient air quality standards. Accordingly, each State must develop requirements for a preconstruction permit program applicable to any new major stationary source or major modification that proposes to increase its emissions as part of the proposed construction project. Each applicable source must demonstrate that it will install the best available control technology to minimize its emissions of any air pollutant, and complete a source impact analysis to ensure that its emissions will not cause or contribute to a violation of any NAAQS or PSD increment, or have an adverse impact on an air quality related value (AQRV).

Regional Haze Rule and Guidelines for Best Available Retrofit Technology (BART) Determinations --- There are 156 Class I areas or parks identified for visibility protection. On June 15, 2005, EPA issued final amendments to its July 1999 regional haze rule. These amendments apply to the provisions of the regional haze rule that require emission controls known as Best Available Retrofit Technology, or BART, for industrial facilities emitting air pollutants that reduce visibility. These pollutants include fine particulate matter (PM2.5), and compounds which contribute to PM2.5 formation, such as nitrogen oxides, sulfur dioxides, certain volatile organic compounds, and ammonia. The amendments include final guidelines, known as BART guidelines, for

states to use in determining which facilities must install controls and the type of controls the facilities must use.

Animal Feeding Operations Air Emissions Monitoring --- The purpose of this monitoring study is to collect data to develop methods for estimating AFO emissions. EPA currently has very little data on air emissions from animal feeding operations; this study will help us take a big step forward toward understanding the amount of pollution these operations may emit, and whether that pollution may vary by climate, season and type of operation. The farms to be monitored represent typical operations for the different animals sectors (swine, dairy cows and poultry) and different regions of the country.

25 different sites (lagoons or barns) will be monitored on 21 different farms in 10 states (NC, NY, IA, WI, CA, KY, TX, WA, IN, OK). Monitoring is anticipated to begin in early spring 2007. The sites will be monitored for two years. This time period allows us to account for emissions variability by season, and for the effect any seasonal operational changes (such as pumping out lagoons) could have on emission levels. The pollutants to be monitored are: particulate matter; hydrogen sulfide; volatile organic compounds; and ammonia.

The data from this monitoring study will help EPA determine whether AFO emissions are exceeding regulatory reporting thresholds under the Clean Air Act; the Emergency Planning & Community Right to Know Act (EPCRA); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Great Waters Program --- Historically, the Great Waters Program in Section 112(m) of the CAA has focused on research, monitoring, assessing the impact, and reporting on the deposition of specific pollutants including nitrogen to important coastal waters. This program evaluates adverse effects of air deposition to public health and ecosystems. In 2000, OAR submitted its Third Report to Congress. The report can be found at www.epa.gov/air/oaqps/gr8water. Recently, EPA has expanded the scope of the program to look at the air deposition issue for all waters of the United States.

International Programs --- Our scientific understanding of the international transport of air pollutants is evolving rapidly. OAR is leading an effort to better understand and quantify the long-range transport, fate and effects of trans-boundary air pollution on U.S. air quality, air deposition to waterways, and other multimedia impacts**.**

Office of Transportation and Air Quality (OTAQ)

Mobile Source Programs that Reduce NOx – On-road and Nonroad

Mobile sources currently account for around half of total NOx emissions. EPA standards for NOx will result in well over 95% control of NOx emissions from on-road/non-road mobile sources on a per vehicle or per engine basis, compared to an uncontrolled vehicle or engine. EPA is continuing to work on reducing NOx from mobile sources and plans to propose strict standards for commercial marine and locomotive engines as well as small

spark-ignition engines in the coming months. This document briefly describes some of the mobile source programs already in place to reduce NOx emissions.

Mobile source programs can be generally broken into vehicle/engine standards and fuel standards. The benefits from a vehicle/engine program which reduces NOx begin when the standards are first implemented and vehicles or engines meeting the standard are introduced. However, the NOx benefits will increase until all the engines have turned over; therefore, benefits can start out small and become substantial as time goes on. The benefits from a fuel program that reduces NOx generally begin as soon as a new fuel is available. The effects are immediate for all vehicles using the new fuel, not just newer ones.

The major mobile sources of NOx emissions are on-road gasoline engines (such as automobiles, light- and medium-duty trucks), nonroad diesel engines, and commercial marine and locomotive engines.

1. On-road NOx Control - Control of NOx from Automobile and Light-Duty Trucks

- **Program Description: Mobile Source NOx Control from 1973-1995**

In this time frame, mobile source NOx control focused almost entirely on on-road vehicles and engines. The first automotive and light-duty truck NOx standards were introduced for the 1973 model year and resulted in exhaust-gas-recirculation in which a small portion of the engine exhaust is reintroduced into the intake charge which reduces peak combustion temperature and, thus, NOx emissions. The introduction of oxidation catalysts in 1975 was designed to reduce HC and CO emissions with minimal additional control of NOx. Starting in 1976, there was limited introduction of the 3-way catalyst designed to simultaneously control HC, CO, and NOx emissions. Stricter NOx standards effective with the 1981 model year resulted in universal use of these 3-way catalysts. The use of the 3-way catalyst resulted in about 90% control of NOx emissions compared to an uncontrolled vehicle.

- **Program Description: Tier 1**

Tier 0 is the description given to all light-duty highway vehicle emission standards, described above, in place prior to the Clean Air Act Amendments of 1990. The 1990 Clean Air Act established stricter Tier 1 standards for light-duty highway vehicles. Tier 1 standards for highway vehicle emission standards started with the 1994 model year and gradually phased in through the 1998 model year. Both Tier 0 and Tier 1 standards resulted in substantial reductions in NOx emissions.

- **Program Description: Tier 2**

The Tier 2 Vehicle and Gasoline Sulfur Program is a landmark program that affects every new passenger vehicle and every gallon of gasoline sold in the U.S. It begins with the 2004 vehicle model year and is fully phased in with the 2006 model year (or 2008 for the heavier weight category of light-duty trucks). By designing cleaner cars that run on cleaner fuels, the result is cleaner air. The program is a series of "firsts." For the first time:

- SUVs, pickups, vans, and even the largest personal passenger vehicles are subject to the same national emission standards as cars;
- vehicles and the fuels they use are treated as a system, so the cleaner vehicles will have the low-sulfur gasoline they need to run their cleanest;
- new emission standards apply to all light vehicles, regardless of whether they run on gasoline, diesel fuel, or alternative fuels.

Level, Type and Timing of Emissions Reductions: The implementation of low-sulfur fuel afforded an immediate drop in NOx emissions, while the phase-in of tighter vehicle standards starting with the 2004 model year will continue to reduce emissions over time. By 2030, these new measures will reduce fleet automotive emissions of NOx by about 75 percent compared to the baseline (1996), which accounts for fleet turnover (the replacement of older higher emitting vehicles by newer low emitting vehicles) and increases in vehicle miles traveled. On a per-vehicle basis , a Tier 2 vehicle emits 99% less NOx than a pre-controlled, pre-1968 automobile.

- **Program Description: National Low Emission Vehicle**

The National Low Emission Vehicle (NLEV) program was developed through an unprecedented, cooperative effort by the Ozone Transport Commission (OTC) states, auto manufacturers, environmentalists, fuel providers, EPA and other interested parties. The OTC states and environmentalists provided the opportunity for this cooperative effort by pushing for adoption of the California Low Emission Vehicle program throughout the northeast Ozone Transport Region. Under EPA's leadership, the states, auto manufacturers, environmentalists, and other interested parties then embarked on a process to develop a voluntary National LEV program, a process marked by extensive public participation and a focus on joint problem solving. Under the National LEV program, auto manufacturers had the option of agreeing to comply with tailpipe standards that were more stringent than EPA could mandate prior to model year 2004.

Level, Type and Timing of Emissions Reductions: National LEV vehicles were required to be 70 percent cleaner than baseline (1997) models. The National LEV program resulted in substantial reductions in non-methane organic gases and NOx, which contribute to unhealthy levels of smog in many areas across the country. Emission reduction estimates are based on a start date of MY1999 in the Northeast and MY 2001 nationwide.

- **Program Description: Reformulated Gasoline (RFG)**

Phase I of the RFG program was conducted from 1995 to 1999. During that time drivers in 17 states and the District of Columbia used fuel blended to burn cleaner and reduce NOx, VOC and toxics emissions. Phase II of the RFG program began in January 2000. The formula for gasoline sold in cities and states that participate in the reformulated gasoline program was again adjusted to help them move toward cleaner air.

Level, Type and Timing of Emission Reductions: Phase I impacted NOx emissions by requiring emission reductions of 2%, as compared to baseline gasoline, between 1995 and 1999. Phase II impacted NOx emissions by requiring emission reductions of 7%, as compared to baseline gasoline, from 2000 to the present.

2. On-road NOx Control - Control of NOx from Heavy-Duty Diesel Trucks

- **Program Description: Heavy Duty Trucks**

EPA first introduced standards for heavy-duty diesel truck engine NOx in 1972. These standards became increasingly stringent over the years resulting in roughly 50% control of NOx from heavy-duty diesel engines in the early 1990s compared to uncontrolled diesel engines.

Stricter standards were later implemented culminating in those for the 2007 and 2010 model year. As part of this program, new emission standards have taken effect in model year 2007 for PM and will take effect in model year 2010 for NOx. Vehicles/engines meeting these standards will use catalytic PM traps and, for 2010, advanced NOx control, possibly selective catalytic reduction. Because these emission control devices are damaged by sulfur, EPA is also reducing the level of sulfur in highway diesel fuel by 97 percent by mid-2006 (from 500 parts per million to 15 parts per million; in the mid-1990s, EPA regulations resulted in diesel fuel sulfur being reduced from about 2,000 ppm to 500 ppm).

EPA projects a 2.6 million ton reduction of NOx emissions in 2030 when the current heavy-duty fleet is completely replaced with newer heavy-duty vehicles that comply with these emission standards.

Compared to a pre-control heavy-duty diesel truck engine from the pre-1970 era, diesels meeting the 2010 NOx standard will have roughly 99% less NOx on a per-vehicle basis.

3. Nonroad Engine NOx Control

- **Program Description: Large Spark Ignition Engine, Recreational Vehicle and Diesel Marine Standards**

In the 1990s, EPA adopted new standards for emissions of oxides of nitrogen (NOx), hydrocarbons and carbon monoxide (CO) from several groups of previously unregulated nonroad engines; large industrial spark-ignition engines, recreational vehicles, and diesel marine engines. Even though these different kinds of engines are combined into one rulemaking, the new requirements reflect differences in the way each type of engine is designed and used.

Level, Type and Timing of Emissions Reductions: When the emission standards for recreational vehicles, marine diesel engines and industrial SI engines are fully implemented they are expected to reduce NOx emissions from these engine from unregulated levels. The Tier I standards for industrial SI engines were the first standards to go into effect in 2004. The standards for recreational vehicles and marine diesel engines will be implemented after the 2004 timeframe.

- **Program Description: Small Spark Ignition Engines**

EPA has established two rounds of emission standards for small SI nonroad engines. EPA's standards for small SI nonroad engine are divided into two broad categories, handheld and nonhandheld engines. EPA's Phase 1 standards for nonroad small SI engines took effect in 1997 for both categories of engines. EPA's Phase 2 standards for handheld engines phased in between 2002 and 2007. The Phase 2 standards for nonhandheld engines phased in between 2001 and 2007.

Level, Type and Timing of Emissions Reductions: The combination of EPA's Phase 1 and Phase 2 standards is estimated to reduce HC plus NOx emissions by 70 to 80 percent from unregulated emission levels. Due to the nature of emissions from small SI nonroad engines, most of the emission reductions will be HC reductions with limited reductions in NOx emissions. These engines are not a large source of NOx emissions.

- **Program Description: Nonroad Diesel Engines**

On May 11, 2004, the U.S. Environmental Protection Agency (EPA) announced a comprehensive rule to reduce emissions from nonroad diesel engines by integrating engine and fuel controls as a system to gain the greatest emission reductions. Exhaust emissions of PM and NOx from these engines will decrease by more than 90 percent. Closely linked to these engine provisions are new fuel requirements that will decrease the allowable levels of sulfur in fuel used in nonroad diesel engines, locomotives, and marine vessels by more than 99 percent. These fuel improvements will create immediate and significant environmental and public health benefits and will enable the use of new, high-efficiency emission-control devices on nonroad engines similar to that used in 2007-2010 heavy-duty diesel truck engines.

Level, Type and Timing of Emissions Reductions: This rule will reduce nonroad diesel fuel sulfur levels (which are higher than those for on road diesel fuel) in two steps. First, starting in 2007, fuel sulfur levels in nonroad diesel fuel will be limited to a maximum of 500 ppm. Second, starting in 2010, fuel sulfur levels in most nonroad diesel fuel will be reduced to 15 ppm. This ultra-low sulfur fuel will create immediate public health benefits and will make it possible for engine manufacturers to use advanced emission-control systems that will dramatically reduce both PM and NOx emissions. The standards will take effect for new engines beginning in 2008 and be fully phased in for most engines by 2014. The standards will cut emissions from nonroad diesel engines by over 90 percent. By 2030, the standards will be reducing 738,000 tons of NOx annually.

- **Program Description: Locomotives**

EPA finalized initial emission standards for locomotives that would provide significant emission reductions, beginning in the year 2000, to help states comply with National Ambient Air Quality Standards (NAAQS) for ozone and PM. Since locomotive emissions had not been regulated before, it was necessary for EPA to create a comprehensive program, including not only emission standards, but also test

procedures and a full compliance program. There are three separate sets of emission standards, with applicability of the standards dependant on the date a locomotive is first manufactured. The first set of standards (Tier 0) applied to locomotives and locomotive engines originally manufactured from 1973 through 2001, any time they are remanufactured in calendar year 2000 or later. The second and third sets of standards (Tier 1 and Tier 2) apply to locomotives and locomotive engines manufactured on or after January 1, 2002 (Tier 2 standards took effect on January 1, 2005).

Level, Type and Timing of Emissions Reductions: Locomotive emissions of NOx were reduced by 2/3 from 1995 levels starting in the year 2000.

EPA plans to propose increasingly stringent locomotive standards shortly since these engines are still a large source of PM and NOx.

Ammonia

Mobile sources are responsible for about 5% of ammonia emissions in the United States. Almost all of the mobile-source related ammonia comes from catalyst-equipped gasoline vehicles. The ammonia is formed over the catalyst from catalytic reduction of nitrogen oxides. Diesel vehicles/engines are responsible for relatively little ammonia emissions.

EPA and other investigators have been measuring ammonia emissions from gasoline equipped vehicles. Recent data suggest that newer catalyst-equipped vehicles meeting the Tier 2 standard may emit less ammonia, possibly due to better control of air:fuel ratios with improved computer-controlled electronic feedback.

OAR Nitrogen-Related Research Needs

Emissions of nitrogen and oxides of nitrogen

- Improve and expand on existing emissions monitoring, improving nitrogen and ammonia emissions inventories.
- Perform additional emissions characterization for ammonia emissions and also determine the effect of ammonia on PM emissions.

Mobile source control technology

- Assure control technology for on-road and non-road engines is achieving required NOx reductions.
- Characterize nitrogenous emissions from advanced control technology mobile source systems to determine what other nitro compounds are being emitted such as NO2 and nitro-PAH compounds.

Air quality

- Speciation of organics – divergent answers in current profiles for ozone modeling (reactivity) and toxics. ORD is currently working on "Speciate" tool, so some enhancements may be in pipeline, but it is unclear whether enhancements will address OAR needs.
- More thoroughly examine how hydrocarbons and NOx form ozone in the ambient air (especially in localized areas) so that we can better quantify the ozone benefits of controlling hydrocarbons and NOx.

Monitoring

- Maintain the TIME and LTM surface water monitoring research programs to provide necessary scientific research infrastructure to understand ecosystem response and recovery from nitrogen emissions and provide the regulatory accountability for current and new programs, as recommended by the NRC Report on air Quality Management.
- Maintain existing long-term atmospheric and deposition monitoring (CASTNET, NADP).
- Expand monitoring network in the western U.S. specifically in relation to sensitive ecosystems in order to better understand nitrogen exposure and deposition in these areas.
- Expand monitoring network in the east in order to determine accurate accounts of nitrogen deposition to sensitive estuarine and coastal ecosystems.
- Expand monitoring capabilities to include nitrogen compounds such as ammonia.

Atmospheric modeling

- Develop methods for nitrogen atmospheric modeling that extend current modeling capability to local-scale, fine-scale, and source receptor applications.
- Evaluate and improve atmospheric modeling to better predict nitrogen deposition and exposure (chemical and physical) in order to better link with multimedia and ecological process models (e.g., MAGIC, Chesapeake Bay Model).

- Develop CMAQ/CASTNET data integration and techniques for routinely estimating regional scale total deposition. Continue to support and improve evaluation and validation of existing models for estimating dry deposition.
    - Develop capability for directly measuring dry deposition for model evaluation.
    - Characterizing the differences and similarities between current MLM and next generation models

Health effects - contributing to standard development and emissions reduction program evaluation efforts

- Build on existing research regarding the human health effects of ozone – conduct research on clinical low level exposure and inflammatory effects of ozone on human health.

Ecosystem effects – Develop and refine national scale assessments of nitrogen exposures and impacts to support NAAQS reviews (e.g., combined NOx/Sox secondary standards) and emission reduction program evaluation efforts.

- Identify nitrogen sensitive ecosystems nationwide and establish ecological baselines for multiple regions of the U.S. to assess ecological response to nitrogen emissions reductions affected by program implementation (e.g., CAIR). Whenever possible, these baselines should build on previous statistically-representative survey research and long-term data records.
- Develop terrestrial (e.g. forest health and soils) and aquatic (e.g. chemical and biological) indicators and innovative benchmarks to track ecological effects and response to atmospheric concentrations and deposition of nitrogen.
- Integrate existing data (e.g., EMAP program data) with existing tools to enhance capability to assess ecological response to nitrogen deposition in various ecosystem types (e.g. forests, coastal).
- Develop approaches to value ecological benefits of programs from reduced atmospheric concentrations and deposition of nitrogen.