Rocky Mountain National Park Initiative
Nitrogen Deposition Reduction Contingency Plan

Memorandum of Understanding Agencies:

National Park Service
Environmental Protection Agency
Colorado Department of Public Health & Environment

Endorsed by the Colorado Air Quality Control Commission
in a non-binding agreement as of June 17, 2010

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SECTION 1 : Introduction/Background

Rocky Mountain National Park (RMNP) was established by Congress in 1915 and is recognized as an outstanding scenic area and natural treasure. Two-thirds of the park is near or above treeline, creating fragile high-elevation ecosystems that park managers are responsible for protecting.

The importance of atmospheric nitrogen (N) deposition relative to the natural processes and natural character of RMNP has become better understood over time, as scientific research and monitoring that began in the early 1980's have documented various changes to ecosystems in the park. These changes include forest and soil biogeochemical changes, enhanced microbial activity in soils, increased N in lakes and streams, changes in surface water chemistry, altered tree chemistry, and shifts in species of aquatic plants. The park's unique resources will continue to be harmed if N deposition remains constant or increases.

A. Evolution of the Nitrogen Deposition Reduction Plan (NDRP)

In 2004 a multi-agency meeting including the Colorado Department of Public Health and Environment (CDPHE), the National Park Service (NPS), and the U.S. Environmental Protection Agency (EPA) was held to address the effects and trends of N deposition in RMNP, and related air quality issues including elevated ozone concentrations and visibility impairment. These agencies proceeded to sign a Memorandum of Understanding (MOU) and agreed to pursue a more in-depth review of the issues and a course of action to address them. The interagency effort to address issues of adverse air quality in RMNP has been termed by the three primary involved agencies – CDPHE, EPA, and NPS (MOU agencies) – the "Rocky Mountain National Park Initiative".

This effort in part resulted from a petition to the Department of the Interior from Environmental Defense and Colorado Trout Unlimited to "carry out its legal responsibilities to protect Rocky Mountain National Park from harmful air pollution," referring specifically to nitrogen deposition.

MOU agency staff collaborated to produce technical and policy papers, culminating in the issuance of the Nitrogen Deposition Reduction Plan (NDRP) in 2007. This plan, endorsed by the three agencies and the Colorado Air Quality Control Commission (AQCC), requires that, by the end of 2009, a contingency plan be developed to put in place corrective measures in the event that initial and any subsequent interim deposition goals are not realized.

B. Achievement Timeline and Interim Goals

Based on past analyses, NPS adopted and the MOU agencies endorsed 1.5 kilograms of nitrogen per hectare per year (kg N/ha/yr) wet deposition as an appropriate science-based threshold for identifying adverse ecosystem effects in RMNP. This threshold is the "critical load" of nitrogen that can be absorbed by ecosystems within RMNP before detrimental changes occur. The critical load will be the benchmark used to link ecosystem protection goals of RMNP with air and possibly other State driven environmental management programs and policies. To achieve this threshold, referred to as the resource management goal (RMG), the MOU agencies have chosen a glidepath approach. This type of approach anticipates gradual improvement over time and is an accepted regulatory/policy structure for long-term, goal-oriented air quality planning.

The glidepath approach allows for the RMG to be met over the course of the next 25 years (by the year 2032). Using this approach, progress towards the RMG must be periodically assessed over time. The baseline condition at RMNP, calculated as the 5-year average of wet N deposition at Loch Vale (2000 – 2004), is 3.1 kg N/ha/yr. The first interim target load, based on recent research, requires a reduction of wet N deposition from baseline conditions to 2.7 kg N/ha/yr (a 13 percent reduction from baseline wet N deposition) by the year 2012. Progress towards interim target goals will be evaluated (refer to Appendix B) at 5-year intervals starting in 2013 until the RMG is achieved in the target year 2032. Below is a table of the interim goals.

Table 1-1: Nitrogen Deposition Reduction Plan – Interim Goals:

2012	2017	2022	2027	2032
2.7 kg N/ha/yr	2.4 kg N/ha/yr	2.1 kg N/ha/yr	1.8 kg N/ha/yr	1.5 kg N/ha/yr

During the first interim period, the MOU agencies will undertake the following tasks:

- Improving emission inventory methods and techniques;
- Continuing to analyze and interpret monitoring data and reporting air quality status and trends;
- Evaluating current NOx emissions reduction efforts and their impacts on nitrogen deposition in RMNP;
- Understanding upcoming NOx emission reductions and their potential for improving nitrogen deposition conditions;
- Assessing the effectiveness of seasonal and annual ammonia best management practices (BMPs);
- Investigating ammonia emission reduction efforts, such as urban fertilizer public education programs, and ammonia reduction methods at water treatment facilities and from land application of bio-solids;
- Reviewing modeling data (e.g. RoMANS) and any additional technical evaluations;
- Reviewing annually this Contingency Plan in the context of new data and knowledge;
- Identifying future legal and policy issues; and
- Assessing whether additional measures are needed to reduce NOx or NH3 emissions in Colorado.

As data are collected and analyzed, measures are studied, and programs are implemented, the MOU agencies will provide updates to the public during the fall of each year via

CDPHE's Rocky Mountain National Park Initiative website (http://www.cdphe.state.co.us/ap/rmnp.html) and to the AQCC annually. The MOU agencies will invite public comment and host a public meeting if requested.

C. Commitment and Basis to Develop Contingency Plan

In order to achieve resource management goals, the MOU agencies believe careful attention to tracking emissions and deposition, implementation of emission reduction strategies, and contingency planning will be necessary. This contingency plan is to be implemented if interim goals are not met, with the intent of achieving the desired goals within the planned timeframes. As stated in the NDRP, the contingency plan will account for implementation strategies during periodic reviews of progress measured against the glide path, and, adjustments in recommendations for or implementation of strategies made to ensure that goals are met.

SECTION 2 : Sources of Nitrogen Emissions and Apportionment

There are numerous factors that affect deposition in a given geographic area: emission type, amount and distance from area of deposit, atmospheric chemical transformations of those emissions, topography, and local- and regional-scale meteorology including precipitation. Techniques do not exist to directly measure the contribution of a particular emission source to nitrogen deposition in RMNP; therefore multiple technical analyses on existing and new data will be considered and interpreted to provide a weight of evidence upon which policy decisions can be based.

"Weight of evidence" in this case refers to an assessment of multiple types of evidence, identifying strengths and weaknesses with the goal of better understanding a cause-effect relationship between emissions and deposition. This chapter summarizes key findings and presents information on trends, emissions inventories, and relevant existing modeling and other analyses.

A. Emission Sources

Emissions of nitrogen oxides and ammonia are the key contributors to N deposition in RMNP.

Nitrogen Oxides

For Colorado, the Western Regional Air Partnership (WRAP) estimates that about a third of nitrogen oxide emissions (NO_x) are from point sources such as coal-fired power plants, another third originates from on-road mobile sources and the remaining third consists of various source categories such as nonroad mobile and biogenic activities. The largest NO_x emissions in Colorado are along the Front Range urban corridor, from mobile source and large point sources. NO_x emissions from power plants and other industrial activities in the western half of the state are also significant.

Figure 2-1: 2002 Statewide NOx emissions

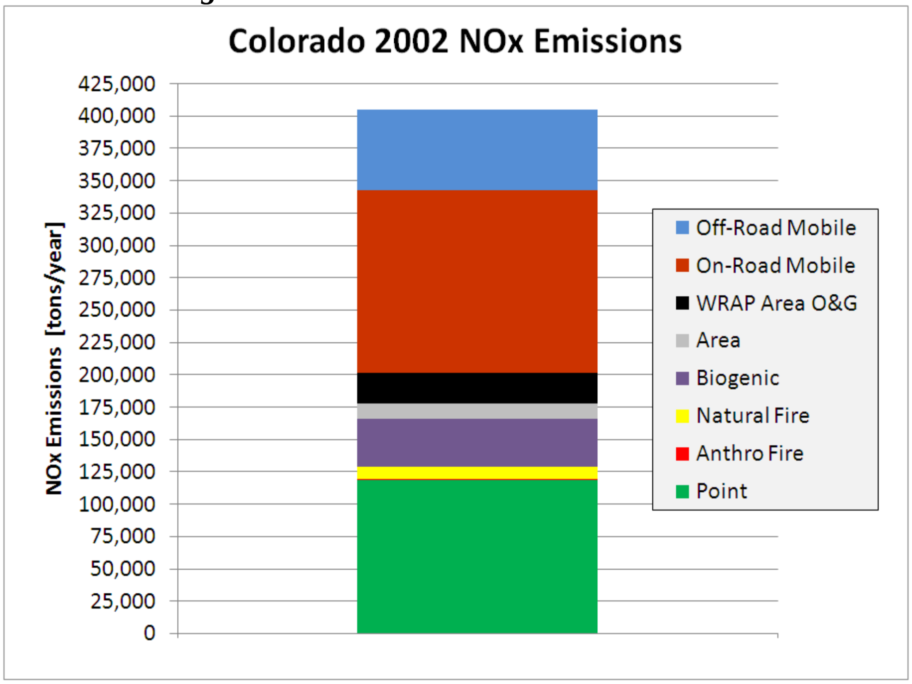
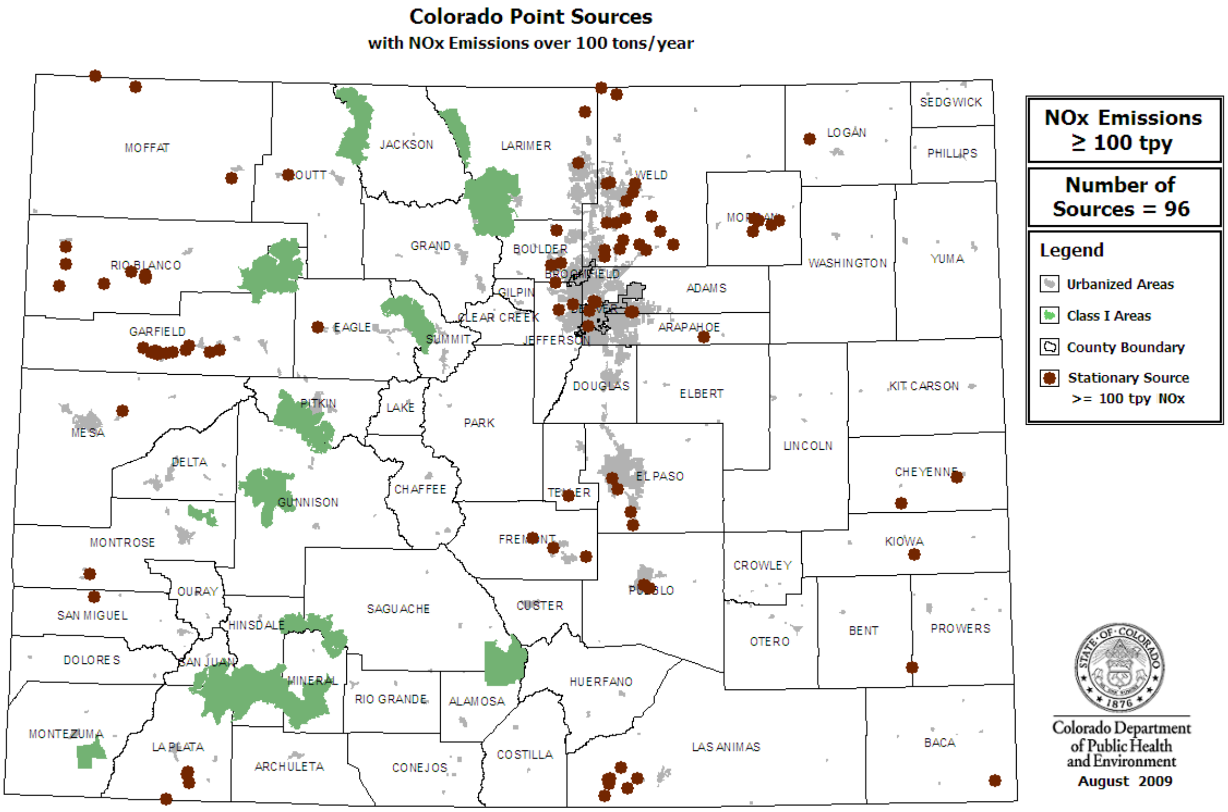


Figure 2-2: Colorado Point Sources of NOx



Ammonia

In 2005, ENVIRON developed an improved ammonia emission inventory using 2002 year data for the Western Regional Air Partnership (WRAP) in support of the Regional Haze modeling effort for the western states. Typically, information on gaseous ammonia (NH3) is limited because it is not a regulated air pollutant and consequently most sources are not required to report ammonia emissions. Because ammonia can react with SO2 or NOx to form fine particulates (PM2.5), and PM2.5 is a regulated air pollutant, some information on ammonium particulates (ammonium sulfate and ammonium nitrate) is reported for some point sources. However, ammonia emissions estimates techniques are evolving and efforts to improve the inventory are ongoing, such as emission estimates for sources such as landfills, road networks, biosolids land applications, and urbanized areas.

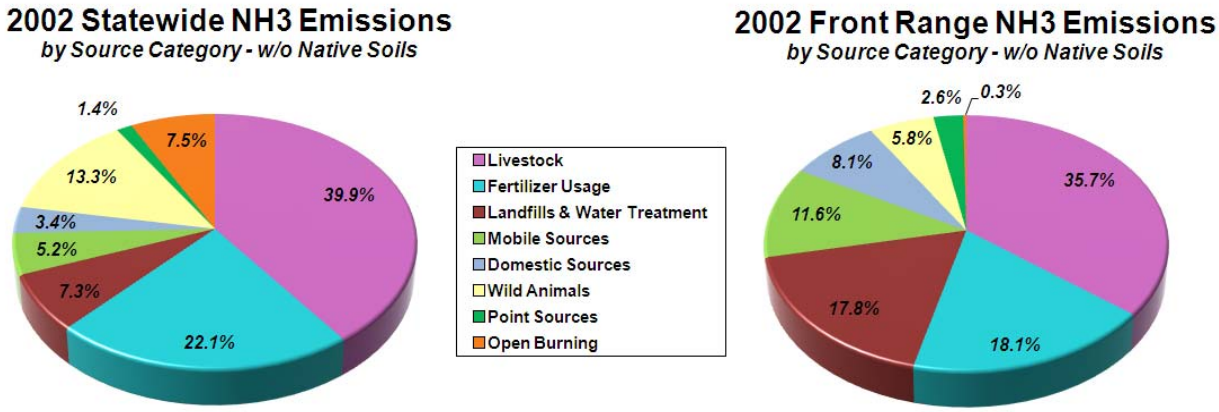
Ammonia (NH_3) emissions account for most ambient inorganic reduced nitrogen. The highest ammonia emissions in Colorado occur in the Platte River valley. The 2002 ammonia inventory presented in Figure 2-3 represents the most current information for the Front Range. It is important to note that this inventory does not include native soils because of the high uncertainty of ammonia emissions from soils and the fact that little can be done to control such emissions. Another natural source, wild animal populations, are included because some are a human-managed resource and for informational comparison to domestic animals and livestock. The Front Range is defined as the following 10 counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, El Paso, Jefferson, Larimer and Weld.

Table 2-1: 2002 Colorado and Front Range Ammonia Emission Estimates

Colorado Ammonia Emission Estimates

Major Source Category/Sub-Category	2002 Statewide NH3 Emissions [tons/yr]	2002 Statewide Total [tons/yr]	2002 Front Range NH3 Emissions [tons/yr]	2002 Front Range Total [tons/yr]
Livestock				
Beef Cattle	24,894	***34,543***	5,207	***10,288***
Dairy Cattle	3,625		2,691	
Swine	3,452		1,242	
Poultry	358		356	
Horses	1,279		452	
Sheep	530		271	
Buffalo (raised on ranches)	405		69	
Fertilizer Usage				
Anhydrous ammonia	2,351	***18,851***	644	***5,183***
Aqueous ammonia	0		0	
Nitrogen solutions	5,579		1,528	
Urea	2,253		642	
Ammonium nitrate	111		30	
Ammonium sulfate	662		182	
Ammonia thiosulfate	75		21	
Other straight nitrogen	0		0	
Ammonium phosphates	7,819		2,135	
N-P-K	0		0	
Calcium ammonium nitrate	0		0	
Miscellaneous	1		0	
Landfills & Water Treatment				
MSW Landfills	4,292	***6,224***	3,512	***5,093***
PO Water Treatment	1,932		1,581	
Mobile Sources				
Non Road	52	***4,455***	34	***3,312***
Highway	4,403		3,278	
Domestic Sources				
Human respiration	7	***2,869***	6	***2,322***
Human perspiration	1,183		968	
Infant cloth diapers	257		216	
Infant disposable diapers	13		11	
Cats	194		155	
Dogs	1,215		967	
Wild Animals				
Black bears	55	***10,976***	8	***1,576***
Bighorn Sheep (CDOW)	37		4	
Mountain Goat (CDOW)	9		0	
Elk (CDOW)	7,521		1,072	
Moose (CDOW)	34		9	
Deer (CDOW)	3,014		430	
Pronghorn Antelope (CDOW)	274		47	
Wild Horses	32		6	
Point Sources				
Point Sources	1,160	***1,160***	747	***747***
Open Burning				
Forest Wildfires	46	***6,406***	18	***81***
Prescribed Burning	6,360		63	
Area - Stationary Source Fuel Combustion				
Boilers/IC Engines	55	***71***	51	***64***
Heating	16		14	
Totals [tons/year]:	***85,485***		***28,601***	

Figure 2-3: Pie Charts of 2002 Colorado and Front Range Ammonia Emission Estimates



The following 12 counties are included in the Front Range: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, El Paso, Jefferson, Larimer, Morgan, Pueblo and Weld.

CDPHE has uploaded existing data on statewide operations such as animal feeding and water treatment into a Geographical Information System (GIS) and will add other significant ammonia sources, such as landfills, road networks, and urbanized areas, incrementally as data is collected. Figures 2-4 and 2-5 illustrate livestock and water treatment ammonia sources throughout the state.

Figure 2-4: Livestock Sources of Ammonia around the State

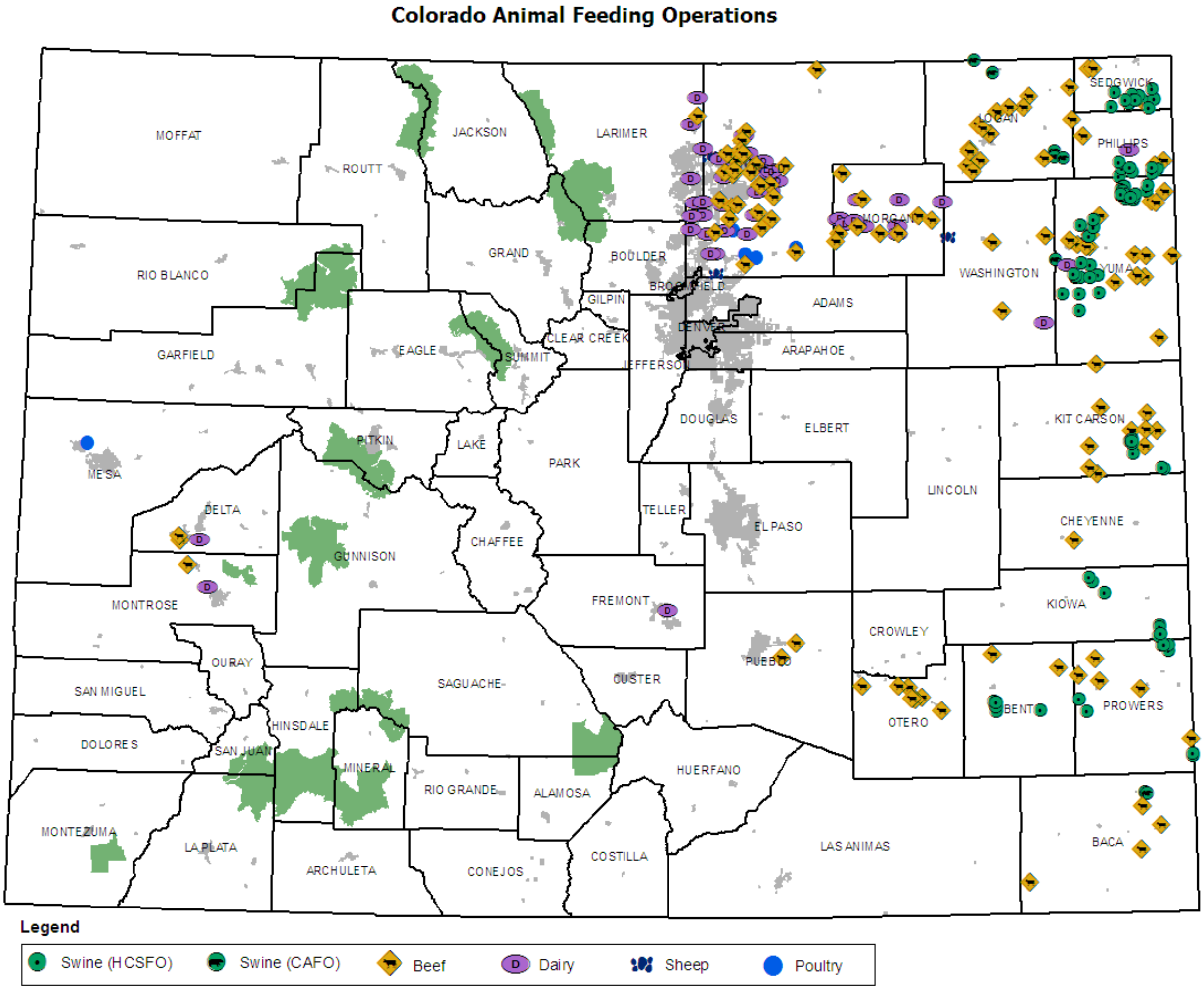
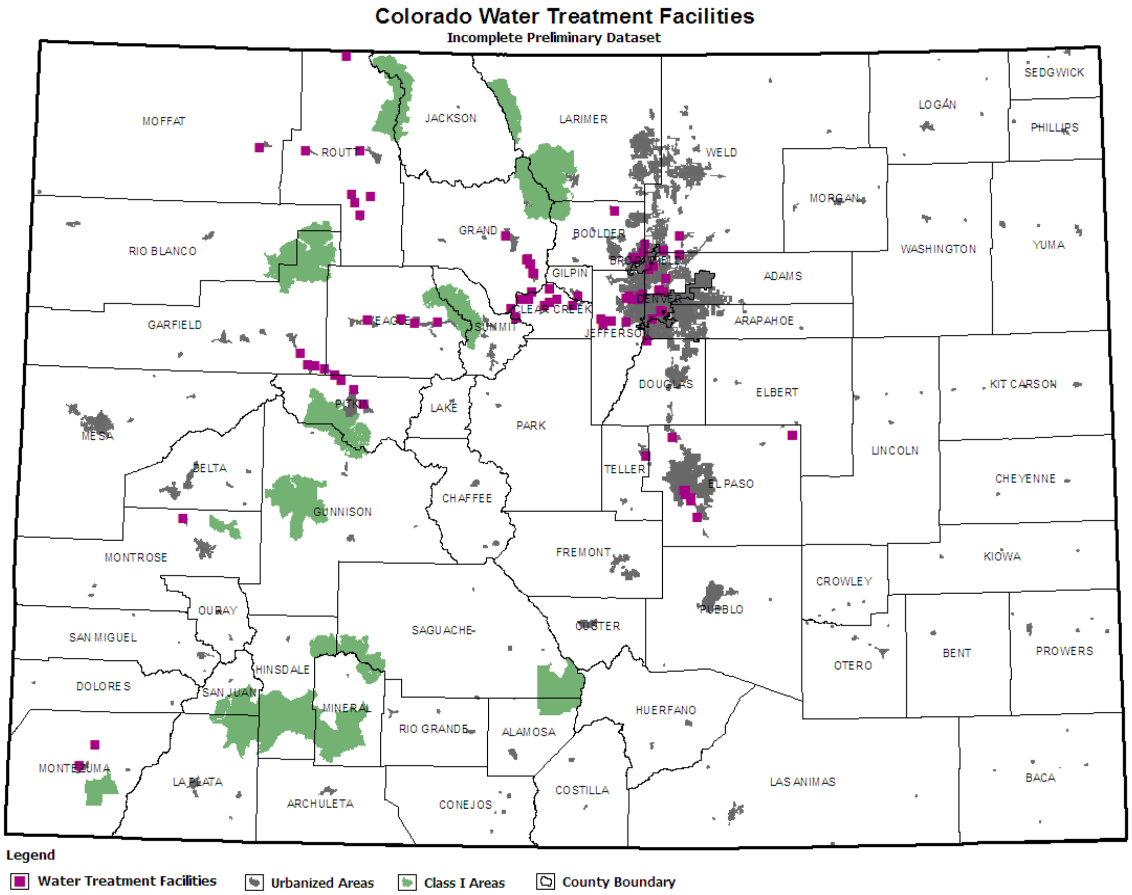


Figure 2-5: Water Treatment Sources of Ammonia around the State



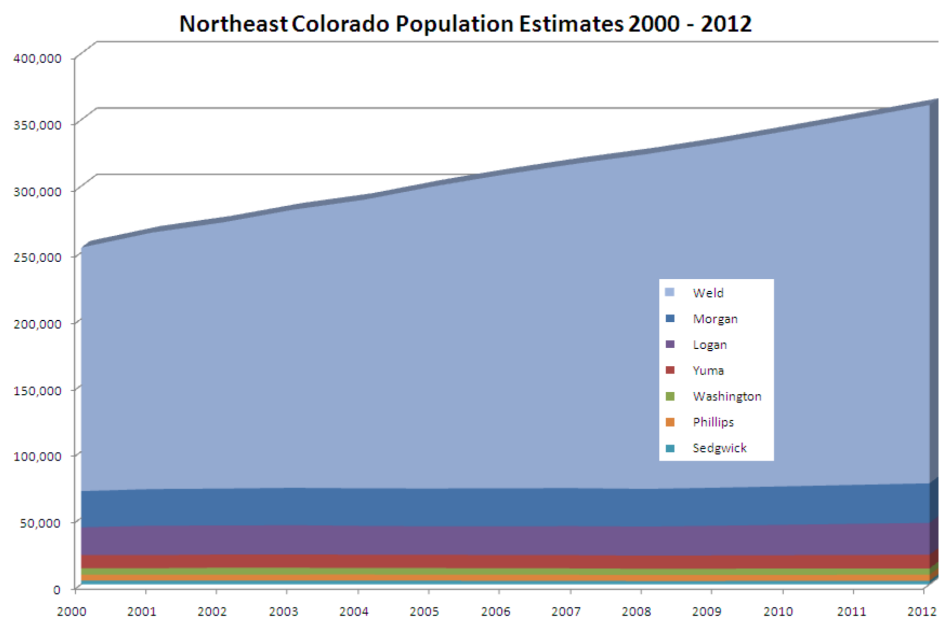
Within the Fertilizer Usage source category, non-farm fertilizer usage is estimated at about 21% (1,063 tons/year) based on a survey of fertilizer usage in the Front Range region. The non-farm fertilizer usage survey was conducted in 2007 and gathered data on fertilizer sales, municipal use in parks and commercial use by the lawn care industry. The remaining 79% of Fertilizer Usage category (4,120 tons/year) is attributed to farming activities, predominantly the application of ammonium phosphate fertilizers or nitrogen solutions.

As the population in Colorado continues to increase, ammonia emissions from agriculture may actually begin to decrease. Weld County, northeast of the Denver metropolitan area, is ranked high nationally for agricultural production, especially for chickens and turkeys. Currently, the county is home two of the largest beef feedlots in the nation and has 105 dairies, providing 48% of Colorado's total output. In addition, Weld County ranks first in lamb feeding and sheep and wool products in the nation. Over the next four years (2009-2012), Weld County is growing rapidly with a projected population increase in the state at 13.8%, which will likely result in increased NOx emissions and possibly decreasing ammonia emissions as farmland is converted to urban use. But the assumption is unfortunately not that simple.

Agricultural technology is changing; traditional crops continue to produce more on less land with less manpower. The acreage of vegetable production in the county is slowly increasing, giving the area more diversity than in the past. This diversity combined with the farmers' ability to adapt to the changing conditions means Weld County will probably remain a major player in the agricultural industry for the foreseeable future.

Data from the National Agricultural Statistic Service illustrates some changes—not all decreases—in Colorado's agricultural community (Appendix A). Given census methodology differences over the years, droughts, movements in between counties, some trends are still evident. For example, while the land in farms has decreased by 7 percent in Colorado since the 1950s and the number of farms has decreased dramatically, it is apparent that there has been a significant consolidation of farming activities. Total cropland has increased slightly, some crop yields have increased due to more efficient farming practices, and numbers of some animals have increased. Statewide, the number of sheep and lambs has decreased 42%, for example, but the number of hogs and pigs has increased 241%. Farming practices and commodities have changed over the years, but agriculture is still a significant sector in the Colorado economy.

Figure 2-6: Population Estimates for Northeast Colorado



B. Apportionment: Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS)

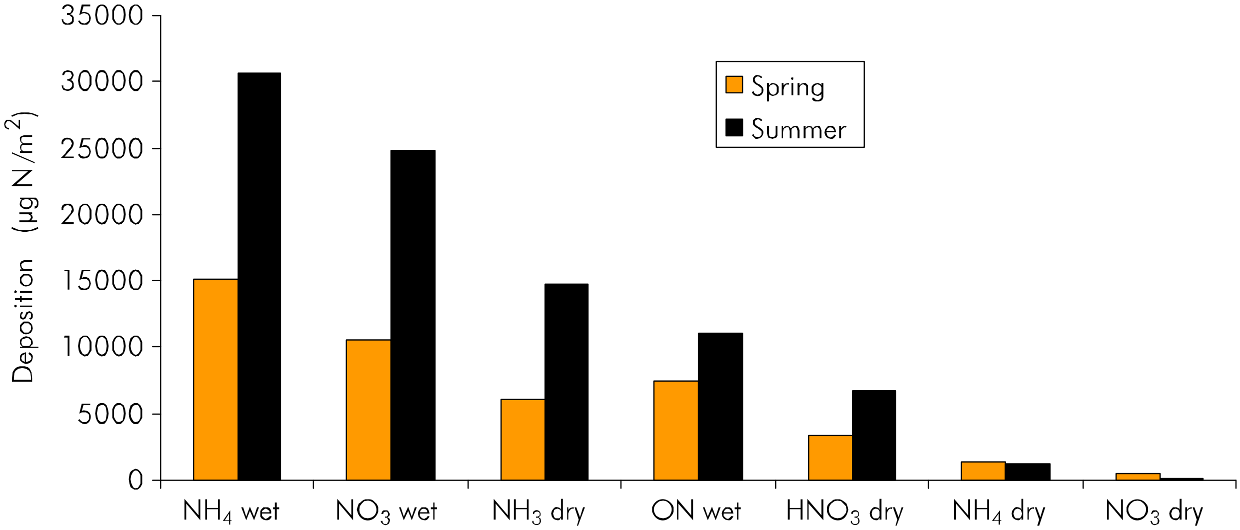
In an effort to further understand the origins of emissions currently affecting ecosystems and visibility in RMNP, a scientific study was conducted by a partnership led by the National Park Service, titled the "Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS)". Specifically, the goals of the study were to characterize the atmospheric concentrations of sulfur and reactive nitrogen species in gaseous, particulate, and aqueous phases (precipitation) along the east and west sides of the Continental Divide; identify the relative contributions to atmospheric sulfur and nitrogen species in the Park originating from within and outside of the state of Colorado; identify the relative contributions to atmospheric sulfur and nitrogen species in RMNP from emission sources along the Colorado Front Range versus other areas within Colorado; and identify the relative contributions to atmospheric sulfur and nitrogen species from mobile sources, agricultural activities, and large and small point sources within the state of Colorado. The main purpose of the RoMANS study is to better understand the origins of nitrogen deposition within RMNP to support future planning efforts associated with the Nitrogen Deposition Reduction Plan. The National Park Service has recently released a peer-reviewed report on the RoMANS study that can be found at the following link: http://nature.nps.gov/air/Pubs/regionPark.cfm

The RoMANS study included two 5-week sampling periods in 2006. One was a spring campaign from March 25 through April 30 and the second a summer campaign from July 7 through August 11. These periods of the year typically have elevated wet nitrogen deposition rates compared to other months. Climatologically, the deposition in these two periods is driven by different types of meteorological events. In the spring, large-scale upslope events occur that can bring contributions from the Front Range and beyond. During the summer, frequent precipitation, often in the afternoon, occurs due to convective activity. The field campaigns were followed by a two-year data and modeling analysis effort.

The major contributors to nitrogen deposition can be classified as inorganic reduced nitrogen, primarily ammonia (NH_3) and ammonium (NH_4), inorganic oxidized nitrogen, primarily nitric acid (HNO_3) and particulate nitrate (NO_3), and oxidized and reduced organic nitrogen (ON). Agricultural sources primarily emit reduced forms of nitrogen while combustion sources produce mainly oxidized emissions. Organic nitrogen emissions can originate from agricultural and natural biological emissions and from oxidation products of combustion emissions.

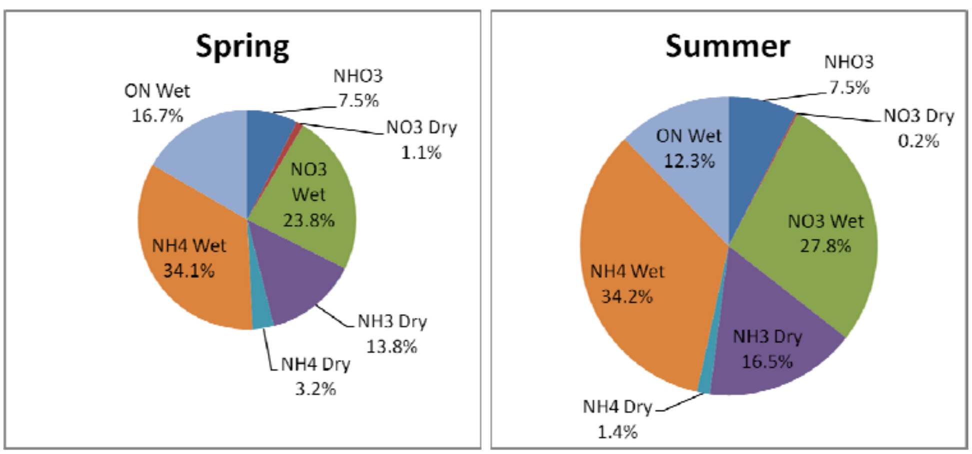
Figure 2-7 shows the dry and wet N deposition inputs from various species at the RoMANS core site, which was located within the Park on the east side of the Continental Divide. Nitrate and ammonium wet deposition and ammonia dry deposition were all more than twice as high during summer than during spring.

Figure 2-7: Dry and Wet N Deposition Totals by Various Species at RoMANS Core Site



Shown in Figure 2-8 are the nitrogen deposition budgets for spring and summer. Dry deposition of organic N was not measured. Although the spring and summer relative wet deposition rates for the different species were similar, they were due to very different meteorological processes. In the spring virtually all of the wet deposition was due to a single synoptic-scale event associated with sustained upslope transport. In contrast, the summer precipitation occurred almost daily, due to typical afternoon convective activity. Together, wet deposition of organic N and dry deposition of gaseous ammonia composed ~30% of the total RoMANS nitrogen deposition budget. Neither of these two pathways is measured in routine deposition monitoring networks.

Figure 2-8: Relative Contributions to Total Measured N Deposition at RoMANS Core Site



The relative size areas of the above pie charts are proportional to the total N deposition during each field campaign. Field measurements indicated that nitrogen concentrations of most species were highest in northeastern Colorado, with a sharply decreasing east-to-west gradient. Ammonia concentrations in northeastern Colorado were 10–100 times greater than in RMNP. Lowest concentrations of nearly all major nitrogen species were west of the Continental Divide.

The strategy taken for apportioning various aerosol species concentrations and deposition to source emissions was a weight-of-evidence approach that included comparing and contrasting results from multiple analyses techniques. The analyses involved examining spatial concentration gradients; simple wind direction as a function of aerosol concentration and wet deposition; and back trajectories for a number of high-concentration and wet-deposition episodes. Statistical analyses of trajectories were conducted and semi-quantitative relationships between back trajectories and measured concentrations were established. Modeled transport of conserved tracer emissions into RMNP and measured data were used in a receptor oriented hybrid model to estimate the contributions from various source regions to dry and wet nitrogen deposition in RMNP.

The spatial gradients observed across the RoMANS network and the relationship between upslope/downslope transport and species concentrations at the RoMANS core site suggest an important link between pollutant emissions east of the park and nitrogen concentrations and deposition inside RMNP.

The relative contribution of ammonium to wet deposition of nitrogen increases moving from western Colorado, east across the Continental Divide, reflecting the higher concentrations of reduced nitrogen in the eastern part of the state.

The apportionment of the dry- and wet-deposited N species during the spring and summer RoMANS periods to Colorado and non-Colorado source regions are presented in Figures 2-9 and 2-10. The "Local" source region approximately encompasses RMNP, but excludes Estes Park, and is interpreted largely as coming from naturally occurring emissions within RMNP. The "Western Colorado" source region encompasses Colorado sources approximately west of the continental divide, exclusive of RMNP. Contributions from all modeled source regions in North America not explicitly defined were grouped into the "Other Non-CO" source region and are interpreted as a background value. Two panels are included for each season, depicting absolute (left) and relative (right) deposition amounts by source region.

Figure 2-9: RoMANS Spring Source Apportionment of Dry and Wet N Deposition

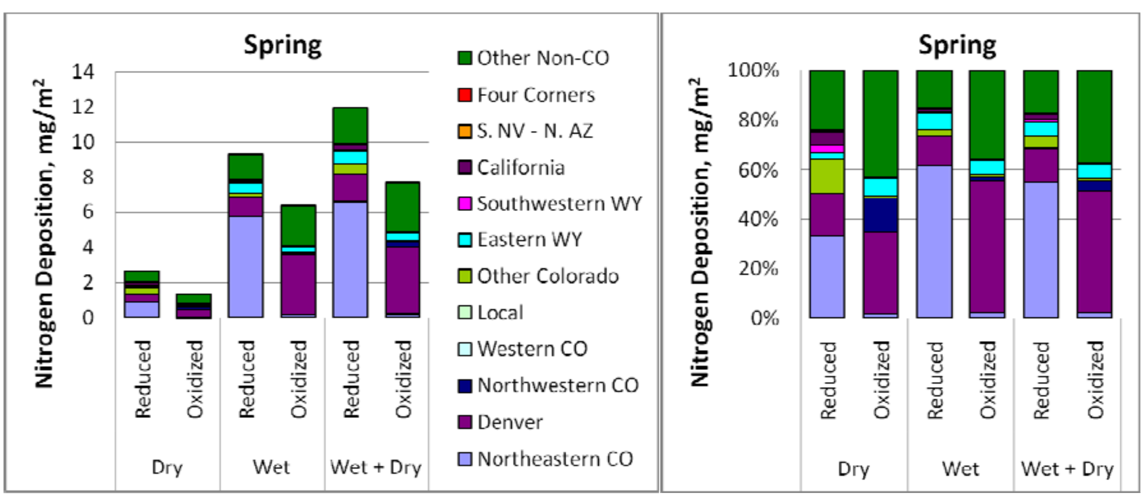


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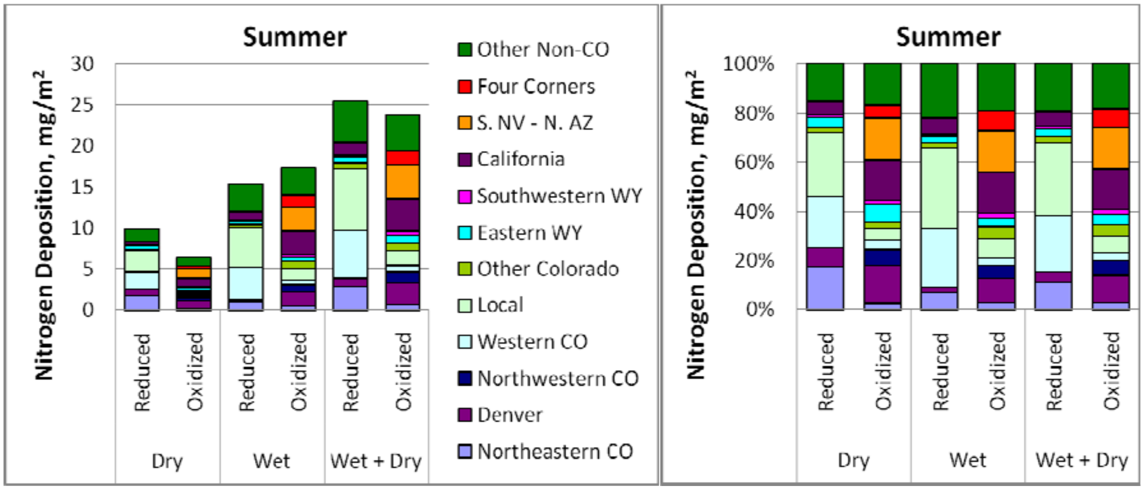
Figure 2-10: RoMANS Summer Source Apportionment of Dry and Wet N Deposition



Summary Conclusions of the RoMANS study include:

- Although the RoMANS study period was limited to 10 weeks in 2006, analyses of historical airmass transport patterns and air quality data indicate that there are broad similarities in the RoMANS N deposition source attribution results compared to those for a typical year.
- Wet deposited nitrogen species accounted for 75% of the total nitrogen deposition.
- During spring and summer, reduced nitrogen (ammonia and ammonium), oxidized nitrogen and organic nitrogen accounted for approximately 50%, 35% and 15% of the total (wet + dry) nitrogen deposition respectively.
- Colorado sources accounted for about 65% and 55% of the N deposition during the spring and summer respectively.
- Roughly half of the deposition was from sources east of RMNP and the other half from source west of RMNP. A diverse number of sources contribute to the western half while the eastern half is primarily comprised of the nearby Front Range and northeastern Colorado.
- Ammonium and oxidized nitrogen had higher contributions from distant sources, such as California, than ammonia.
- The upslope events in the spring, although infrequent, result in RMNP often experiencing the highest ambient nitrogen concentrations. The less frequent but high rate of nitrogen deposition associated with sources east of RMNP leads to the high nitrogen contributions from these sources.

In the Nitrogen Deposition Reduction Plan, the MOU agencies reviewed the Western Regional Air Partnership's Particulate Matter Source Apportionment (PSAT) modeling study. While this study looked at atmospheric fine particulates that affect visibility (regional haze), it found that over 30% of the nitrate and over 50% of the ammonium in fine particulates in RMNP originates from Colorado sources. The RoMANS results are consistent with previous modeling exercises.

SECTION 3 : **Emission Reductions from Current Programs**

A. Current NOx Reduction Strategies

There are numerous NO_x emission control programs that have been recently implemented or have been scheduled to be implemented over the next 20 years. Implementation of all of these programs will reduce NO_x emissions and reduce the nitrate deposition at RMNP. The following summarizes relevant federal and State efforts:

- Minor Source BACT for Natural Gas Compressor Engines (greater than 100 hp): The AQCC adopted emission limits for new and relocated engines in 2006 that reduce the growth in NO_x emissions across the State.
- Regional Haze: For western states, the regional haze program will reduce NOx emissions from major stationary sources due to the Best Available Retrofit (BART) Technology provisions and from any other sources required to reduce emissions to demonstrate reasonable progress toward the regional haze goal. This Regional Haze effort should reduce NO_x emissions approximately 30% by the year 2020 in the western half of the U.S. (included in this percentage are benefits from other existing programs, such as mobile source reductions). New emission reductions gained through the Regional Haze program (possibly thousands of tons of NOx each year) is vital to successfully reducing N deposition at RMNP. Regional Haze is driving the assessment of large NOx emitting facilities throughout the State, and emission controls implemented by 2020 should positively impact N deposition.
- Require general application of permit requirements in Regulation No. 3 and reasonably available control technology (RACT) for NOx stationary sources greater than five tons per year in the Front Range ozone nonattainment area
- Implement a motor vehicle inspection/maintenance program in the North Front Range (Larimer and Weld counties)
- Implement more stringent cut-points in for inspection/maintenance program
- Implement retrofit control requirements for existing reciprocating internal combustion engines (RICE) over 500 horsepower statewide
- Of particular note, the federal on-road vehicle TIER II, III and IV gasoline and diesel exhaust standards, gasoline and diesel fuels standards, and federal off-road and small engine standards will provide significant NOx emission reductions. Note that for TIER IV diesel, urea will be used to control NOx emissions, but estimates are that very little ammonia will be released into the air. Other techniques may be deployed that do not utilize urea – this will be monitored. Generally, it should be noted that ammonia emissions from the gasoline fleet is and will be much larger that from the diesel fleet.
- Mobile Source NO_x Trends East of the Park: Table 3-1 provides current and projected estimates of mobile source NOx emissions for the Front Range. This data

indicates that NO_x emissions will be about 68% less by 2020 and 75% less by 2030. The Fort Collins and Greeley areas are currently experiencing and are expected to experience rapid urbanization and growth. Fortunately, the federal TIER II tailpipe and fuels standards and a soon to be implemented inspection and maintenance program are countering this growth and significantly reducing projected emissions. It can be assumed that these future trends will also manifest themselves in the Estes Park and RMNP region, which are also experiencing dramatic mobile source activity and increases in vehicle miles traveled.

The AIR Program is a vehicle inspection and maintenance program currently operating in the Denver Metro Area (DMA). In 2010, the AIR Program will be expanded to the North Front Range (NFR) to include parts of Larimer and Weld Counties, in accordance with both regulatory changes adopted in late 2008 and the enactment of SB09-003 during the 2009 legislative session. Pursuant to the program, vehicles registered in the area must meet established criteria for emissions of excess carbon monoxide (CO), nitrogen oxides (NOx) and hydrocarbons (HC). To ensure compliance with these standards, vehicles are required to undergo periodic emissions testing at the time of their registration renewal. Vehicles that fail the tests must be repaired and pass a retest before they can be re-registered. The environmental benefit from the program is derived primarily from the emission reductions that occur when vehicles failing the initial test are repaired, with additional benefit derived from pre-inspection vehicle maintenance and repair performed to ensure compliance with program requirements. While most vehicles that are inspected pass the established standards, the vehicles that fail disproportionately contribute to the overall atmospheric emissions loading from the vehicle fleet.

The Estes Park area is under consideration for inclusion into the Northern Front Range I/M Program. Based on modeling, this potential incorporation will result in approximately 15 tons per year NOx reduction in 2014.

Table 3-1: Mobile Source NOx Emissions Estimates for North Front Range (NFR)

Year	M6 NO_x EF (gr/mi)	Fort Collins VMT	Fort Collins NO_x – TPD	Greeley VMT	Greeley NO_x – TPD	NFR total VMT	NFR total NO_x – TPD
2000	3.083	2,651,091	9.0	1,264,236	4.3	9,658,415	32.8
2010	1.578	3,179,615	5.5	1,516,855	2.6	12,003,242	20.9
2012	1.312	3,317,204	4.8	1,575,099	2.3	12,559,100	18.2
2020	0.650	3,778,538	2.7	1,851,248	1.3	14,840,487	10.6
2030	0.393	4,709,117	2.0	2,327,133	1.0	19,280,346	8.4

- NO_x Trends Inside the Park: RMNP is taking various actions aimed at reducing fossil fuel (as well as greenhouse gas) pollutants, including seeking an energy audit to identify energy efficiency and renewable energy projects in the park, working towards replacing the park fleet with high efficiency vehicles, and expanding the shuttle system to reduce vehicle miles traveled within the park.

- Ozone planning in Colorado over the next 10 years will also focus on NOx-emitting sources. EPA is scheduled to promulgate a new, more stringent ozone standard in August 2010 which will drive new efforts to reduce Colorado's and the nation's ozone precursor emissions. NOx emission controls implemented for improving ozone conditions should positively impact N deposition.

Statewide reduction strategies, with estimated NO_x emission reductions detailed below, include realization of BART controls, described above, shutdown of several power plants, engine retrofits (greater than 500 HP), implementing of a Northern Front Range I/M program, executing a Denver Metro I/M cutpoint tightening and high emitter program, and phase-in of federal on/off road vehicle standards, which may be further constricted in the future. The State will track these reduction strategies and the resulting emission reductions achieved, as outlined in Table 3-2.

Figure 3-1: Projected NOx Reductions from 2002 to 2018

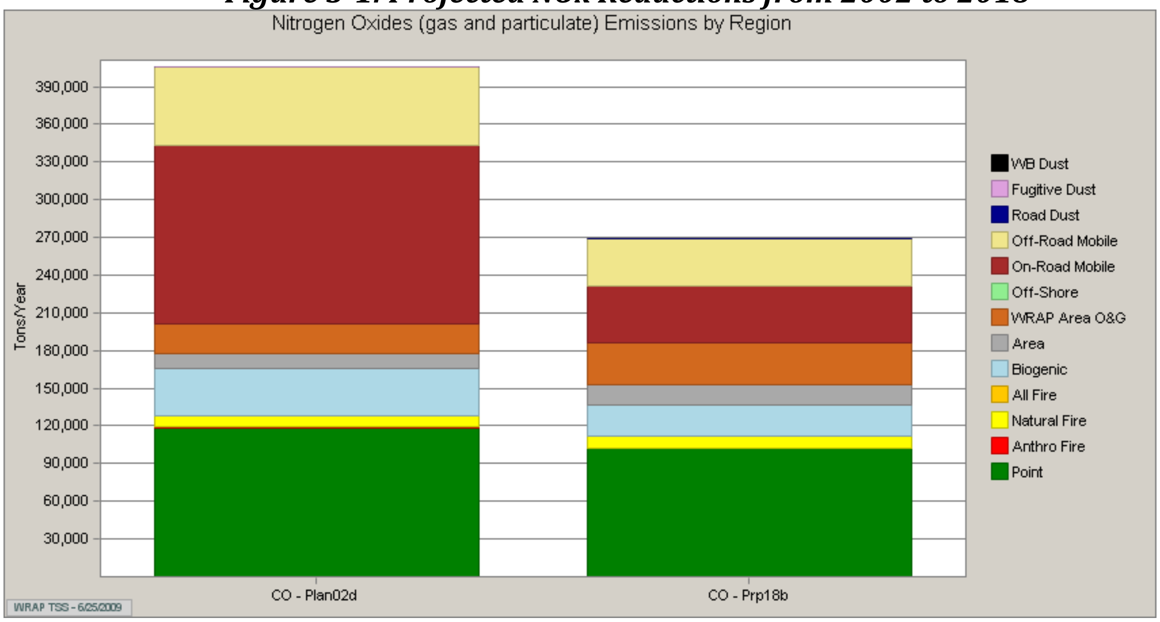


Table 3-2: Statewide NO_x Reduction Strategies

Statewide Reduction Strategies	Estimated NO_x Reduction (TPY)
BART (by 2018)	6,177 (estimated)
Shutdown of Arapahoe 3&4, Cameo 1&2 (~2011 to 2013)	3,590
Retrofit RICE > 500 HP (~2010)	5,800
Northern Front Range I/M (~2014)	591
Denver I/M Cutpoint Tightening & High Emitter (2010)	1,095

Estes Park I/M (to be determined)	15 (estimated)
Phase-In of Federal On/Off Road Vehicle Standards (2008 to 2018)	60,396 (on-road) 13,527 (off-road)
Total:	**91,191**
Statewide NOx Emissions (2007)	**284,037**

The MOU agencies will present to the public the status and findings of NOx reducing research and measures each fall via the Rocky Mountain National Park Initiative website (http://www.cdphe.state.co.us/ap/rmnp.html).

B. *Current Ammonia Reduction Strategies*

The MOU agencies are working with a number of different entities on various ammonia reduction techniques. Many of these options are voluntary. For urban sources, the State is working with the Environmental Defense Fund as well as seeking the guidance and input of the Colorado Pollution Prevention Advisory Board to develop a public information campaign to reduce fertilizer use by homeowners, municipalities and other applicators of domestic fertilizer. In addition, CDPHE's Office of Environmental Integration and Sustainability may be able to distribute information to state agencies on proper application rates of fertilizer, as well as assist in the development of cross media approaches to reduce emissions while achieving several other objectives.

CDPHE will examine potential nitrogen emissions and the contribution to nitrogen deposition in RMNP from activities such as the treatment of wastewater at municipal wastewater treatment plants, land application of biosolids to agricultural land, and several other potential ammonia sources. The identification of potentially new ammonia sources includes conducting research to help fill data gaps and reduce uncertainties in emission calculations and inventories, and exploring alternative emission control systems for municipal treatment plants, such as packed scrubbers, biofilters, or thermal oxidization.

Based on the most recent information available, agricultural activities are the largest producer of ammonia emissions. Together with all ammonia sources, the NDRP calls for agricultural producers to achieve reductions of ammonia emissions in order to reach resource management goals set forth in the plan. Effective, field-tested management practices that can help to reduce ammonia emissions from livestock operations, in particular, are now being identified. A considerable amount of uncertainty regarding the efficacy of these management practices in diverse production systems, however, still exists. While testing is showing some practices to be promising, each produced will need to consider practices on a case-by-case basis to determine the appropriateness of a practice for that particular operation.

In agriculture, best management practices (BMPs) are operations or activities designed to reduce environmental impacts to water, air, or land. In general, BMPs are recommended methods, structures or practices designed to prevent or reduce environmental impacts. BMPs are inherently voluntary, site-specific, and are applied at the local or ground level.

Many BMPs are considered standard industry practice and often provide both environmental and economic benefits to agricultural operators.

RMNP Agricultural Subcommittee
In September 2006, a diverse group of agricultural interests came together to form a Rocky Mountain National Park Agricultural Subcommittee. The goal of the subcommittee is to proactively address concerns related to agriculture's contribution to nitrogen deposition in RMNP. Participants in the subcommittee include the livestock and crop production sectors, academia, non-governmental entities, and state and local government.

In October 2007, the subcommittee submitted agricultural-specific action items to the MOU agencies for incorporation into the Nitrogen Deposition Reduction Plan. The objective of the action items is for the agricultural industry to take actions that reduce emissions of ammonia from livestock and crop production activities. For example, some of the activities implemented by the subcommittee include: meeting regularly to track progress and discuss next steps; completion of a comprehensive literature review of ammonia-based best management practices; conducting field-based testing of best management practices (BMPs) to better quantify and document ammonia reductions; formation of a grant working group to explore potential grant opportunities in support of additional research and implementation of BMPs; and, participation in an agricultural trends study to identify important patterns in the industry, including the economic viability of BMPs for livestock producers.

While it is true that on a daily basis there are a number of best management practices being used by agricultural producers, and that these BMPs likely provide some ammonia emission reductions, few have been evaluated for this purpose (i.e., to quantify ammonia reduction potential). In order to improve the state-of-the-science, research is underway at Colorado State University to field test potential best management practices (BMPs) for reducing ammonia emissions from dairies and feedyards in Colorado. To date, 12 BMPs for feedyards and dairies have been evaluated for ammonia reduction and cost efficacy, with more field testing and one-on-one producer assistance on BMP implementation taking place during the period of 2009 - 2013. Researchers have published initial results for 12 BMPs and state:

> [O]ur findings show that there are some BMPs available that are effective, economical and easy to use. However, individual characteristics of an operation need to be considered when choosing BMPs for dairy and feedlot operations. It is important to note that not all BMPs are viable on every operation. BMPs must be selected individually for an operation based on current management practices, BMPs already in place, operation layout, economics, and ammonia reduction goals.

BMP evaluation results are available at www.AmmoniaBMP.info. The following practices are potential BMPs for reducing ammonia emissions from livestock operations and application of commercial fertilizers on farming operations:

Animal Agriculture

Feedyards

- Reduce dietary crude protein in feed rations (this practice is currently under evaluation by scientists at multiple institutions in Colorado and other locations)
- Develop feed rations in consultation with an animal nutritionist (already an industry standard practice)
- Group animals by age (already an industry standard practice)
- Oscillate the protein content of feed rations (this practice is currently under evaluation by scientists at multiple institutions in Colorado and other locations)
- Feed additives such as antimicrobial or beta-adrenergic additives to improve animal health and feed conversion efficiency
- Alter pen scraping practices (this practice is currently being evaluated)
- Alter management practices for manure after it is removed from pens (multiple alternatives including stockpiling, composting, etc. are currently being evaluated)
- Apply manure to land based on agronomic requirements (already an industry standard practice and required by Colorado Water Quality Control Commission Regulations No. 61 and 81)
- Incorporate manure and/or irrigate immediately after land application of manure

Dairies

Many of the BMPs proposed for feedyards have also been suggested for dairies, although management practices between these facilities are different. Additional BMPs for dairies include the following:

- Design new freestall barns with slotted, sloping, or grooved alleys to promote separation of urine and feces
- Alter the types of bedding materials used in freestall barns (this practice is currently being evaluated)
- Harrow woodchips into the surface of drylots (this practice is currently being evaluated)
- Flush alleys with fresh or recycled lagoon water rather than scraping alleys
- Aerate lagoons (evaluation of this proposed BMP has had mixed results)

Hog Farms

- Develop feed rations in consultation with an animal nutritionist (already an industry standard practice)
- Develop feed rations to reduce nutrient concentrations in effluent (already a standard practice required by Colorado Water Quality Control Commission Regulation 61, Colorado Discharge Permit System Regulation, 5 CCR 1002-61, Section 61.13)
- Use cover technologies for anaerobic lagoons (already a standard industry practice required for odor control by Colorado Air Quality Control Commission Regulation No. 2, Part B, Section IV.A.3.c)
- Control wastewater flow into treatment lagoons to control nutrient loading rates (already a standard practice required by Colorado Water Quality Control

Commission Regulation 61, Colorado Discharge Permit System Regulation, 5 CCR 1002-61, Section 61.13)

- Discharge wastewater into treatment lagoons through submerged pipelines (already a standard practice required by Colorado Air Quality Control Commission, Regulation No. 2, Part B, 5 CCR 1001-4)
- Land apply effluent at optimal times for crop utilization (already a standard practice required by Colorado Water Quality Control Commission Regulation 61, Colorado Discharge Permit System Regulation, 5 CCR 1002-61, Section 61.13(4)(d))
- Land apply effluent through low-drift irrigation nozzles and only when wind speeds are below thresholds to prevent volatilization (already a standard practice required by Colorado Air Quality Control Commission, Regulation No. 2, Part B., Section IX.A.4)

Crop Production

- Apply nitrogen fertilizers at agronomic rates based on yield estimates, soil analysis, time of need, and recognizing credits from all other N sources (already an industry standard practice)
- Apply nitrogen fertilizers in smaller amounts at multiple times during the growing season to reduce opportunities for loss and maximize crop uptake efficiencies (already an industry standard practice)
- Use variable rate applications of nitrogen fertilizer to match application rates with variations in soil and crop production potential. (being adopted as farmers are able to afford the technology)
- Adopt methods of tillage to reduce volatility potential by increasing surface residue levels, increasing water absorption properties. (already a significant trend in Colorado and Western High Plains region)
- Adopt methods of tillage that stimulate increased organic matter levels and decrease soil erosion potential. These methods (strip-till, reduced-till, no-till, ridge-till, conservation-till) help facilitate reductions in need for applied nitrogen. (a recognized industry trend)
- Use less volatile forms of fertilizer (already an industry standard practice)
- Use slow-release forms of nitrogen fertilizers (already an industry standard practice when appropriate)
- Apply fertilizers below the soil surface (already an industry standard practice when feasible)
- Incorporate surface-applied fertilizers by mechanical means soon after application (already an industry standard practice)
- Incorporate surface-applied fertilizers by sprinkler irrigation immediately after fertilizer application when possible (already an industry standard practice for irrigated producers)
- Make surface applications to non-irrigated growing crops during weather periods that favor nitrogen retention (already an industry standard practice)
- Use nitrogen stabilization additives to reduce volatility of surface applied nitrogen where incorporation or irrigation is not possible. (already an industry standard practice)

- Use crop cultivars with high nitrogen use efficiency (already an industry standard practice)
- Add acidifiers to calcareous soils to reduce soil pH (management of soil pH already an industry standard practice since crop productivity and overall soil health is optimized near pH levels of 7)

At the national level, the U.S. Environmental Protection Agency has initiated efforts to address cross-media management of reactive nitrogen, including implementation of a research effort to evaluate management practices to reduce emissions of reactive nitrogen from a host of sources. Therefore, it is likely that more specific and better-tested mitigation measures for reducing ammonia emissions from agricultural sources will be available in the future.

During the next three years, additional measures that will be explored and developed by the MOU agencies include:

- Environmental Quality Incentive Program (EQIP) measures under the Natural Resources Conservation Service in order to provide a voluntary conservation program for farmers and ranchers including financial and technical assistance;
- Voluntary agreements and/or BMP reporting for environmental recognition and/or regulatory assurances;
- BMP menu and credit; and
- Seasonal BMP implementation techniques.

The MOU agencies will present to the public the status and findings of all ammonia reducing research and measures each fall via the Rocky Mountain National Park Initiative website (http://www.cdphe.state.co.us/ap/rmnp.html).

SECTION 4 : Contingency Measure Development Process

This contingency plan does not automatically require the implementation of additional emission control measures designed to reduce the deposition of nitrogen in RMNP. Instead, the MOU agencies have developed a focused process to develop appropriate responses if and when nitrogen deposition goals are not achieved.

If nitrogen deposition goals are not achieved, an "adaptive management" approach will be used to adjust strategies, as approved by the MOU agencies. Adaptive management is a management method based on clearly identified goals: monitoring to determine if actions are meeting goals, and if not, facilitating change that will best ensure goals are met. Adaptive management can effectively address complex and sometimes uncertain issues like atmospheric deposition.

A review of this contingency plan will be conducted annually by September to coincide with the Loch Vale National Atmospheric Deposition Program (NADP) data (from previous year) review and availability. The results of this annual review will be presented to the public each fall via the Rocky Mountain National Park Initiative website (http://www.cdphe.state.co.us/ap/rmnp.html). The annual review allows for timely adjustments to the contingency plan considering the latest deposition data from Loch Vale and research that identifies the most effective contingency measures. An adaptive management approach will occur throughout the implementation of the NDRP upon approval by the three MOU agencies.

This contingency plan ensures that contingency measures are adopted expeditiously once the need is triggered. The primary elements of the contingency plan are A) the tracking of the wet deposition of nitrogen compounds in RMNP; B) triggering mechanisms to initiate the rapid development and implementation of specific contingency measures; C) a description of the process for developing and proposing the contingency measures; and D) a list of potential contingency measures; and E) and public outreach.

A. Nitrogen Deposition Data Tracking Plan

In the case that interim goals are not achieved, the contingency plan will be implemented. The interim goals in the NDRP are based on a five-year rolling average of wet nitrogen deposition data from the National Atmospheric Deposition Program (NADP) monitoring site in Rocky Mountain National Park at Loch Vale (Appendix B-1). The interim goals can be found in Table 1-1.

The first interim goal of the NDRP calls for nitrogen deposition at the park to be reduced from the baseline loading of 3.1 in 2006 to 2.7 kg N/ha/yr in 2012. Another goal of the NDRP is to "reverse the trend of increasing nitrogen deposition at the park." Determination of the success or failure of the goals of the NDRP will be determined by the weight of evidence. Several analyses will provide the evidence to determine whether an interim goal is achieved or not. These analyses may be modified as better information becomes available and will include, but are not limited to:

- Assessment of progress along the glidepath – This assessment compares current wet N deposition (calculated as the most recent 5-year average) at the Loch Vale NADP site to the interim goals on the NDRP glidepath. This analysis allows us to answer the question: Is wet nitrogen deposition in 2012 (calculated as the 5-year average from 2008-2012) below the first interim goal of 2.7 kg/ha/yr?
- Long-term trends analyses for RMNP and other regional sites – These analyses show how nitrogen in precipitation has changed over the period of record. Loch Vale began monitoring precipitation chemistry in 1983, so the period of record is 25 years. Deposition is an additive process, meaning that each year more nitrogen is being added to the ecosystem. Statistical trends on several different parameters (including nitrogen deposition, nitrate and ammonium deposition, nitrate and ammonium concentration, and precipitation) will provide information on how nitrogen has changed over time. It is also important to ensure that data from Loch Vale are consistent with other sites that are exposed to similar Front Range emissions. Four other NADP sites will be included in the analyses to provide a regional context. All of these analyses will allow us to answer the question: Has nitrogen decreased at the park, and at other sites in the region?
- Shorter-term trends analyses for RMNP and other regional sites – These analyses show how nitrogen in precipitation has changed over a more recent time period, which is more responsive to recent changes in emissions. Statistical trends on several different parameters provide information on how nitrogen has changed in the past 5 or 7 years. Both time periods were evaluated because trends are more difficult to evaluate statistically using shorter time periods. The parameters include inorganic nitrogen deposition (kg N/ha/yr), nitrate and ammonium concentrations (μeq/L), and precipitation (cm). This information will allow us to answer the question: Has nitrogen recently decreased at the park, and at other sites in the region?

A detailed description of these analyses and results are included in Appendix B.

B. Triggering Mechanism

The MOU agencies will work together each year to update the analyses used to track nitrogen deposition at the park (Appendix B-3) with the most recently available data. They will meet annually in the fall of each year to discuss the analyses and determine whether the Contingency Plan should be revised based on new information. Public input and consultation will occur prior to this Plan revision. The RMNP website (www.cdphe.state.co.us/ap/rmnp.html) will be updated after this annual meeting. A summary of the meeting, glide path progress, and task developments will be available to the public and contain updated task information and nitrogen deposition data by the end of the calendar year annually.

Within 180 days of the issuance of the NADP data in 2013, 2018, 2023, and 2028, by a weight of evidence approach, the MOU agencies will evaluate how deposition is changing at RMNP and determine whether an interim goal was achieved. This weight of evidence approach expands the basic "glidepath" approach (which relies on a rolling 5-year average of deposition data collected at Loch Vale) presented in the 2007 Nitrogen Deposition Reduction Plan to also include an analysis of regional deposition trends, N emission trends, precipitation amounts, and other factors the MOU agencies deem relevant. The findings will be posted on the Rocky Mountain National Park Initiative website (http://www.cdphe.state.co.us/ap/rmnp.html).

At the end of this 180 day period, if the agencies concur that a goal was not achieved ("the concurrence"), the contingency process will be triggered and the MOU agencies will immediately work to identify and evaluate contingency measures for proposal and implementation, as appropriate. Depending on the contribution of various pollutants to nitrogen deposition, contingency measures may be directed towards reducing the emissions of NO_x, ammonia/ammonium, or both.

C. Process for Recommending and Implementing Contingency Measures

Within 30 days of "the concurrence" that a goal was not met, the MOU agencies will initiate a committee process to develop appropriate contingency measures for proposal and implementation. At a minimum, the committee will include representatives from all three MOU agencies as well as representatives from industrial facilities, the livestock industry, crop production industry, environmental groups, and affected local, state, and federal agencies. Any contingency measure developed will include the consideration of the following:

- A review of available monitoring, emissions, depositions, and modeling (e.g. RoMANS) data and any additional technical evaluations;
- The latest understanding of contributions from various sectors and source regions to nitrogen deposition in RMNP;
- A review of NOx emission reductions and their potential for improving nitrogen deposition conditions; and
- The status of ammonia-reducing best management practices for the agriculture and urban sectors and any associated research efforts.

If future, planned emission reductions are determined to not make the necessary nitrogen deposition improvements, within 120 days of "the concurrence", the committee will present a recommended course of action to the MOU Agencies' management.

Within 180 days of "the concurrence", the MOU agencies will complete their review of the committee's recommendations and present a recommended course of action to the AQCC for consideration. The MOU agencies will request that the AQCC hold a public hearing, as appropriate, to consider the MOU Agencies' recommendation(s), along with all other measures and approaches the Commission believes may be appropriate to effectively address nitrogen deposition issues in RMNP. Adopted approaches and contingency measures will then begin to be implemented within one year of "the concurrence".

D. List of Potential Contingency Measures

The MOU agencies will evaluate potential strategies in order to expedite nitrogen deposition reduction recommendations in the most appropriate and effective manner possible. These strategies include, but are not limited to:

Nitrogen Oxides

- Stationary source NOx controls, such as:
  - Fuel additives and switching
  - Combustion controls
  - Post-combustion controls
- Gasoline and diesel vehicle NOx controls, such as:
  - Alternative fuels
  - Reformulated fuels
  - Tailpipe controls, such as tightening inspection and maintenance requirements
  - Vehicle miles traveled reduction measures

Ammonia

- Wide-spread implementation of best management practices for livestock and cropping activities that have been identified to show ammonia reduction benefits, such as:
  - Seasonal BMP implementation
  - Refining dietary crude protein in feed rations
  - Designing new dairy freestall barns to promote separation of urine from feces
  - Flushing alleyways with fresh or recycled lagoon water
- Urban ammonia controls, such as:
  - Wide-spread implementation of methods (such as public education campaigns) to improve urban fertilizer application efficiency, reducing urban fertilizer usage
- Industrial and mobile source ammonia controls, such as:

- Ammonia- and NOx-reducing techniques at water treatment facilities
- Ammonia reducing techniques for land applications of bio-solids ("sludge" from in- and out-of-state water treatment facilities
- Vehicle miles traveled reduction measures and technology applications.

In addition to these potential strategies, the contingency measures may consist of commitments that will allow the MOU agencies to better achieve future nitrogen deposition goals, such as, but not limited to:

- Further refinement of our understanding of the sectors and source regions that contribute to nitrogen deposition conditions and our understanding of the benefits of emission control programs inside and outside of Colorado
- Identifying potential strategies that have legal authority limitations and developing approaches to address these limitations
- Funding research efforts to better understand ammonia emissions from agriculture, urban fertilizer use, vehicles, and water treatment facilities
- Enhancing ammonia monitoring throughout the state
- Considering methods and approaches that would allow for enhanced control of emissions from unregulated and under-regulated sources
- Pursuing emission reductions from outside of the State of Colorado

E. Public Outreach & Participation

Informal

- Stakeholder meetings will be held if it is determined that interim goals are not being achieved
- Stakeholder discussions will be initiated within 90 days of the notification that a goal is not being achieved, and will likely continue until a formal Air Quality Control Commission public hearing process begins

Formal

- The AQCC public comment process that occurs during a formal public hearing will serve as a mechanism for stakeholders and the public to provide input on any recommended contingency measure approach. The Commission may initiate stakeholder discussions as it may determine appropriate.