

## Final report for Task # J2350064155 (September 2006 – December 2007)

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### 1. Overview of Project

The National Parks are immensely popular public resources. Protection of these national treasures requires understanding of various threats to park resources. Included are threats to visibility and to sensitive ecosystems. The research in this project relates directly to diagnosing and remedying air quality problems in our national parks. It provides the basis for informed decision-making about steps to protect park resources by improving and managing air quality.

The long-term goals of this project are to improve understanding of visibility degradation in national parks, to improve understanding of deposition of pollutant species to sensitive park ecosystems, to diagnose contributors to air quality problems in specific parks, and to generate fundamental new knowledge about specific pollutant species contributing to air quality problems in national parks. Attainment of these goals involves the planning, execution, and analysis of field measurements of air quality at select national parks.

### 2. Major National Park Service Research Activities Completed by CSU

- ***Fate and Origin of Nitrogen and Sulfur Pollutants in Rocky Mountain National Park***

Rocky Mountain National Park is experiencing a number of deleterious effects due to atmospheric nitrogen and sulfur compounds. These effects include visibility degradation and changes in ecosystem function and surface water chemistry from atmospheric deposition. The nitrogen compounds include both oxidized and reduced nitrogen. Emissions of both nitrogen and sulfur compounds will need to be reduced to alleviate these deleterious effects. A large field campaign and modeling effort was conducted in spring/summer 2006 to further our understanding of what will be needed in the longer term to address effects at the park, and to reduce uncertainties for future planning efforts.

During this project we completed chemical analysis of aerosol, trace gas, and precipitation samples collected during the 2006 Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS)

study. We also assembled and reviewed real-time monitoring data from the RoMANS study, including particle size distributions, trace gas concentrations, and fine particle composition. Initial findings from the RoMANS study were presented both to stakeholder groups and at scientific conferences, including meetings of the National Acid Deposition Program (NADP). Work was initiated on the preparation of multiple manuscripts for publication in peer-reviewed journals. Chief accomplishments from our efforts are outlined below:

- Analysis of denuder and filter-pack samples collected at all RoMANS field study sites
  - Analysis of precipitation samples collected at all RoMANS field sites
  - Measurements of organic nitrogen in selected RoMANS precipitation samples
  - Preparation and submission to NPS personnel of RoMANS data sets including continuous trace gas concentrations, PM<sub>2.5</sub> speciation, denuder trace gas concentrations, particle size distributions, event and sub-event precipitation amounts and composition
  - Comparison of wet and dry nitrogen and sulfur deposition fluxes at the Rocky Mountain NP RoMANS core study site
  - Presentations of RoMANS findings at the 2006 and 2007 National Acid Deposition Program Annual Meetings
  - Presentations of RoMANS findings at the Air and Waste Management Association 2007 Annual Meeting
  - Presentations of RoMANS findings at the 2006 and 2007 Fall Meetings of the American Geophysical Union
  - Fall 2006 presentation of initial RoMANS observations to the CDPHE Agricultural Air Quality Committee
  - Preparation of a first draft journal manuscript highlighting wet deposition fluxes during the RomANS study
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- *Analysis and publication of findings from previous NPS air quality monitoring projects*

During this project CSU researchers continued to analyze data from prior NPS-sponsored field campaigns. The primary focus was on analysis, presentation, and publication of findings from the Nitrate Study campaigns conducted during the 2003-04 period and from the 2002 Yosemite Air Quality Study. Presentations from these projects were made at a number of scientific meetings including the 2006 fall meeting of the American Geophysical Union, the 22<sup>nd</sup> Clean Air Conference, and the Conference on Visibility, Aerosols and Atmospheric Optics in Vienna. A journal manuscript concerning the importance of coarse mode aerosol nitrate at IMPROVE monitoring sites was submitted to, and accepted for publication in, *Atmospheric Environment* (Lee et al., in press). A second manuscript, describing temporal variability in PM<sub>2.5</sub> aerosol composition at rural IMPROVE sites is currently in review at *Atmospheric Environment* (Lee et al., in review).

- ***Maintenance and operation of the NPS Mobile Air Sampling Laboratory***

During this project CSU researchers continued to maintain, improve, and operate the NPS Mobile Air Sampling Laboratory (MASL). The MASL was deployed during this time period in support of smoke characterization studies conducted in spring 2007 at the USDA-FS Fire Science Laboratory in Missoula, Montana.

### **Project Deliverables**

Deliverables for this project include submission of several RoMANS project data sets and submission of this final report. In addition, quarterly progress reports were delivered throughout this project to NPS personnel. The following RoMANS data sets were submitted to NPS personnel as promised: (1) continuous gas measurements, (2) precipitation composition and amount, (3) 24 hr denuder/filter-pack measurements, (4) Semi-continuous PM<sub>2.5</sub> composition measured with a Particle Into Liquid Sampler (PILS), (5) Particle size distributions.

### **Project presentations and publications**

Aerosol Number and Volume Concentrations During the Rocky Mountain Nitrate and Sulfate Study (ROMANS), EZRA LEVIN, Gavin McMeeking, Christian Carrico, Jeffrey Collett, Jr., Sonia Kreidenweis, William Malm, 11J.6, American Association for Aerosol Research Conference, Sept. 2007.

Air Quality Observations during the 2006 Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS), Christian M. Carrico, Jeffrey L. Collett, Jr., Sonia M. Kreidenweis, Taehyoung Lee, Suresh Raja, Amy Sullivan, Courtney Gorin, Katie Beem, Gavin R. McMeeking, Department of Atmospheric Science, Colorado State University, William C. Malm, Derek E. Day, Bret A. Schichtel, Michael Barna, Kristi Gebhardt, Jenny L. Hand, Marco Rodriguez, CIRA/U.S. National Park Service presented to the Rocky Mountain States Section Air and Waste Management Conference, May 2007.

An Overview of the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (ROMANS). Malm, W., Schichtel, B., Barna, M., Gebhart, K., Day, D., Collett, Jr., J., Kreidenweis, S., Carrico, C., Lee, T., Schwandner, F., Proceedings of the 100th Air and Waste Management Association Annual Meeting, Pittsburgh, Pennsylvania, 2007.

Atmospheric aerosol particles and their impact on visibility, J. Collett, presented at the 22nd Annual Clean Air Conference, Keystone, CO, Sept. 28, 2006.

Nitrogen transport and deposition in Rocky Mountain National Park, Collett, J., presented to the CDPHE Agriculture team, Denver, Colorado, Sept. 2006.

Nitrogen transport and deposition during the Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) study Collett, J.L., S. Raja, C. Taylor, C.M. Carrico, F. Schwandner, K. Beem, T. Lee, A. Sullivan, D. Day, G. McMeeking, S. Kreidenweis, J. Hand, B. Schichtel, W. Malm, *Eos Trans. AGU*, 88(52), Fall Meet. Suppl., B24A-02, 2007.

Observations of airborne pollutants and deposition during the 2006 Rocky Mountain Airborne Nitrogen and Sulfur (RoMANS) study, Collett, J., Gorin, C., Raja, S., Carrico, C., Lee, T., Schwandner, F., Day, D., Sullivan, A., McMeeking, G., Kreidenweis, S., and Malm, W. Proceedings of the 100th Air and Waste Management Association Annual Meeting, Pittsburgh, Pennsylvania, 2007.

Observations of fine and coarse particle nitrate at several rural locations in the United States, Lee, T., Yu, X.-Y., Ayres, B., Kreidenweis, S. M., Malm, W. C., and Collett, Jr., J. L., *Atmos. Environ.*, in press. doi:10.1016/j.atmosenv.2007.05.016.

Observations of hygroscopic and optical properties of biogenic secondary organic aerosol generated using a simple continuous flow reaction chamber, Markus D. Petters, GAVIN R McMEEKING, Taehyoung Lee, Sonia M. Kreidenweis, Christian M. Carrico, Jeffrey L. Collett, Jr., Paul J. Ziemann, 11K.8, American Association for Aerosol Research Conference, Sept. 2007.

Representativeness of the ROMANS spring and summer monitoring campaigns, Schichtel, B., Gebhart, K., Hand, J., Day, D., Collett, J., Barna, M., Rodriguez, M. And Malm, W., Proceedings of the 100th Air and Waste Management Association Annual Meeting, Pittsburgh, Pennsylvania, 2007.

Semi-continuous measurement of PM<sub>2.5</sub> ionic composition at several rural locations in the United States, T. Lee, X. Yu, S. M. Kreidenweis, W. C. Malm, and J. L. Collett, Jr., *Atmos. Environ.*, in review.

The contribution of biomass combustion to ambient particulate organic carbon, J. COLLETT, A. Sullivan, G. Engling, C. Gorin, P. Herckes, L. Mazzoleni, A. Holden, S. Kreidenweis, W. Malm, W.M. Hao, 2007 Regional Haze Science Meeting, Timonium, MD, July 2007.

The importance of coarse mode aerosol at several IMPROVE monitoring sites, T. Lee, X. Yu, B. Ayres, S. M. Kreidenweis, J. L. Collett, Jr., and W. Malm, Vienna, Austria, Sept. 2006.

The Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) Study Sampling Network and Initial Results, C. Gorin, J. Collett, W. Malm, C. Carrico, S. Kreidenweis, T. Lee, S. Raja, D. Day, J. Hand, F. Schwander, B. Schichtel, K. Gebhart, A. Sullivan, G. McMeeking, and K. Beem, presented at the 2006 Annual Meeting of the National Acid Deposition Program, Norfolk, VA, 24-26 Oct. 2006.

Understanding Anthropogenic Impacts on Air Quality at Rural Locations Using High Time Resolution Particle Composition Measurements, J.L. Collett, Jr., T. Lee, X-Y. Yu, A.

Sullivan, S.M. Kreidenweis, and W. C. Malm, *Eos Trans. AGU*, 87(52), Fall Meet. Suppl., Abstract A13H-07, AGU Conference, Dec. 2006.