V. WRNF AIR RESOURCE MONITORING

As directed by the Wilderness Act and the Clean Air Act, the Forest Service is responsible for protecting the ecosystems of wilderness areas under its administration. In addition, the Clean Air Act also requires that the Forest Service comply with local, state and federal air quality regulations and directives. Given these requirements the objectives of Forest Service air resource management are[1]:

1. Protect air quality related values within class I areas, as described in 42 U.S.C. 7475(d)(2)(B) and (C) and section 2580.5.
2. Control and minimize air pollutant impact from land management activities.
3. Cooperate with air regulatory authorities to prevent significant adverse effects of air pollutants and atmospheric deposition on forest and rangeland resources.

To comply with these requirements, the WRNF has established an air quality monitoring program. Much of the program focuses on the protection of air quality related values (AQRVs) in Class I and Class II wilderness areas. Data collected can be used to determine general ecosystem health related to ambient air quality conditions, for use in NEPA disclosures including modeling of project impacts, and for use in the Prevention of Significant Deterioration (PSD) permit process. Results of the WRNF AQRV monitoring effort are presented in this section.

The importance of collecting air quality related data was underscored in 1993 when the Forest Service submitted a letter to the State of Colorado certifying visibility impairment in the Mt. Zirkel Wilderness. Data from a nearby IMPROVE monitor was used to support this certification. Following additional monitoring and a lawsuit filed by the Sierra Club and the EPA against the Hayden Power Plant, steps were taken to reduce emissions from this site.

Other monitoring efforts on the WRNF include documentation of the effects on air resources of wildland fires. This information assists the Forest in determining compliance with local, state and federal laws and regulations as well as with mitigation measures identified in NEPA documents. Results of these efforts are tied to specific projects and, as such, are not presented in this section.

[1] USDA, Forest Service Manual 2580.2.

A. Visibility Monitoring

Section 169A of the Clean Air Act states, "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution." Within the Clean Air Act, visibility is specifically mentioned as a Class I air quality related value that must be protected.

Visibility monitoring is a critical component to protecting AQRV's on the WRNF. The data can be used to model potential management impacts to visibility as well as to answer the following questions:

1. Is visibility affected by changes in concentration of particulates, SOx, NO2, NOx, or organic and inorganic carbons?
2. What types of particulates most commonly cause visibility impairment on the Forest?
3. What is the current visibility from the selected viewpoints? How does it change seasonally?
4. What is the median and best (90th percentile) visual range that is representative of wilderness visibility for use in PSD analysis?

The first visibility monitoring efforts on the WRNF were via photographic images to records specific scenes. Current visibility monitoring on the Forest is through IMPROVE, an aerosol monitoring program. Additional information for the lay person regarding visibility monitoring can be found in the following online document entitled "Introduction to Visibility" by William Malm: http://vista.cira.colostate.edu/improve/Education/intro_to_visibility.pdf.

1. MONITORING DESCRIPTIONS

Photographic Images

Since the 1970's photographic images were used to establish visibility conditions at Class I wilderness areas on the WRNF. Between 1991 and 1999, visibility at the Maroon Bells-Snowmass Wilderness was monitored using photographic images. These images were archived and are available at http://www.fsvisimages.com/gallery/MABE/start.htm. Scene monitoring via photographic images of Eagle's Nest Wilderness was conducted between 1993 and 2000. These images are available at http://www.fsvisimages.com/gallery/EANE/start.htm.

Results of the photographic effort yielded standard visual range (SVR) values of 262 km for the Maroon Bells-Snowmass Wilderness and 314 km for Eagle's Nest.

In the late 1990's the use of cameras for visibility monitoring was discontinued nationally and the resulting photographs archived for baseline reference. Today, the agency monitors visibility trends through the IMPROVE program. More detail of past scene monitoring efforts on the WRNF can be found in Appendix A.

IMPROVE PROGRAM

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program was established in 1985 to aid in the protection of visibility in Class I areas. The four objectives of IMPROVE are to:

1. establish current visibility and aerosol conditions in mandatory Class I areas;
2. identify chemical species and emission sources responsible for existing man-made visibility impairment;
3. document long-term trends for assessing progress towards the national visibility goal; and
4. provide regional haze monitoring as part of the enactment of the Regional Haze Rule.

IMPROVE – WHRI Site

An IMPROVE module A monitor was installed at Aspen Mountain (Aspen Ranger District) in 1993 to collect fine mass data including trace elements, sulfates, nitrates, and organics. Named WHRI the monitoring system was upgraded in 1999 to a full IMPROVE which includes four modules that provide more discreet analyses of fine and coarse mass particles that influence visibility.

Wilderness Workshop has partnered with the WRNF to operate and maintain the WHRI IMPROVE site which hosts the highest IMPROVE monitor in the United States (11,200 feet elevation). It is well sited for monitoring regional visibility conditions at all three of the Class I Wilderness areas on the WRNF along with the West Elk Wilderness on the GMUG National Forest.

Because of the elevation of WHRI, local visibility impacts to any of the Class I wilderness areas on the WRNF are not likely picked up by this IMPROVE monitor (pers. comm. with Scott Copeland, USFS visibility data analyst). Other monitoring sites will need to be considered in order to capture air quality impacts to WRNF wilderness areas from the ongoing growth in vehicle travel and natural gas development in western Colorado and eastern Utah, areas upwind of these sensitive air quality areas.

IMPROVE-like Monitor – Ripple Creek Pass

In late 2002, Shell Oil established an air monitoring site near Ripple Creek Pass on the Blanco Ranger District under a Special Use Permit with the WRNF. The site includes IMPROVE instrumentation that is powered by a large array of solar panels. While the monitor is identical to that used in the IMPROVE program, its configuration did not fully meet IMPROVE protocol. As such, the data collected at this site between 2002 and 2008 is not publicly available through the IMPROVE program.

Data up through 2005 from this site has been shared with Scott Copeland (visibility data analyst for the Forest Service). According to Copeland the visibility monitoring location near Ripple Creek Pass is well positioned to detect visibility impacts to the Flat Tops

Wilderness from relatively local oil and gas development occurring in western Colorado and eastern Utah.

In March, 2008, Shell Oil discontinued their IMPROVE monitoring at the Ripple Creek Pass site. The IMPROVE instrumentation has remained on-site, however. The WRNF plans to restart this monitoring effort in 2009.

2. MONITORING RESULTS

Visibility is measured by using a metric called a "deciview", which is basically a change in visibility that the human eye can detect. One deciview represents a 10 percent change in the light extinction equation used to calculate visibility. The higher the deciview, the less a person can see into the distance.

In a visibility report prepared by the Colorado State Air Pollution Control Division (APCD) images are provided to depict natural visibility conditions and actual visibility conditions during monitoring period at WHRI between 2001 and 2004 (CDPHE 2007). Using EPA Guidance the APCD estimated natural visibility for the Maroon Bells-Snowmass Wilderness at 0.52 deciviews for the top 20% of the best visibility days and 6.54 deciviews for the lowest 20% of the worst visibility days (CDPHE 2007). The images below illustrate these visibility conditions.

Figure 6: *Maroon Bells-Snowmass Wilderness – Natural Best Days*

Reference Vista of Maroon Bells-Snowmass Wilderness
WinHaze Modeled Image

Haze Index (HI) = 0.52 deciviews
Bext = 10.5 Mm^{-1}
Visual Range = 371 km/231 mi

(CDPHE 2007)

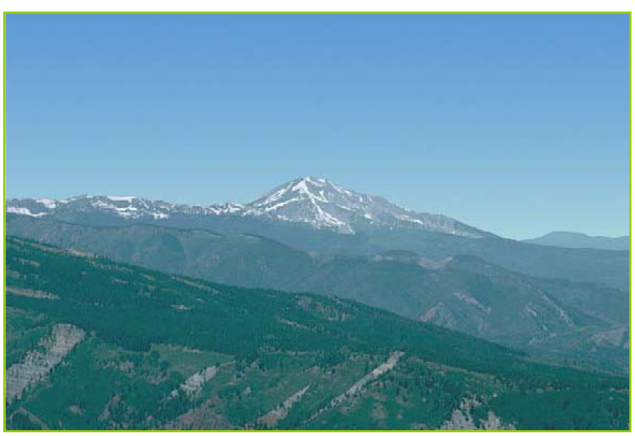

Figure 7: *Maroon Bells-Snowmass Wilderness – Natural Worst Days*

Reference Vista of Maroon Bells-Snowmass Wilderness
WinHaze Modeled Image

Haze Index (HI) = 6.54 deciviews
Bext = 19.2 Mn^{-1}
Visual Range = 203 km/126 mi

(CDPHE 2007)

Figure 8 compares the average condition of the 20 percent best days and 20 percent worst days measured during the 2001-2004 monitoring period.

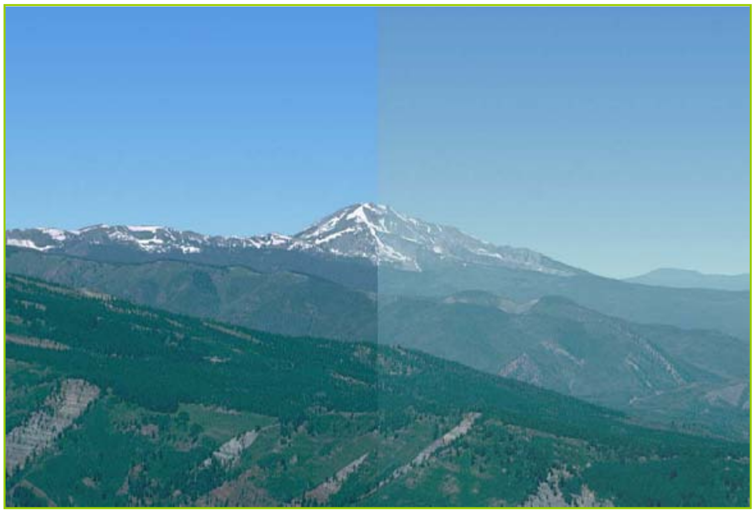

Figure 8: *Maroon Bells-Snowmass Wilderness - Simulation of the Best and Worst Conditions Monitored 2001-2004*

Reference Vista of Maroon Bells-Snowmass Wilderness
WinHaze Modeled Image

Haze Index (HI) =
Best: 0.7 deciviews
Worst: 9.6 deciviews
Visual Range =
Best: 365 km/227 mi
Worst: 150 km/93 mi
(CDPHE 2007)

These images can be found in the Colorado State Regional Haze State Implementation Plan (CDPHE 2007) which used data from the WHRI site to estimate the impacts of Regional Haze to the WRNF's three Class I areas. This report is a requirement under the Regional Haze Rule enacted in 1999 by the EPA to reduce regional haze and improve visibility in national parks and wilderness areas.

Data collected at WHRI between 2000 and 2004 indicates that this site had the best visibility when compared to Colorado's other five IMPROVE sites. However, when the WHRI data is compared to expected natural conditions, visibility degradation is indicated. The APCD is currently working on establishing a *reasonable progress goal* to move visibility impacts during the worst 20 percent days towards natural conditions as well as prevent degradation of the cleanest 20 percent days.

Data from WHRI indicate that the top three major constituents that impact visibility in this area are:

1. organic mass carbon (sources include road dust, mobile sources, fires and industrial activity),
2. ammonium sulfate (major source is coal fired power plants), and
3. coarse mass (sources are the same as organic mass carbon).

Figures 9 and 10 show the composition of visibility reducing particles measured at WHRI between 2001 and 2004.

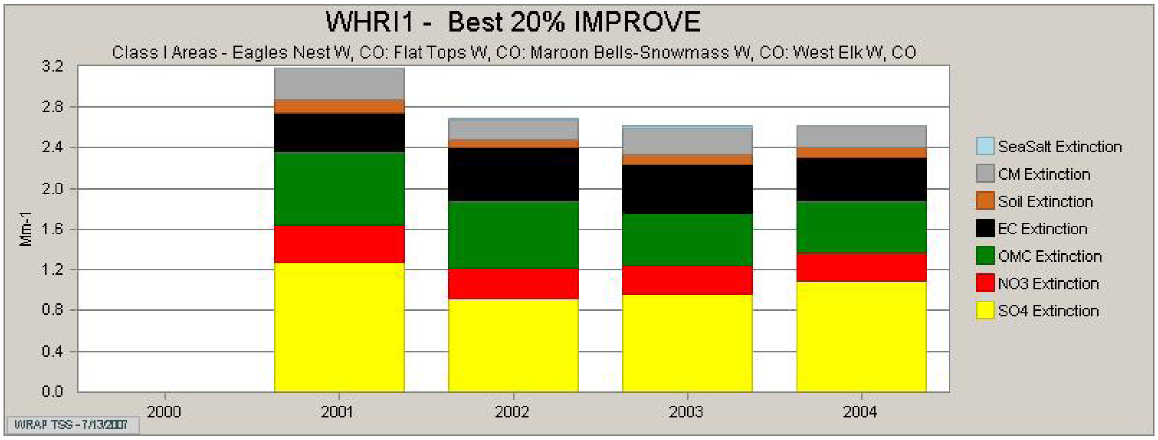

Figure 9. *Reconstructed Extinction for 20% Best Days over Baseline Period*

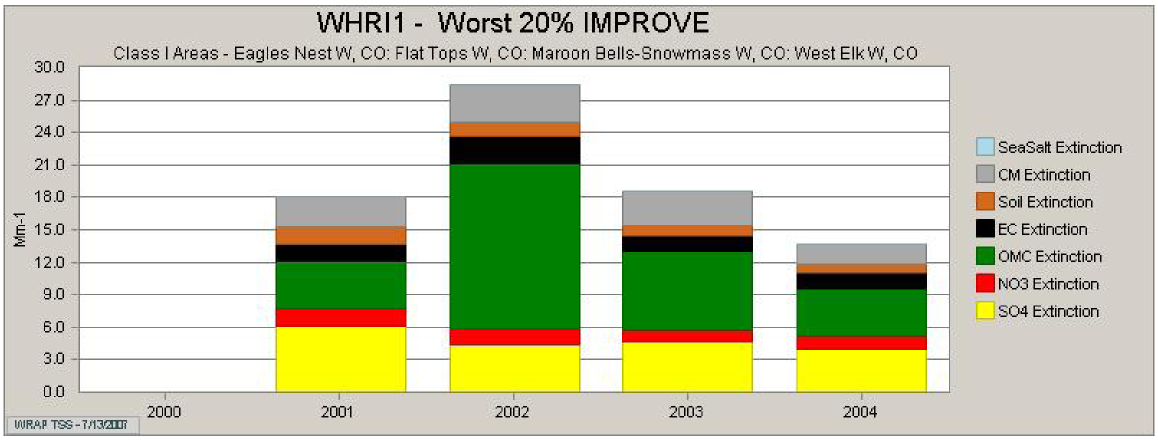

Figure 10. *Reconstructed Extinction for 20% Worst Days over Baseline Period*

An analysis of the sources of emissions reaching WHRI is available online at http://vista.cira.colostate.edu/tss/. Figures 11 through 18 are pie graphs and charts that pertain to 2002 data acquired from this site. The pie charts depict emission contributions by region for the best and the worst 20 percent days. The source titled *CENRAP* essentially represents states within the Midwestern United States. The source title *WRAP* represents Western States. *Outside Domain* is all other sources not specifically identified.

The bar graphs break down the source type (e.g. point, area, mobile) for each source contribution for the best and the worst 20 percent days.

These data indicate that most of the sources of nitrate come from the western states during the best and worst visibility days. Most of the sources of sulfate on the best visibility days are from *Outside Domain* sources. The majority of sulfate sources during the worst visibility days are about evenly split between western states and *Outside Domain* sources.

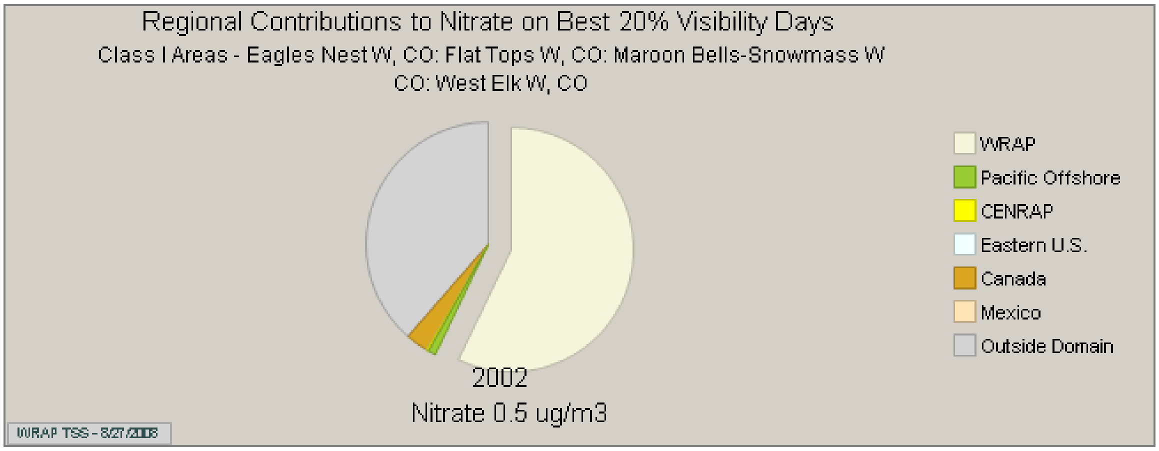

Figure 11. Regional contributions to nitrate at WHRI: Best 20% visibility days.

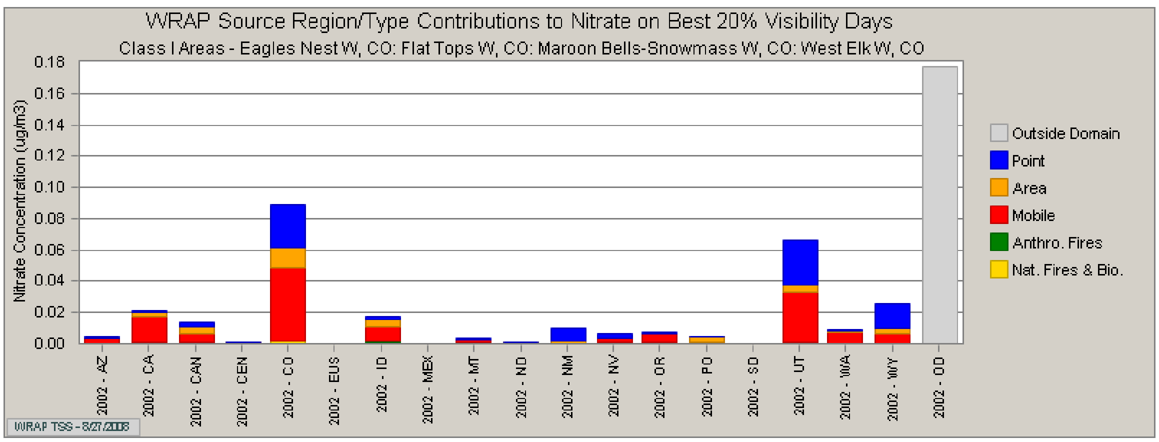

Figure 12. Nitrate source contributions to WHRI by state or region: Best 20% visibility days.

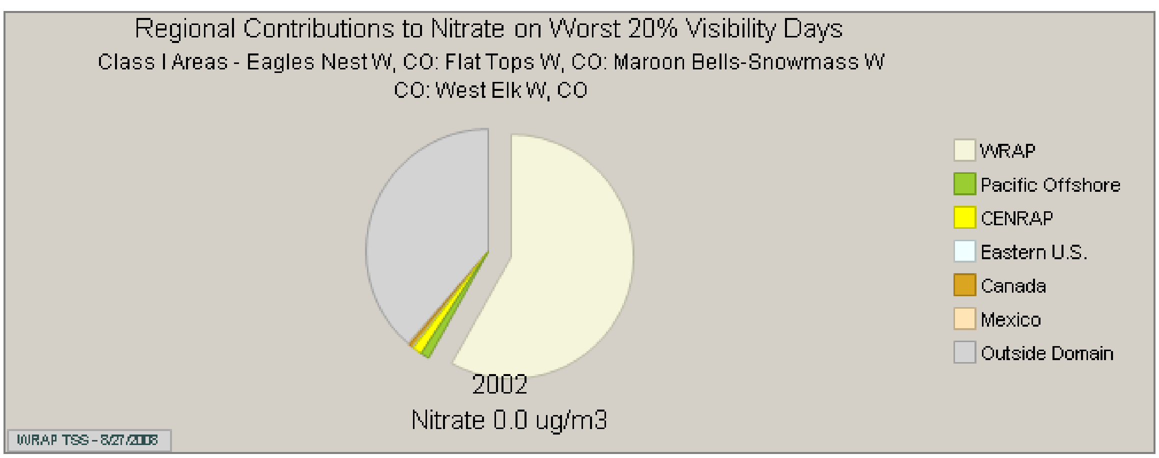

Figure 13. Regional contributions to nitrate at WHRI: Worst 20% visibility days.

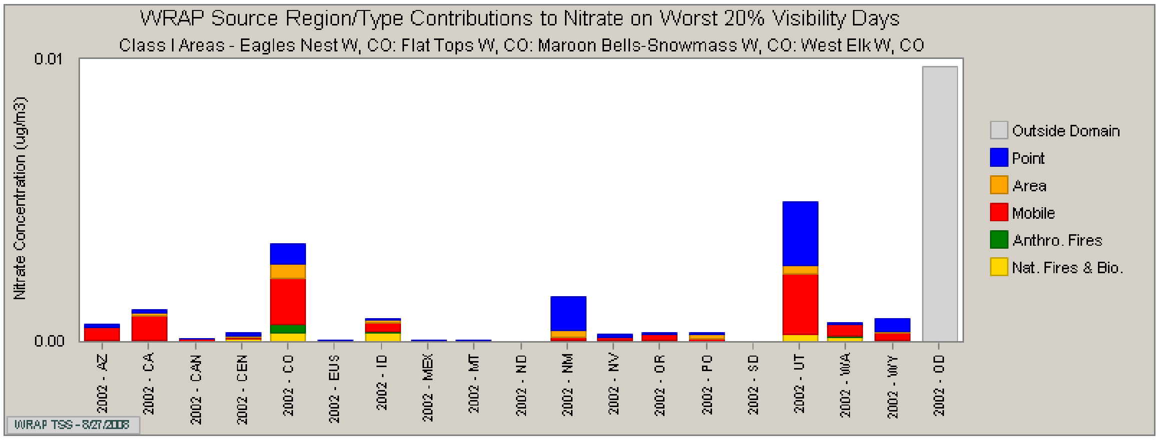

Figure 14. Nitrate source contributions to WHRI by state or region: Worst 20% visibility days.

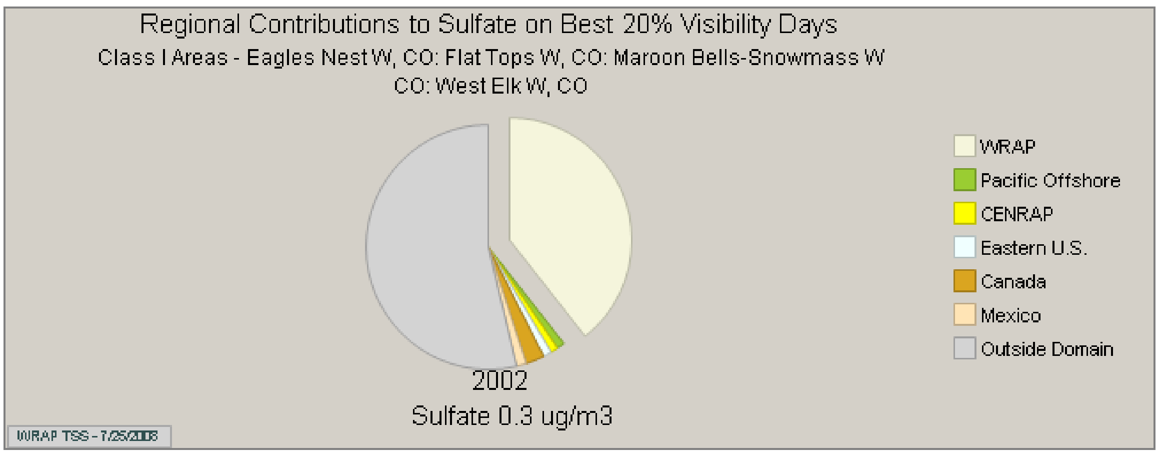

Figure 15. Regional contributions to sulfate at WHRI: Best 20% visibility days.

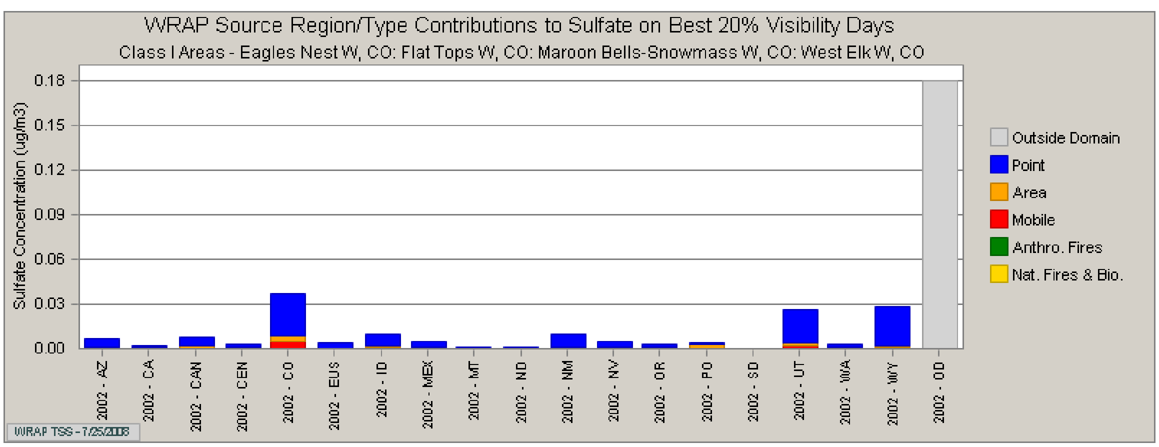

Figure 16. Sulfate source contributions to WHRI by state or region: Best 20% visibility days.

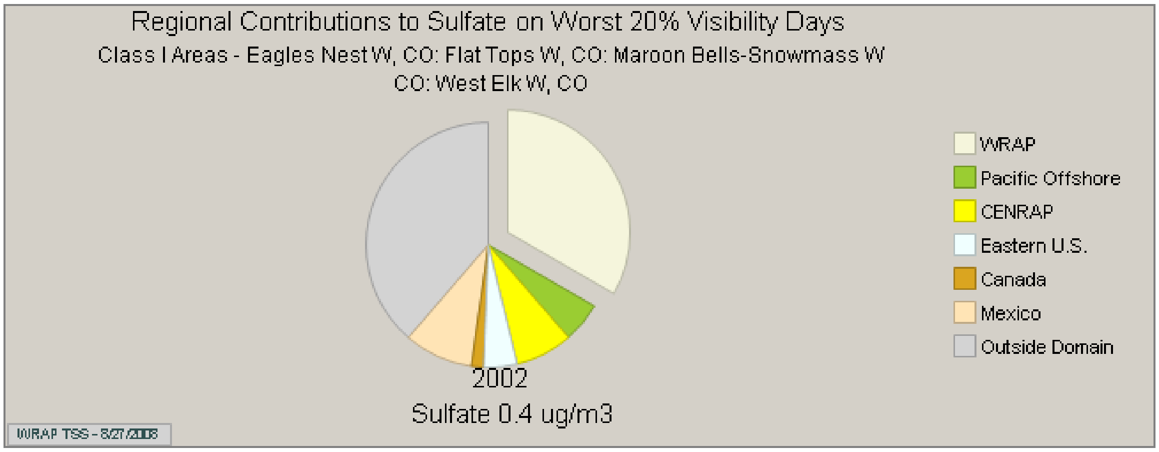

Figure 17. Regional contributions to sulfate at WHRI: Worst 20% visibility days.

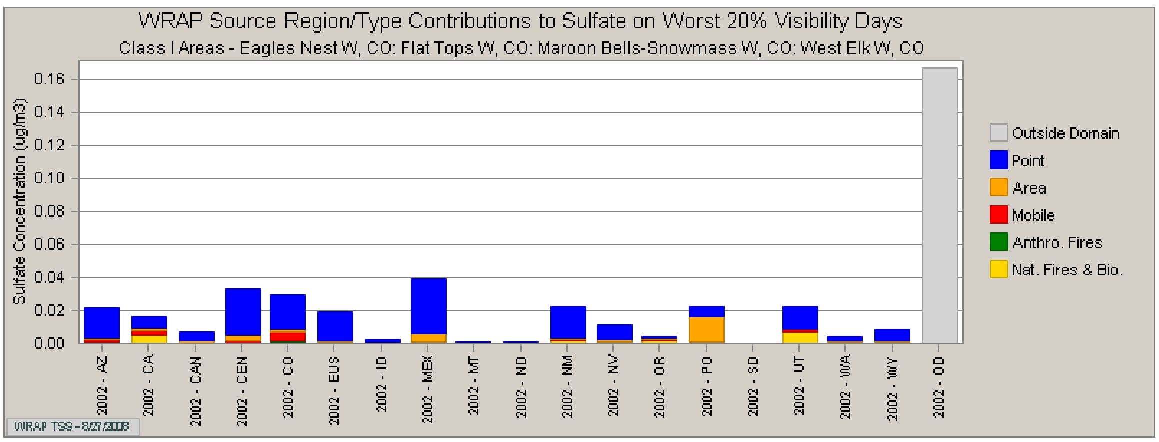

Figure 18. Sulfate source contributions to WHRI by state or region: Worst 20% visibility days.

B. Wilderness Lake Monitoring

Lake sampling on the WRNF has been conducted over the last two decades by the EPA, U.S. Geological Survey (USGS), and the WRNF. These programs have been designed to characterize wilderness lake chemistry and sensitivity to acidic deposition. Data from these monitoring programs have been instrumental in identifying current conditions and trends of acid deposition in selected WRNF wilderness lakes. Past lake monitoring efforts are described in more detail in Appendix A. The section below describes the Forest's current lake monitoring program.

The wilderness lake monitoring program on the WRNF was originally set up to establish baseline data from which to determine future trends in acidic deposition in the Class I and

Class II wilderness areas on the forest. Data from both the USFS and USGS lake monitoring studies are used in air quality modeling efforts to determine the impacts nitrogen and sulfur deposition and on acid neutralizing capacity impacts of large scale management proposals such as oil and gas development. Recent analyses of the program's historic data indicate that the lake monitoring program may also be useful in investigating the role of climate as a driver of changing the chemistry in high elevation lakes.

1. MONITORING DESCRIPTIONS

WRNF WILDERNESS LAKE SAMPLING PROGRAM

Since 1991, the forest has annually sampled from ten established lake monitoring sites in the Holy Cross, Eagle's Nest, Collegiate Peaks, and Maroon Bells-Snowmass Wilderness Areas. Each lake is visited three times throughout the summer, usually between June and late August. Sampling is performed using standard protocol established in 1991 for all Region 2 Forests (see Appendix D and Turk 2001).

Lake samples are sent to the USFS/USGS Air Resource Management Laboratory in Fort Collins for analysis for major anions and cations, pH, acid neutralizing capacity, and conductivity. Lab results are kept on the forest in a database maintained by the Forest Air Resource Specialist.

Training in monitoring protocol is provided sporadically and usually when there is a change in protocol or in personnel performing the work. The five lakes located within the Holy Cross Ranger District are monitored in-house by wilderness program personnel. The five lakes located within the Aspen Ranger District are monitored through an agreement with Wilderness Workshop by one of their employees who has been involved with the lake monitoring program since the early 2000's.

USGS NED WILSON LAKE STUDY

The USGS has been conducting extensive lake chemistry work in the Flat Tops Wilderness since 1981. Their work has contributed to understanding natural long-term variation in lake chemistry. The three lakes identified as sensitive receptors are: Ned Wilson, Oyster, and Upper Island. These lakes were selected because they represent an east-west transect across the Wilderness and because of their low buffering ability, high flushing rates, and no watershed sulfate sources. The significance of the latter is that sulfate levels in these lakes are likely to come from human-caused emissions (Campbell, Turk and Spahr 1990).

Water samples are analyzed in the USFS/USGS Air Resource Management Laboratory in Fort Collins for acid neutralizing capacity (ANC), pH, nitrate (NO_3), ammonium (NH_4), sulfate (SO_4) and a few other chemical constituents.

Up until 2006, the Regional Forester granted the USGS permission to install and maintain monitoring instruments in the wilderness at the Ned Wilson Lake area and to access it by helicopter in the spring when travel to the lake was hindered by avalanche danger. The instrumentation that was installed at the Ned Wilson Lake Area is described in more detail in Appendix A.

In 2006, the Regional Office denied permission to the USGS to continue helicopter access to the Ned Wilson Lake area, requiring the removal of all instrumentation at the area. The bulk precipitation collector has been relocated to a site near Shell Oil's Ripple Creek Pass air monitoring station. Meterological and precipitation data collected at the Ripple Creek Pass station provide an estimate of conditions at the Ned Wilson Lake site. However, data from the streamflow and temperature measuring devices at the Lake site cannot be replicated elsewhere.

Currently water quality samples for major constituents are collected on three separate occasions between July and September from Ned Wilson Lake and four other surface water locations nearby. Samples are collected at one-meter depths in this non-stratified lake using a vanDorn sampler from a raft. Other samples are also collected from an unnamed spring, two potholes, and a small lake tributary to Ned Wilson Lake. In addition, water samples from Ned Wilson Lake are analyzed for total mercury and methylmercury.

2. MONITORING RESULTS

WRNF WILDERNESS LAKE SAMPLING PROGRAM

The WRNF has monitored wilderness lakes for nearly 20 continuous years. In 2008 a statistical analysis of trends in the lake chemistry data was performed. Table 21 presents a summary of this analysis.

Table 21 - Wilderness Lake Chemistry Trends

	Chemical Constituent and Trend[1]									
Lake Name	**ANC**	**Cond.**	**Na**	**NH_4**	**K**	**Mg**	**Ca**	**Cl**	**NO_3**	**SO_4**
Avalanche	+	+	+	NT	+	+	+	NT	NT	+
Capitol	NT	NT	+	+	+	+	+	+	+	+
Moon	+	+	+	NT	+	+	+	NT	NT	NT
Brooklyn	+	+	+	-	+	+	+	-	NT	+
Tabor	+	+	+	+	NT	+	+	-	-	+
Booth	NT	+	+	NT	NT	+	+	NT	NT	-
Willow	+	+	+	NT	+	+	+	+	NT	+
Blodgett	+	+	+	NT	+	+	+	NT	NT	+
Up.W.Tennessee	+	+	+	NT	+	+	+	NT	NT	+
Up. Turquoise	+	+	+	NT	+	+	+	NT	NT	+

[1] ANC = Acid Neutralizing Capacity
Cond. = Specific Conductivity
Na = Sodium
NH_4 = Ammonia
K = Potassium
Mg = Magnesium
Ca = Calcium
Cl = Chloride
NO_3 = Nitrate
SO_4 = Sulfate
'+' = Statistically signif. increase
'-' = Statistically significant decrease
NT = No statistically significant trend

The data presented for sulfate (SO_4) in table 21 seems to contradict monitoring results of regional National Acid Deposition Program (NADP) sites (see section D of this chapter). The NADP study indicates a decreasing trend in SO_4 deposition, whereas the WRNF wilderness lake data show a statistically significant increase in SO_4 in eight of the ten lakes.

Recent research efforts indicate that an increase in air temperature may be the cause of similar trends in SO_4 and other weathering agents in lakes in Austria (Sommaruga-Wograth, et al 1997 and Thies, et al 2007), Canada (Lafreniere 2005) and Colorado (Williams 2006). Further study will be required to determine the cause of the significant trends in SO_4 and other chemical constituents in WRNF wilderness lakes.

USGS NED WILSON LAKE STUDY

Sulfate concentrations appear to be declining which correspond well to trends seen in NADP data. A temporal increasing pattern seen in alkalinity over this time period does not appear to correspond to the sulfate decline (Mast 2008).

C. USGS SNOWPACK CHEMISTRY MONITORING

Snowpack chemistry reflects the winter accumulation of atmospheric deposition in the snowpack. The ion content of a snowpack remains relatively stable prior to initial snowmelt (Cadle 1984; Stottlemyer 1987). Research suggests the first 10-20% of spring snowmelt water may contain 50-70% of the acid rain material in the snowpack, resulting in an "acid pulse" being released into the watershed (Baird 1987; Cadle 1984; Galloway 1987; Phillip 1986; and Stottlemyer 1987).

1. MONITORING DESCRIPTIONS

In 1993 the USGS began taking full depth snow samples each spring at a minimum of 50 sites along the spine of the Rocky Mountains. One of the regularly visited sites, Sunlight Peak, is located on the WRNF. The Forest is a partner with the USGS in this endeavor and assists in data collection at this site.

Up through 2005, the USGS, under USFS authorization, accessed the Ned Wilson Lake site each spring to collect snowpack samples. The site is located within the Flat Tops Wilderness. In 2006, concern was expressed regarding motorized access to the Wilderness. Subsequently, the USFS Regional Office required the USGS to use non-motorized access to the Ned Wilson site or find a surrogate monitoring site outside the Wilderness. Because spring time access to Ned Wilson Lake can entail long days and unsafe travel across avalanche slopes, the USGS decommissioned all of its monitoring equipment at the Ned Wilson site and established a site near Ripple Creek Pass as an alternate.

2. MONITORING RESULTS

For the past five years the USGS has published findings reports for each year's snowpack chemistry data. A 2008 report summarizes the 1993-2004 snowpack chemistry results from 54 snowpack study sites and compares it to the wetfall data collected under the NADP program (16 sites) (Ingersoll *et al*. 2008). Figure 19 displays the study area for this report.

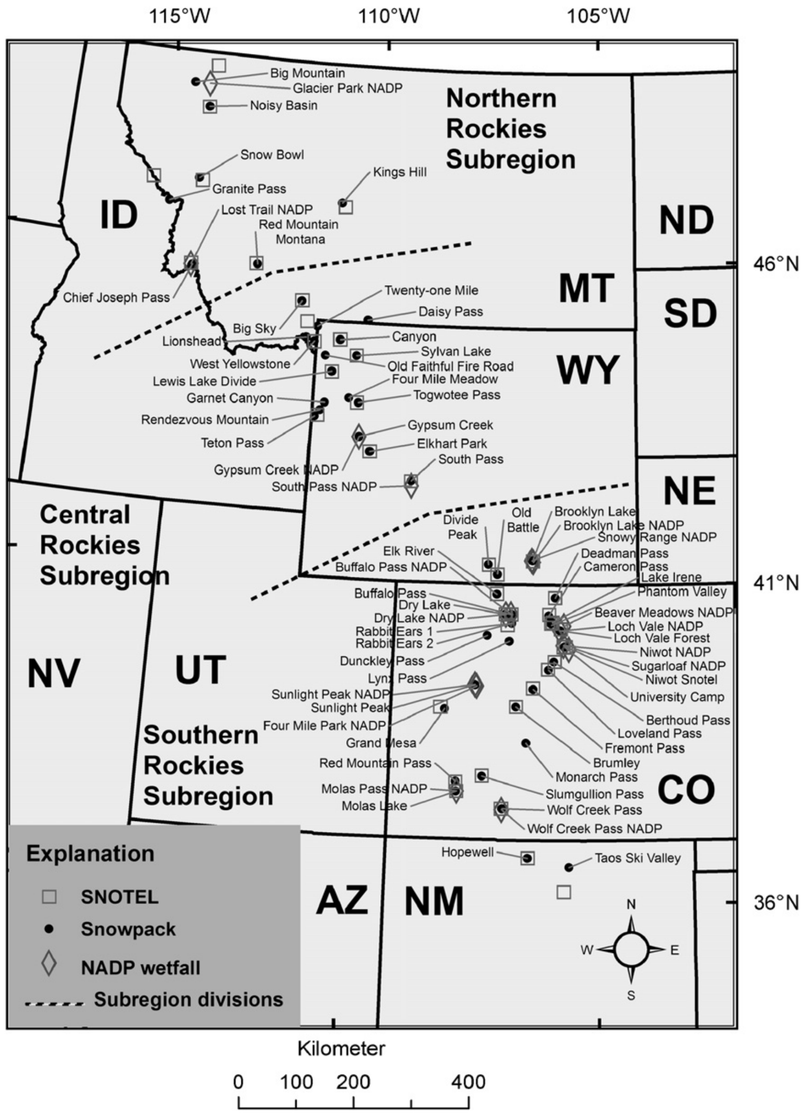

Figure 19. Snowpack study sites and NADP wetfall sites in subregions of the Rocky Mountain Region (Ingersoll *et al*. 2008).

In the Southern Rockies, where the WRNF is located, NADP and USGS monitoring efforts show increasing trends in the concentrations of ammonium (NH4) and nitrate (NO_3) and decreasing trends in sulfate (SO_4). Figure 20 displays these findings.

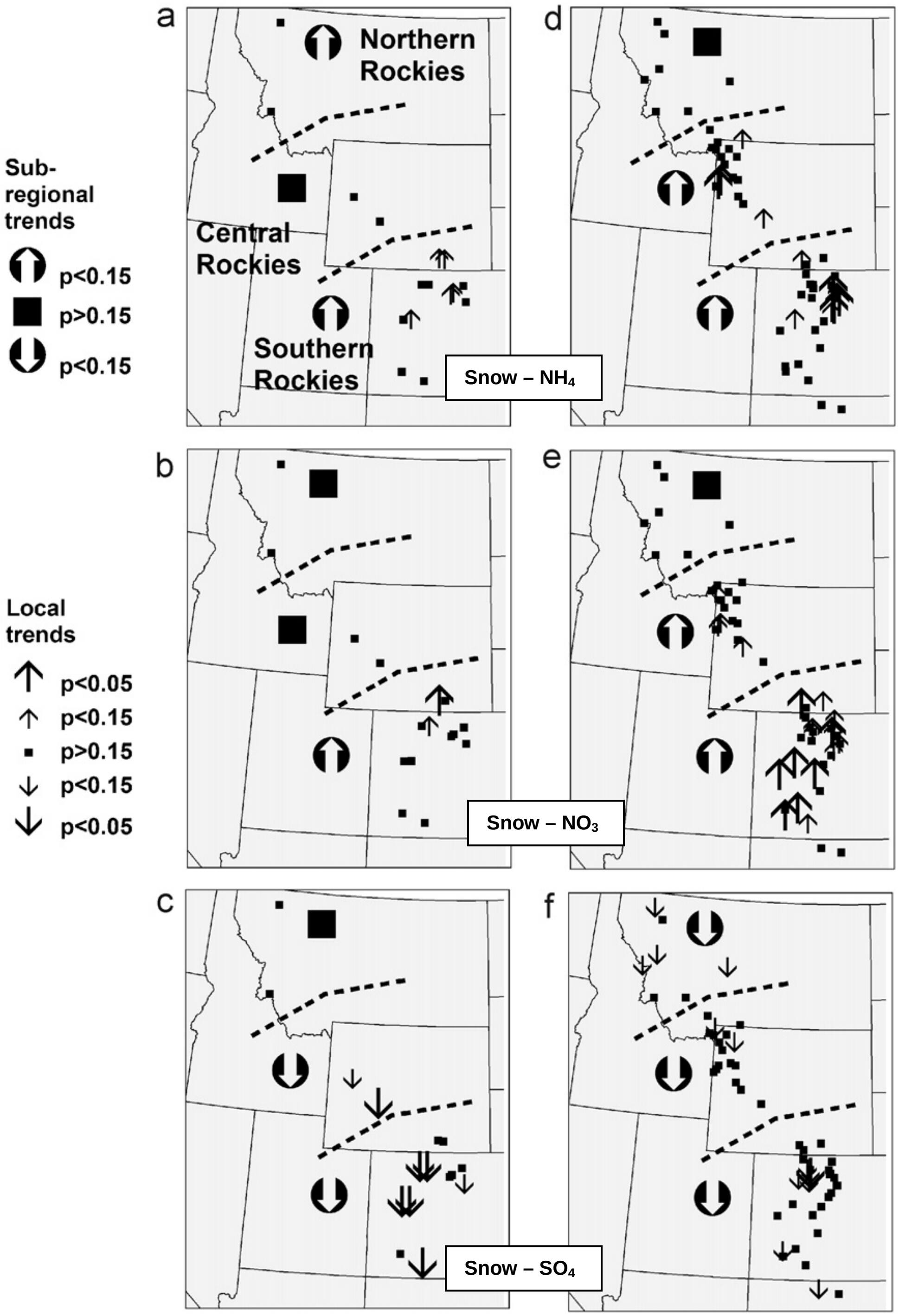

Fig. 20. Concentration trends at NADP wetfall sites (a-c) and USGS snowpack sites (d-f) in the Rocky Mountain region. Dashed lines divide subregions. Arrows indicate trend directions. Solid squares indicate no significant trend (Ingersoll *et al*. 2008).

An analysis of atmospheric deposition indicates that within the wilderness areas on the WRNF nitrate deposition is between 0.5 to 2.0 kilograms per hectare (kg/ha) and sulfate deposition is 2.0 to 6.0 kg/ha (Nanus *et al*. 2003). These values represent moderate levels of deposition. Higher values occur along the Front Range of Colorado and in the Park Range of northwest Colorado where local sources including urban development and power plants are prevalent sources.

In order to obtain a perspective of atmospheric deposition rates along the Rocky Mountains, the following figures 21 through 23 show average snowpack concentration values for ammonium, nitrate and sulfate as monitored by the USGS between 1993 and 1997 (Ingersoll *et al*. 2001). The diameter of the circle represents average concentration values. Site number 36 is located on the Grand Mesa; site 47 is Sunlight Peak; site 48 is near Trapper's Lake.

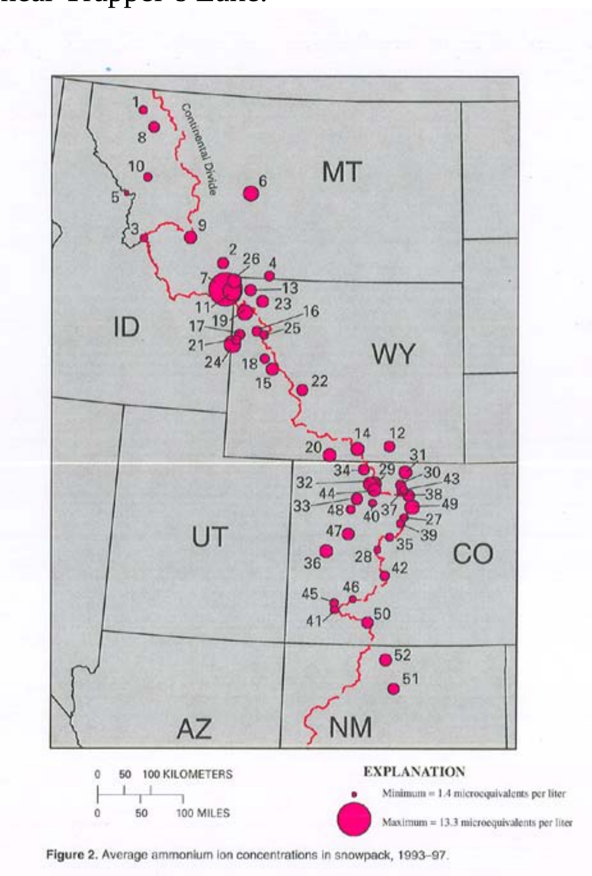

Fig. 21. USGS snow pack survey: average ammonium concentrations.

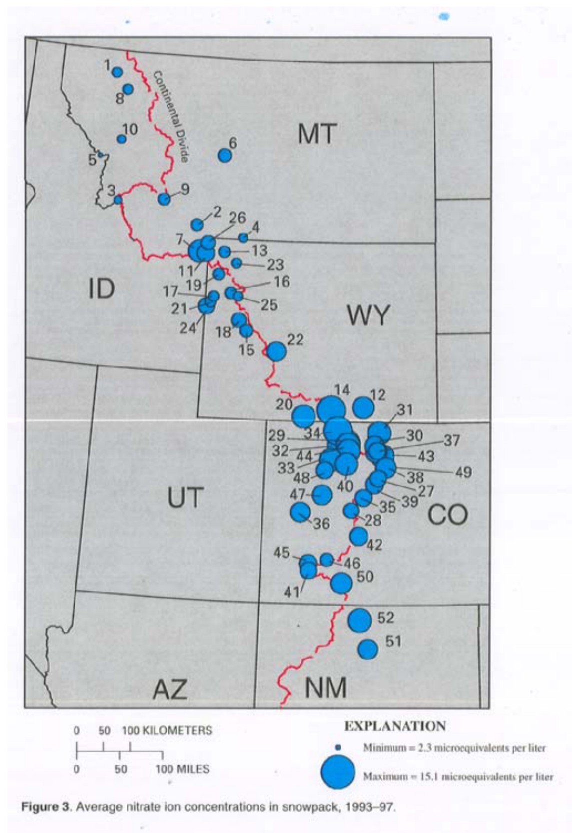

Fig. 22. USGS snow pack survey: average nitrate concentrations. *(Note that the higher nitrate concentrations occurred along the continental divide in northern Colorado and southern Wyoming.)*

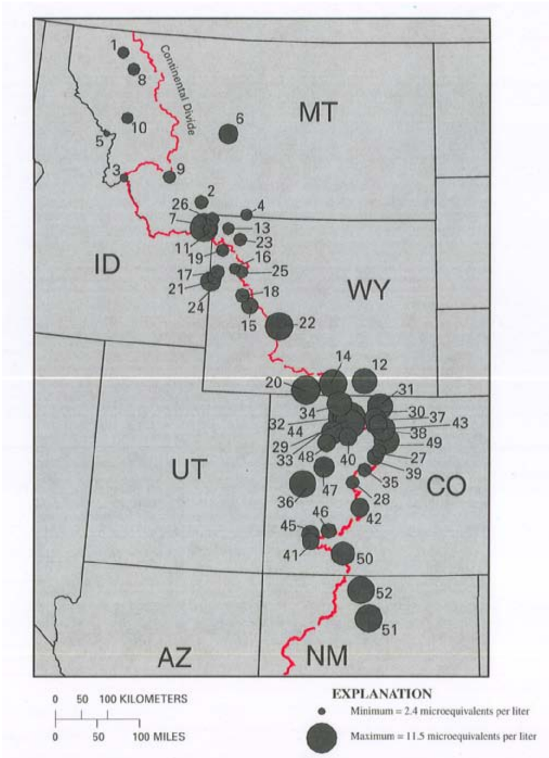

Fig. 23. USGS snow pack survey: average sulfate concentrations. The higher concentrations in WY, CO and NM are generally downwind of industrial sources such as coal fire power plants.

Fig 24. George Ingersol (USGS) takes a snow sample at the Sunlight Peak snow chemistry monitoring site.

Trapper's Lake in the Flat Tops Wilderness

D. NADP Monitoring Program - WRNF

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The purpose of the network is to collect data on the chemistry of precipitation for monitoring geographical and temporal long-term trends. It provides data for use by researchers, land managers, policy makers, and others concerned with atmospheric deposition.

The NADP/NTN program is a cooperative effort between many different groups, including the State Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and other governmental and private entities. The NADP/NTN has grown from 22 stations in 1978 to over 250 sites spanning the continental United States, Alaska, Puerto Rico, and the Virgin Islands.

In partnership with the Environmental Protection Agency (EPA), the WRNF has operated and maintained two NADP monitoring sites on the Forest since 1988. These sites are the Sunlight Peak station (Site No. CO92) and at Four Mile Park near Ski Sunlight Resort (Site No. CO08).

1. MONITORING DESCRIPTION

The WRNF operates and maintains two NADP sites: **Four Mile** (located near the base of Sunlight Ski Resort at about 8,210 feet elevation) and **Sunlight** (located at the top of Sunlight Peak at about 10, 560 feet elevation). Both sites are located on the Sopris Ranger Station and were established in 1988. The Sopris District staff make weekly visits to the sites to collect precipitation samples. Preliminary tests are performed on the samples in the office and then sent to the NADP Central Analytical Laboratory where they are analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium).

Specific protocols are followed in site location, operation, and sample collection. A copy of these protocols can be found on the Sopris Ranger District office. Quality assurance and control techniques are employed in the analytical procedures and in the overall site operation, and assure that the data is of sufficient quality to be used in the regulatory process. Data are available online at http://nadp.sws.uiuc.edu/.

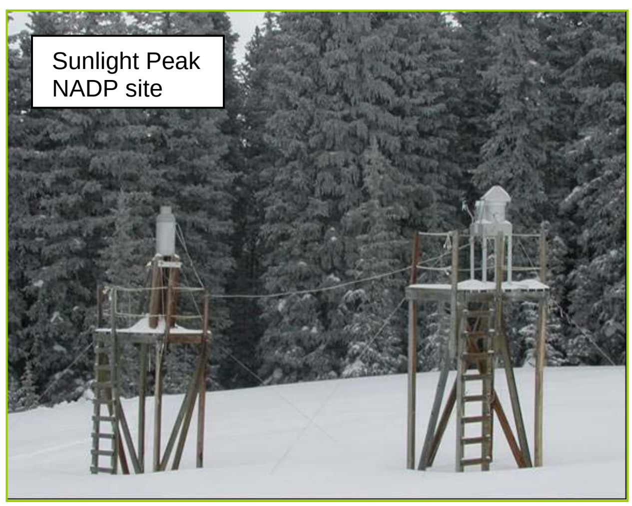

Figure 25. Sunlight Peak NADP Site

2. MONITORING RESULTS

Trend analyses indicate that sulfate deposition (SO_4) is decreasing at both stations. This trend is also being seen nationwide. Generally in the west, the trends for ammonium (NH_4) and nitrate (NO_3) concentrations are increasing. Four Mile Park is seeing statistically significant trends of increasing nitrogen deposition and ammonium concentrations (Burns 2003).

The following graphs of chemical constituents of interest are available through the NADP website (http://nadp.sws.uiuc.edu/). Figures 26 and 27 show trends in the deposition of NH_4 at each NADP sites. Figures 28 and 29 are graphs of NO_3 deposition at each respective site and Figures 30 and 31 show SO_4 deposition values.

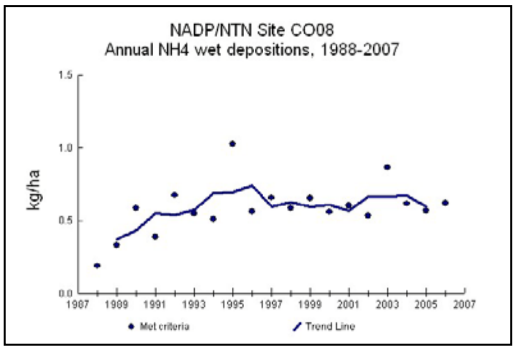

Fig. 26. NH_4 deposition - Four Mile Park

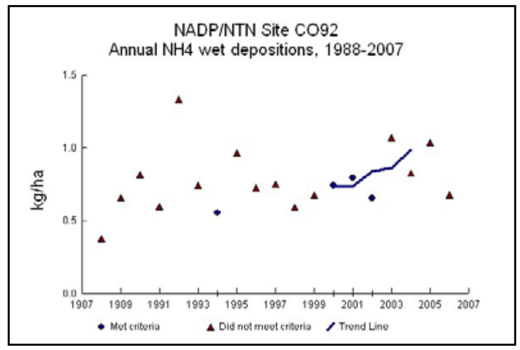

Fig. 27. NH_4 deposition - Sunlight Peak

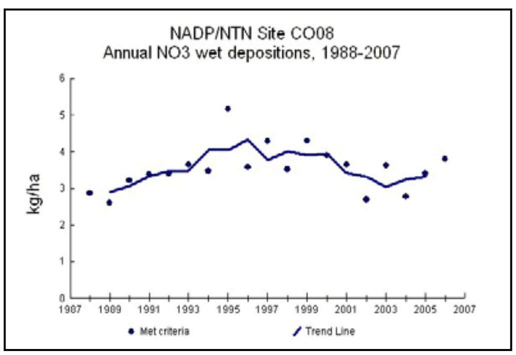

Fig. 28. NO_3 deposition – Four Mile Park

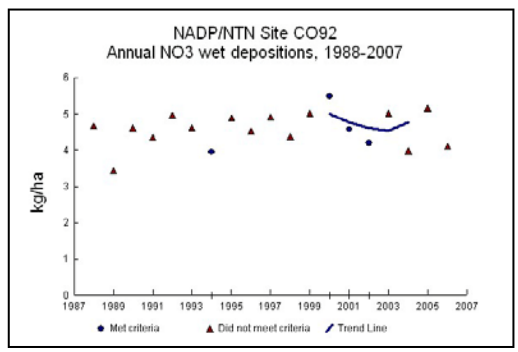

Fig 29. NO_3 deposition – Sunlight Peak

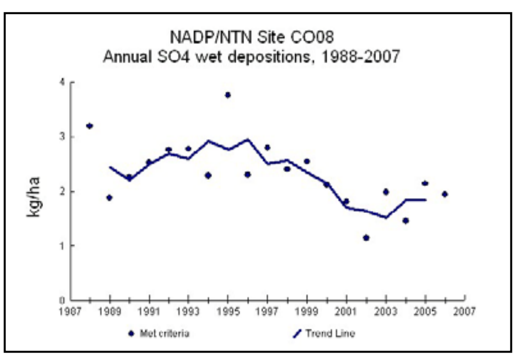

Fig. 30. SO_4 deposition – Four Mile Park

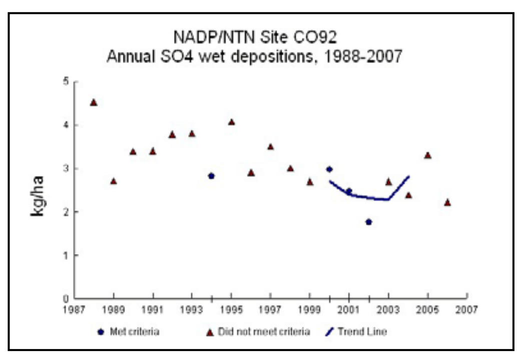

Fig. 31. SO_4 deposition – Sunlight Peak

E. OZONE MONITORING

Western Colorado has seen a recent increase in population and associated vehicle traffic as well as a boom in natural gas development. Exhaust from highway vehicles and gas development equipment are sources of nitrogen oxides (NOx) and volatile organic carbons (VOC), precursors to the formation of ozone.

The State of Colorado periodically conducts emissions inventories to determine air pollution sources within each county. The 2004 inventory for Garfield County shows that 41 percent of NOx emissions come from highway vehicles and 47 percent come from stationary sources. Ninety-two percent of these stationary sources are related to oil and gas development. This inventory also shows that 75 percent of the VOC emissions come from biogenic sources such as forests and agricultural lands. Overall these emissions are non-anthropomorphic. Of the remaining 25 percent of VOC emissions, 19 percent are from stationary sources. Ninety-six percent of these stationary emission sources pertain to oil and gas development.

The current NAAQS for ozone is 0.075 parts per million (ppm). This value is the same for the primary standard (protection of public health) and secondary standard (protection of public welfare, which includes protection against damage to crops and vegetation). Research indicates that foliar injury can occur in sensitive plants exposed to ozone levels above 0.06 ppm (pers. comm. with Robert Mussellman, Research Plant Physiologist, USDA Rocky Mountain Research Station).

1. MONITORING DESCRIPTIONS

With funding from a grant by the Aspen Ski Company's Environment Foundation and support from Garfield County, the WRNF began a synoptic ozone monitoring program in 2006. Fourteen monitoring sites were initially established to cover a range of elevations as well as a wide geographic distribution east to west and north to south in and around the Forest.

A passive ozone monitor was installed at each site. These inexpensive samplers react with the ozone during the time they are exposed to ambient air conditions. At the end of a sampling period (usually between one and two weeks), the sampler is collected and sent to the RMRS lab in Fort Collins for analysis.

In addition to the passive monitors, continuous ozone monitors were installed at two to four sites during each monitoring year through 2008. These monitors provided hourly ozone concentration readings which were useful for determining daily ozone fluctuations. Figure 32 shows a map of the locations of the ozone monitors deployed in 2008.

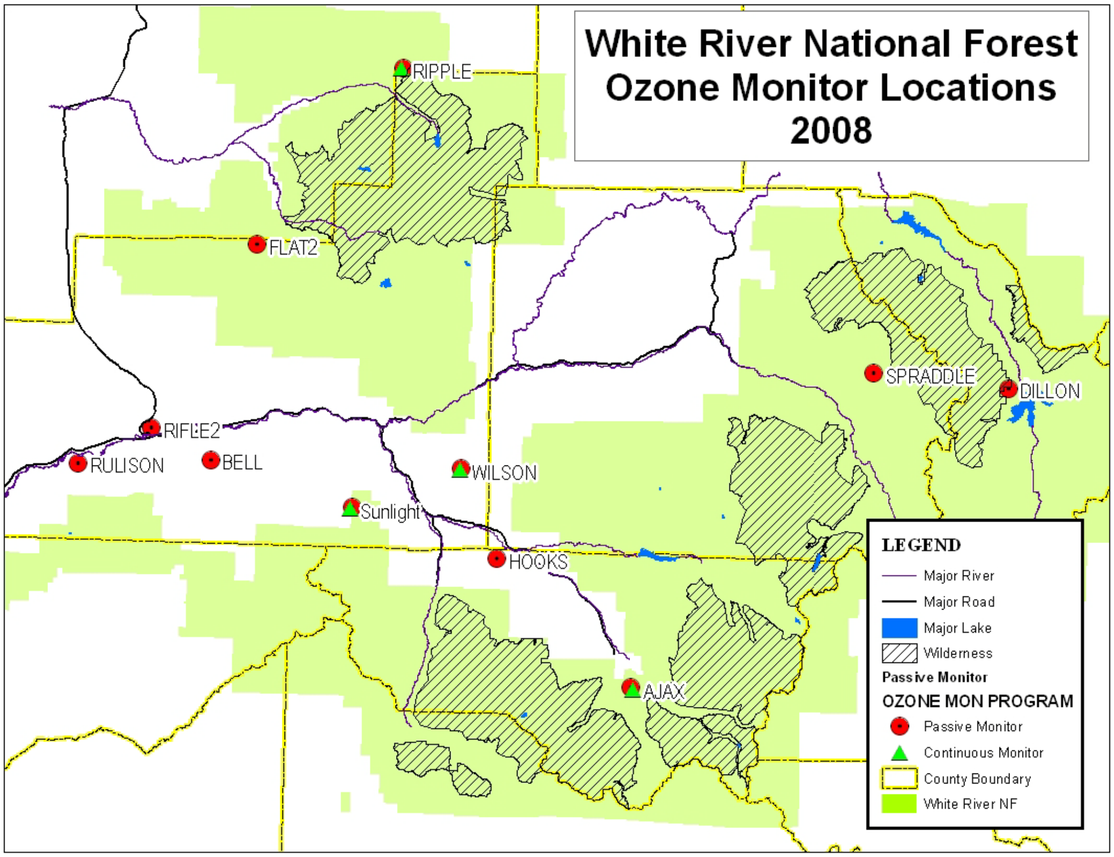

Figure 32. WRNF Ozone monitor locations in 2008

2. MONITORING RESULTS

Passive monitors do not measure ozone directly. These samplers are coated with nitrite which reacts with ozone to form nitrate. Following exposure (usually between one and two weeks), the samplers are analyzed in the lab for nitrate. Nitrate values presented below provide a surrogate for ozone concentrations measured at each monitoring site.

Research has shown that ozone concentrations tend to increase with elevation. The causes for this can vary and are still under study. Figure 33 was prepared with this observation in mind, comparing ozone concentrations measured in 2006 and 2007 to site elevation. Although one of the lowest elevation sites monitored, the BELL site has shown ozone concentrations closer to or higher than those seen at the higher elevation sites. The BELL site is located within a heavily developed natural gas area.

When looking at Figure 33, it is also noteworthy to compare distances of monitoring sites from the concentration of natural gas development in and around the western portion of the Forest. The DILLON and SPRADDLE sites are furthest east on the WRNF (see Figure 32). Both sites are higher in elevation than the HOOKS, WILSON, BELL, RULISON and RIFLE sites but indicate smaller ozone concentrations than the lower elevation sites.

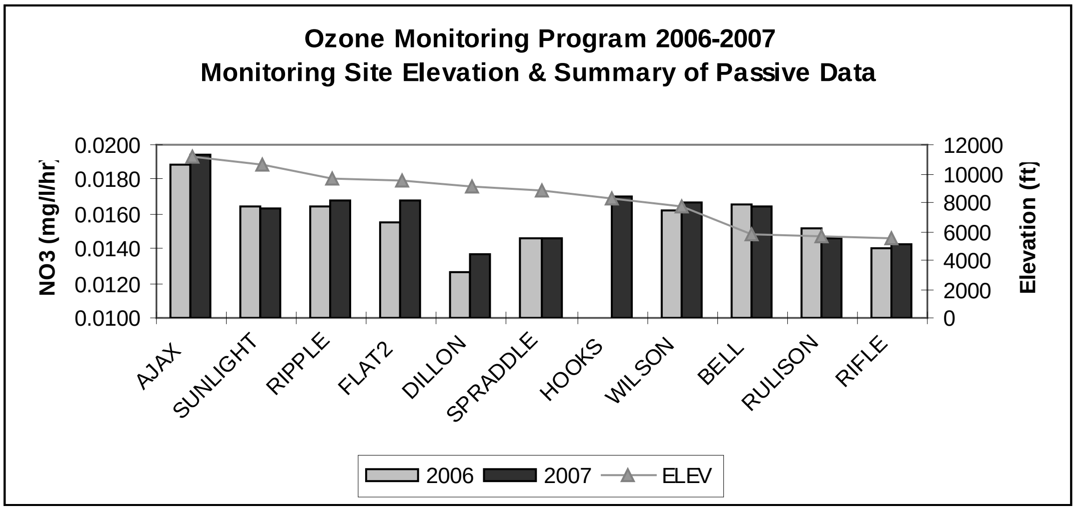

Figure 33. Comparison of site elevation to mean ozone concentrations (NO_3 is a surrogate for ozone).

Data collected in 2007 from the continuous monitors are presented in Figures 34 through 37. The data is compared to the newly established NAAQS for ozone (8-hour average concentration = 75 parts per billion).

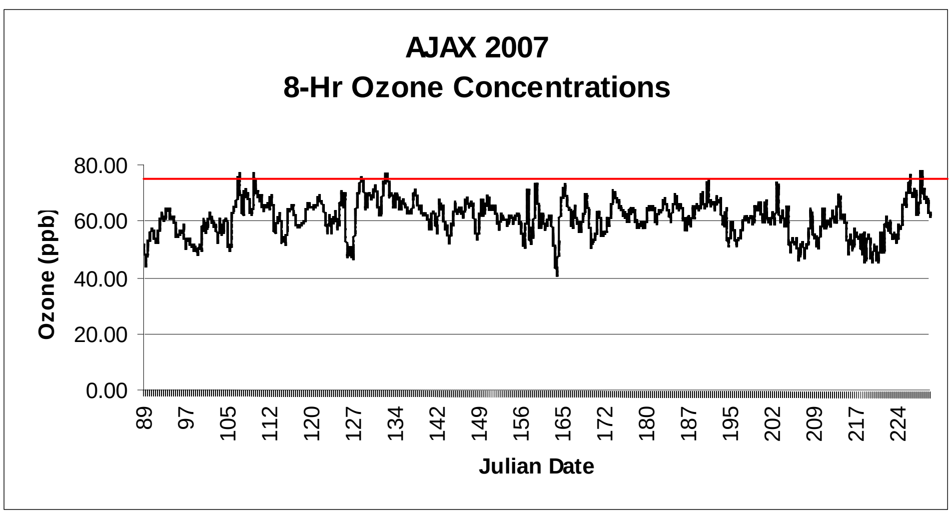

Figure 34. 8-Hr ozone concentrations measured at the top of Aspen Mountain. *(Note that the 8-hr standard for ozone in 2007 was 80 ppb. The red line indicates the new ozone standard of 75 ppb).*

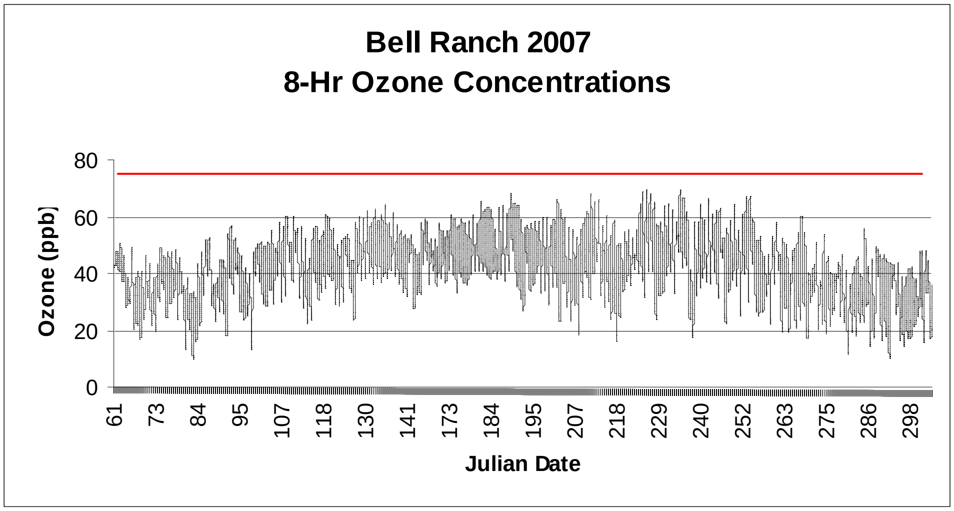

Figure 35. 8-Hr ozone concentrations measured at the Bell Ranch, south of Silt.

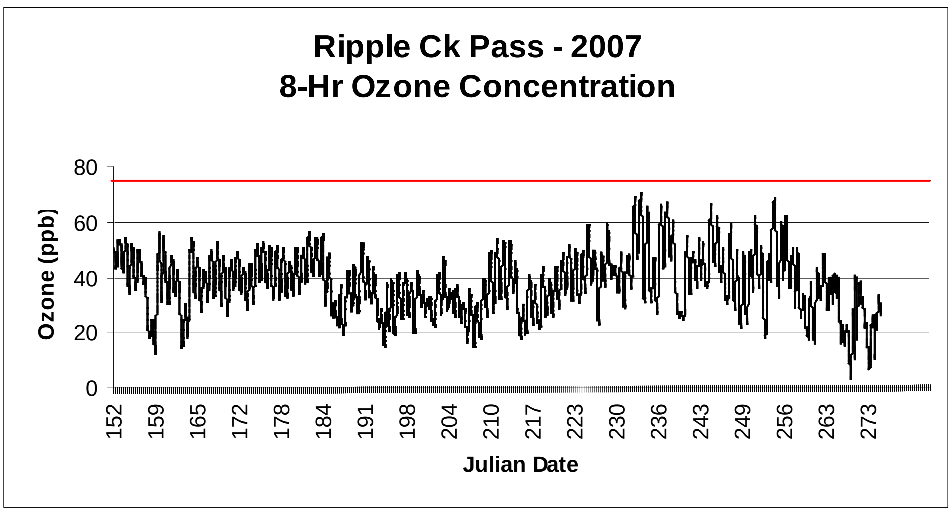

Figure 36. 8-Hr ozone concentrations measured at Shell Oil Monitoring site near Ripple Creek Pass**.**

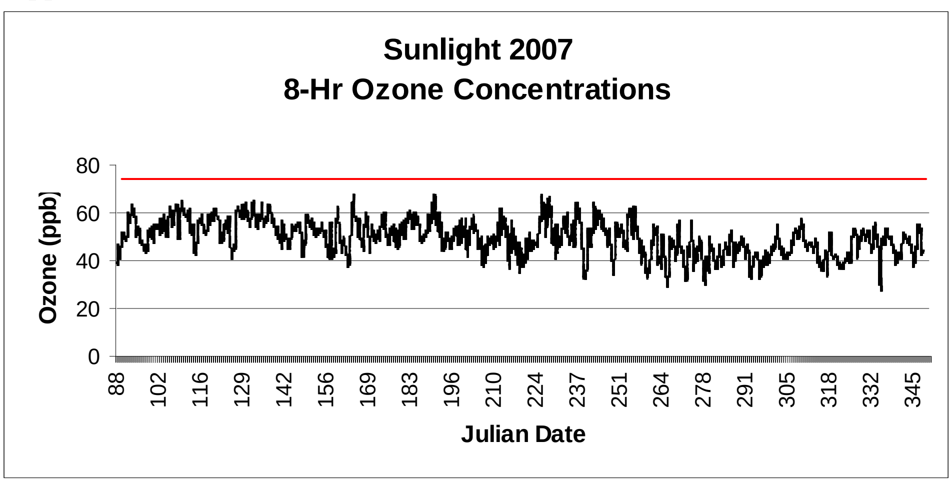

Figure 37. 8-Hr ozone concentrations measured at Sunlight Peak