IV. AIR QUALITY RELATED VALUES & SENSITIVE RECEPTORS

Air quality related values (AQRV's) are general features or properties of an area that have the potential to be changed by air pollution. Their categories include visibility, water, soils, flora, fauna, cultural resources, and odor. A sensitive receptor is an element of an AQRV that is most sensitive to or first modified by air pollution. Forest components, primarily those in Class I and Class II wilderness areas, were selected as sensitive receptors on the basis of the following criteria:

1. Known or suspected sensitivity to atmospheric pollutants.
2. Availability of logistically manageable, cost effective sampling and analysis methods.
3. Availability of modeling capabilities for predicting effects of proposed emissions on the sensitive receptor. (Currently there are acceptable models for predicting impacts to visibility, atmospheric deposition and changes in alkalinity.)

Levels of acceptable change (LAC's) are criteria used to determine whether monitored or predicted air pollution caused changes are tolerable changes from natural physical, chemical, biological, and/or social conditions of a sensitive receptor. Table 18 displays the LAC's for sensitive receptors monitored on the WRNF.

Table 18 – AQRV, Receptors & Levels of Acceptable Change

AQRV	**Sensitive Receptor**	**Sensitive Receptor Indicator**	**LAC**
Flora	Lichens	Metal concentration (Cu, Pb, As, Se, Zn)	Upper limit of 10% change
Visibility	Scenic Vista	Haziness	Upper limit of 0.5 deciviews
Water	Lakes with ANC $\geq$ 25 ueq/l	Acid Neutralizing Capacity	Upper Limit of 10% change
	Lakes with ANC < 25 ueq/l	Acid Neutralizing Capacity	Upper Limit of 1 ueq/l change

This section provides brief descriptions of AQRV's and their sensitive receptors on the WRNF. Some of the monitoring efforts on the WRNF provide information for more than one AQRV. For instance, while the lake and snow chemistry monitoring programs are listed under Water, their results can also help determine impacts to cultural resources, fauna, flora, and soils.

A summary of monitoring data from current efforts is available in Section V. Additional information regarding past monitoring efforts is provided in Appendix A.

A. VISIBILITY

The CAA specifically identifies visibility as an AQRV in Class I wilderness areas. Visibility is also an important component in other areas popular for their scenic vistas. Important vistas can be visually impaired by pollution in three ways:

1. "uniform haze" (pollutants from one or several sources are well mixed in the atmosphere and obscure the view uniformly),
2. "layered haze" (pollutants from one or several sources appear as a layer because of poor atmospheric mixing conditions), or
3. "plume" (pollutants appear as a continuous plume that originates from a single source).

Viewing a landscape through "clean, fresh air" has been shown in several surveys to be the most important wilderness attribute to wilderness visitors in Colorado (Brown 1977 and 1980; Walsh, et al 1981).

There are a variety of monitoring techniques that document visibility conditions and make quantitative measurements of atmospheric properties that effect visibility. The WRNF has used two techniques described below:

1. **Aerosol monitoring** looks at the physical properties of the ambient atmospheric aerosols (chemical composition, size, shape, concentration, temporal and spatial distribution, and other physical properties) through which a scene is viewed. Fine particle measurements are commonly made to quantify aerosol characteristics. The Interagency Monitoring of Protected Visual Environments (IMPROVE) program is representative of this type of monitoring. Data from IMPROVE provides a means of determining the sources of visibility impacts such as soil, soot, and sulfate. A summary of this program's data can be found in Section V of this report.

2. **Scene monitoring** considers the appearance of a scene viewed through the atmosphere. Scene characteristics include observer visual range, scene contrast, color, texture, clarity, and other descriptive terms. Scene characteristics change with illumination and atmospheric composition. Photographs, video images, and digital images are effective ways to document scene characteristics. This system of monitoring was employed on the WRNF between 1991 and 2000. It is described in more detail in Appendix A.

1. IMPROVE MONITORING

Visibility is monitored on an annual basis under the IMPROVE program. The WRNF operates and maintains an IMPROVE monitor on the top of Aspen Mountain, Aspen, CO. Between the fall of 2002 and spring of 2008, Shell Oil operated an IMPROVE-like program near Ripple Creek Pass. The WRNF is working towards restarting the IMPROVE monitoring effort at this site in 2009.

2. SCENIC AND/OR IMPORTANT VIEWS

The Colorado Air Pollution Control Division has published a database of "scenic and/or important views" database of sensitive views in Class II areas (CDPHE 2005). This database is used by the Division to determine if there are any sensitive Class II views that might trigger the visibility "additional impact analysis" requirements under the PSD rules. Table 19 lists those sensitive views that occur on the WRNF.

Table 19 – Scenic and/or Important Views on the WRNF

View Number	View Name	Viewing Site	Compass Vectors of View	
			Start	End
47	Dillon Reservoir	T5S, R78W, Sec. 23	0	360
48	Ute Pass to Gore Range	T3S, R78W, Sec. 3	0	360
49	Copper Mountain	T7S, R78W, Sec. 6	0	360
50	Continental Divide from Ruedi	T8S, R84W, Sec. 7	80	120
51	McClure Pass Vista	T11S, R89W, Sec. 1	10	180
52	Mt. Sopris (Red Hill Overlook)	T7S, R88W, Sec. 28	130	180
53	Red Table Mtn. Vista	T7S, R85W, Sec. 16	0	360
54	Burro Mountain	T2S, R91W, Sec. 14	40	180
55	Big Marvine Peak	T1S, R89W, Sec. 23	0	360
56	Trapper's Lake/Amphitheater	T1S, R88W, Sec. 2	30	280
57	Big Mountain	T3S, R93W, Sec. 18	0	360
58	Ripple Creek Overlook	T2N, R88W, Sec. 31	70	350
59	Deep Creek Overlook	T4S, R87W, Sec. 19	255	115
60	Five Range Overlook	T4S, R87W, Sec. 30	0	360
61	Ashcroft Area	T11S, R84W, Sec. 32	0	360
62	Taylor Pass	T12S, R84W, Sec. 10	130	360
63	Aspen Mountain	T10S, R85W, Sec. 24	210	90
64	Independence Pass alng Continental Divide	T11S, R82W, Sec. 9	0	360
65	Kobey Park	T9S, R84W, Sec. 15-16	130	330
66	Burnt Mountain/Elk Camp	T10S, R85W, Sec. 19	320	230
67	Entrance to Snowmass Village	T9S, R85W, Sec. 31	170	270
68	Maroon Lake	T11S, R86W, Sec. 13	160	360
69	Beaver Ski Area	T5S, R81W, Sec. 19	0	180
70	Vail Ski Area	T5S, R80W, Sec. 17	330	120
71	Mt. of the Holy Cross Overlook	T6S, R80W, Sec. 6	170	280
72	Eagles Nest Wilderness	T4S, R79W, Sec. 19	0	360
73	Holy Cross Wilderness	T7S, R82W, Sec. 13	0	360
74	Blair Mountain	T3S, R89W, Sec. 7	0	360
75	Windy Point	T5S, R89W, Sec. 18	20	190
76	South Fork	T2S, R91W, Sec. 36	320	40

B. WATER

The impacts of acid deposition and other nutrient inputs can affect not only aquatic based resources but cultural resources and the health of soils, plants and wildlife. On the WRNF, acid deposition is monitored through the Wilderness lake monitoring program, the USGS snow chemistry monitoring program, and the EPA's National Acid Deposition program (NADP).

The deposition of ammonium, nitrate, and sulfate are a concern with regard to biomass production in aquatic systems, soil productivity, native plant communities, and the preservation of historic and prehistoric rock art. Acting as a fertilizer, nitrate deposition can lead to the eutrophication of water bodies and can affect soil nutrient cycling and plant community composition. Sulfate can combine with calcium and other nutrients necessary for plant growth, causing them to leach more quickly from the soil. These changes may, in turn, adversely impact aquatic fauna and wildlife habitat.

1. LAKE WATER CHEMISTRY

Water chemistry (lake, stream, and snow-pack) is generally one of the primary and first sensitive receptors that the Forest Service measures to detect air pollution effects. In particular lake and stream chemistry are generally considered good indicators because they integrate the effect of acid deposition across a watershed. Data collected are compared to concern thresholds to determine impacts. Table 20 lists the lakes annually sampled on the WRNF for water chemistry analyses. Each lake is sampled three times a year and generally between June and late August.

Figure 4 – Moon Lake, sensitive receptor for water, is located in the Maroon Bells-Snowmass Wilderness.

Table 20 – Wilderness Lake Monitoring Program

Wilderness Area	**Designation**	**Lake Name**	**Comment**
Collegiate Peaks	Class II	Brooklyn	Sampled under Partnership with Wilderness Workshop
		Tabor	
Eagle's Nest	Class I	Booth	
		Upper Willow	
Flat Tops	Class I	Ned Wilson	Sampled by the USGS
		Oyster	
		Upper Island	
Holy Cross	Class II	Blodgett	
		Upper Turquoise	
		Upper West Tennessee	
Maroon Bells-Snowmass	Class I	Avalanche	Sampled under Partnership with Wilderness Workshop
		Capitol	
		Upper Moon	

2. SNOW CHEMISTRY

The U.S. Geological Survey annually conducts snow chemistry surveys along the Rocky Mountain range. The data provide an estimate of acid deposition derived from snowfall. Included in their monitoring sites are two on the WRNF: Sunlight Mountain and Ripple Creek Pass area.

3. ATMOSPHERIC DEPOSITION – WET DEPOSITION

The National Acid Deposition Program is a cooperative monitoring 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. Precipitation chemistry is monitored at the following NADP/NTN sites on the WRNF:

1. Sunlight Peak (cooperative effort with EPA)
2. Fourmile Park (cooperative effort with EPA)
3. Ripple Creek Pass (currently operated by Shell Oil)

C. Soils

Soil is an important component of the biogeochemical cycling process. Soil can trap or buffer pollutants in runoff water before they enter the aquatic system.

Currently the WRNF is not monitoring air quality impacts to soils. Monitoring of lake and snow chemistry along with atmospheric deposition data can provide an indication of soil health.

D. Flora

Plants can be impacted by air pollution either directly, through respiration, or indirectly, through the process of nutrient uptake from the soil. Plant responses to changes in acid deposition and air chemistry are often difficult to quantify and, in some cases, are unknown. Many studies have focused on the impacts of ozone pollution to plant health. Floristic inventories have been studied in each of the WRNF's three Class I wilderness areas and assumed to be representative of the WRNF's five Class II wilderness areas.

Overall, inventories of plant species occurrence on the WRNF are generally associated with project implementation related to land management activities. The Flat Tops area is annually inventoried for a variety of plant and animal species, depending on participant interest. This effort is led by Kim Potter, Wildlife Biologist for the Rifle Ranger District.

1. LICHENS

It is well established that certain lichens are sensitive to, and can serve as monitors of air pollution (Ferry 1973; Hawksworth 1976; Lawrey 1984; Nash 1988). Many physiological and structural factors contribute to this:

1. Lichens have no protective cuticle to serve as a barrier to material from the atmosphere;
2. They absorb most of their nutrients and water directly from the atmosphere;
3. They have a high retention capacity and accumulate elements;
4. They are long-lived;
5. They have a large surface to mass ratio.

Recent research has explored many atmospheric pollution effects in sensitive lichen species. These can include visible changes in thallus color, decrease in thallus size, plasmolysis of algal cells, decreases in respiratory, photosynthetic, and nitrogen fixation rates, decrease in growth rate, damage to plasma membrane integrity, increase in cytoplasmic concentration of mineral elements including sulfur, chlorophyll degradation, and changes in thallus pH, conductivity, and potassium efflux.

The analytical methods to determine these effects on lichens include measurements of photosynthetic, respiratory, and nitrogen fixation rates, determination of chlorophyll content by fluorescence, electron microscopical studies of ultrastructure, conductivity tests and elemental analysis of finely ground thalli by ICP, and x-ray fluorescence.

Permanent study plots of lichen communities have been established in the Flat Tops Wilderness (Hale 1982; Nash 1992). A cursory inventory and elemental analyses of lichen in the Flat Tops, Eagle's Nest and Maroon Bells/Snowmass Wilderness Areas was performed in 1994 (Jackson et. al. 1996). Additional information regarding some of these studies is provided in Appendix A. Appendix B provides a list of pollution sensitive lichens including those identified in the Flat Tops Wilderness.

2. VASCULAR PLANTS

Information on the presence, abundance, and distribution of vascular plants is useful baseline data to determine the presence of plants that have known sensitivities to air pollutants (e.g. NOx, SO2, and ozone). Further field monitoring of sensitive species can then be planned if warranted.

Two vascular plant surveys have been conducted within Wilderness areas on the WRNF. They include:

1. "A floristic survey of the Eagles Nest Wilderness Area in the southern Gore Range of central Colorado" (Hogan 1992), and
2. "Floristic Survey of the Flat Tops, White River Plateau and Vicinity, Colorado: Colorado Plant Species of Special Concern" (Vanderhorst 1991 and 1993).

Table A2 in Appendix A identifies air pollution sensitive plant species within WRNF Class I Wilderness areas.

Figure 5. *Populus tremuloides* (Quaking aspen) is sensitive to ozone pollution.

3. PLANKTON

Plankton are widely dispersed, free-floating microscopic organisms that reproduce rapidly. These characteristics often allow changes in response to ecosystem stress to be seen and quantified at an earlier stage of perturbation than with larger organisms. Phytoplankton can display significant change in species composition in as little as two weeks (Biological Methods Panel Committee on Oceanography 1969).

Acidification may affect the food chain of a lake. Phytoplankton are primary producers in the food chain and zooplankton are intermediary producers. Disruptions in these players in the food chain may lead to widespread injury at upper trophic levels.

Research has indicated that phytoplankton (free-floating algae) can serve as indicators of acidification (Keller 1984; Yan 1985; Malley 1986; Mills 1986). Recent research in lakes within the Rocky Mountain National Park found that plankton taxa changed around the 1950's indicating a shift towards eutrophication. This change was more pronounced on the east side of the continental divide and believed to reflect biogeochemical and ecological responses to elevated levels of nitrogen deposition from anthropogenic sources (Wolfe et al. 2003).

Plankton sampling is a low priority on the WRNF due to the logistical drawbacks and the uncertainty for use of this data in the PSD regulatory process.

4. OZONE INJURY MONITORING

Some vascular plants are particularly sensitive to ozone concentrations (see Table A2 in Appendix A). Currently the WRNF does not monitor for ozone injury in vegetation.

E. FAUNA

Aquatic biota can be profoundly impacted by changes in acidification. However, these effects are difficult to quantify and document. Baseline monitoring must often be conducted for several years to determine the range of species variability under natural conditions. As such, the WRNF does not currently monitor aquatic fauna as part of its AQRV monitoring program. However, inventories of amphibians and benthic lake fauna have been conducted on the WRNF and may provide useful information for future monitoring efforts.

1. AMPHIBIANS

As with plants, inventories of aquatic and terrestrial animal species typically occur prior to implementation of a forest management activity. Inventories of aquatic animal species have been conducted on the WRNF by the Colorado Natural Heritage Program, Colorado Division of Wildlife, and the WRNF. Such inventories can assist in determining potential air quality impacts on aquatic fauna. Information on some of these inventories is available in Appendix A.

2. BENTHIC LAKE FAUNA

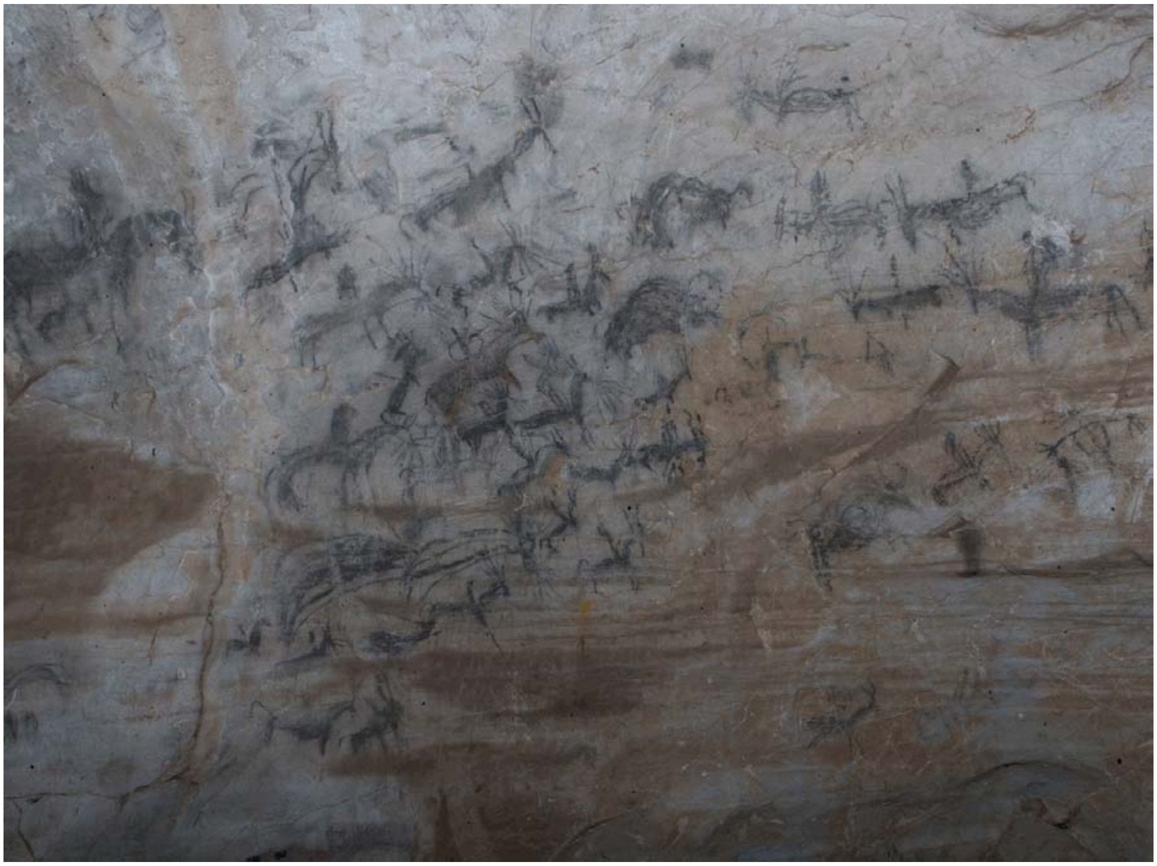
Benthic lake fauna are not a Forest AQRV. They are mentioned here because a population of invertebrates was sampled in 1995 by Barry Baldigo of the USGS (pers. comm, 4/2/97) using an Ekman sampler.

F. CULTURAL AND ARCHEOLOGICAL

On the WRNF, there are archaeological sites, primarily in limestone caves, with culturally significant paintings that could potentially be affected by acidic deposition. At this time these are not monitored for air pollution impacts.

G. ODOR

Odor is not a Forest identified AQRV and, as such, is not monitored in Class I or Class II Wilderness areas on the WRNF at this time.



Cultural site within the WRNF

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