



# Winter Air Quality in Yellowstone National Park

## *2008-2009*

Natural Resource Technical Report NPS/NRPC/ARD/NRTR—2010/285



ON THE COVER

Upper Gyser Basin in Yellowstone National Park, Wyoming  
Photograph by JR Douglass

---

# Winter Air Quality in Yellowstone National Park

## *2008-2009*

Natural Resource Technical Report NPS/NRPC/ARD/NRTR—2010/285

John D. Ray, Ph.D.  
National Park Service  
Air Resources Division  
PO BOX 25287  
Denver, CO 80225

February 2010

U.S. Department of the Interior  
National Park Service  
Natural Resource Program Center  
Denver, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report are those of the author(s) and do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

This report is available from the NPS Air Resources Division (<http://www.nature.nps.gov/air>) and the Natural Resource Publications Management Web site (<http://www.nature.nps.gov/publications/NRPM>) on the Internet.

Please cite this publication as:

Ray, J. D. 2010. Winter air quality in Yellowstone National Park: 2008-2009. Natural Resource Technical Report NPS/NRPC/ARD/NRTR—2010/285. National Park Service, Denver, Colorado.

# Executive Summary

The air quality in Yellowstone National Park was monitored at two locations within the park as part of the adaptive management program on the use of over-snow winter motor vehicles and at a location near the center of West Yellowstone. The leading indicators used were ambient concentrations of carbon monoxide (CO) and particulate matter of 2.5 micrometers or less (PM<sub>2.5</sub>).

The monitoring data from West Entrance—near the town of West Yellowstone, MT—is the primary indicator for overall air quality and the relationship to traffic, because of its longer record and detailed traffic counts. Old Faithful is a destination for most of the winter use vehicles; CO and PM<sub>2.5</sub> concentrations are lower at Old Faithful than at the West Entrance. CO and PM<sub>2.5</sub> are also monitored outside the park in the town of West Yellowstone, MT in cooperation with the park; summary data are reported here for comparison.

This report updates prior air quality and emission reports. Prior reports (<http://www.nature.nps.gov/air/studies/yell/yellAQwinter.cfm>) provide monitoring details and background information.

The results for the winter season of 2008-2009 are:

- Hourly and 8-hour average concentrations of CO are down slightly at the West Entrance, but are nearly the same as the previous year at Old Faithful.
- Air quality at Yellowstone meets the national standards set by the Environmental Protection Agency (EPA) for CO and PM<sub>2.5</sub> to protect human health. The CO, however, is present above regional background concentrations (between 0.1 and 0.2 ppm) in areas near vehicle routes, especially during the winter.
- Daily average concentrations of PM<sub>2.5</sub> continue to decrease in the park while measurements of PM<sub>2.5</sub> within the town of West Yellowstone are the same or higher than in previous winters. PM<sub>2.5</sub> concentrations in the Town of West Yellowstone do not violate the national standard.



## Introduction

This report is an annual update that summarizes the carbon monoxide (CO) and particulate matter of 2.5 micrometers or less (PM<sub>2.5</sub>) monitoring data from winter 2008-2009. It also provides a historical perspective on monitoring data at Yellowstone National Park (Ray 2007, 2008). The primary objective is to identify trends in air quality that might reflect on winter use policy and present conditions as compared to the national standards set by the Environmental Protection Agency (EPA) (EPA 2008).

Details on monitoring locations and methods were given in prior reports (Air Resource Specialists 2009; Ray 2007, 2008). (<http://www.nature.nps.gov/air/studies/yell/yellAQwinter.cfm>)

## Summary Statistics

Hourly data are summarized here for comparison to the National Ambient Air

Quality Standard (NAAQS)—set by EPA for CO and PM<sub>2.5</sub>—and to several other statistical metrics used in prior reports. The standards given in Table 1 are for averaging periods of 1-hour, 8-hours, or 24-hours. Normally, air quality data compared to a standard encompass a full year. However, the data summary tables here are only for the winter vehicle traffic period in Yellowstone National Park, a three-month period when snow conditions are suitable for over-snow travel.

Summaries of over-snow vehicle (OSV) traffic counts are provided in Tables 2 and 3. The OSV traffic is down for the 2008-2009 winter by 28% for the West Entrance (NPS 2009). The daily average snowmobile traffic is about 112 units/day through the West Entrance and 174 units/day for all entrances. In practice, holidays and weekends tend to have higher traffic counts and other periods less.

Table 1. Ambient air quality standards (AAQS) for carbon monoxide (CO) and particulate matter less than 2.5 micrometers (PM <sub>2.5</sub> ) ppm = parts per million; µg/m <sup>3</sup> = Micrograms per cubic meter			
Standard	Pollutant	1-hr CO (ppm) *	8-hr CO (ppm) *
National AAQS	CO	35	9
Montana AAQS	CO	23	9
Wyoming AAQS	CO	35	9
Standard	Pollutant	24-hr PM <sub>2.5</sub> 98 <sup>th</sup> percentile (µg/m <sup>3</sup> ) †	
New NAAQS ‡	PM <sub>2.5</sub>	35	
Montana AAQS	PM <sub>2.5</sub>	35	
Wyoming AAQS	PM <sub>2.5</sub>	65§	

\* Not to be exceeded more than once per year. Link to EPA NAAQS standards: <http://www.epa.gov/air/criteria.html> ; WY DEQ <http://deq.state.wy.us/aqd/standards.asp> ; MT DEQ <http://www.deq.state.mt.us/AirMonitoring/citguide/appendixb.html>

† The 3-year average of the 98<sup>th</sup> percentile of 24-hour concentrations at each monitor within an area must not exceed 35 µg/m<sup>3</sup>. The winter 98<sup>th</sup> percentile in the associated tables is given only to demonstrate the improvement between winter seasons. Comparison with the annual standard is not shown. For consistency, the 24-hour day is used to average the hourly PM<sub>2.5</sub>.

‡ Revised PM<sub>2.5</sub> standard by EPA Oct. 2006, down from 65 µg/m<sup>3</sup>

§ Wyoming has proposed a state standard of 35 µg/m<sup>3</sup>. <http://deq.state.wy.us/aqd/proposedrules.asp>

**Table 2. Winter OSVs entering at the Yellowstone West Entrance station**

Winter Season	Snowmobiles West	Snowcoaches West	West Entrance Total
2008-2009	10,139	1,495	11,634
2007-2008	14,135	1,582	15,717
2006-2007	14,682	1,453	16,135
2005-2006	13,104	1,371	14,475
2004-2005	8,743	1,185	9,928
2003-2004	14,765	1,181	15,946
2002-2003	33,458	998	34,456
2001-2002	50,888	889	51,777
2000-2001	45,689	816	46,505
1999-2000	42,620	777	43,397
1998-1999	44,213	767	44,980
1997-1998	40,869	706	41,575

\* Data presented in this table are from the NPS Public Use Statistic web page:  
<http://www.nature.nps.gov/mpur/>

**Table 3. Winter OSVs entering all Yellowstone gates**

Winter Season	Snowmobiles	Snowcoaches	Total
2008-2009	15,655	2,418	18,073
2007-2008	23,814	2,653	26,467
2006-2007	24,516	2,448	26,964
2005-2006	21,916	2,463	24,379
2004-2005	15,695	1,926	23,842
2003-2004	22,423	2,058	17,753
2002-2003	47,799	1,653	24,076
2001-2002	69,196	1,605	49,404
2000-2001	67,653	1,591	70,787
1999-2000	62,531	1,535	69,188
1998-1999	62,878	1,396	63,927
1997-1998	60,110	1,326	64,204

\* Data presented in this table are from the NPS Public Use Statistic web page:  
<http://www.nature.nps.gov/mpur/>

## Discussion

The West Entrance station continues to have higher concentrations of CO and PM<sub>2.5</sub> than the Old Faithful station (Tables 4 & 5). This is a result of higher traffic density at the entrance station, where over-snow vehicles (OSV) stop and idle for a time and then accelerate (Bishop et al. 2007; Ray 2008). In addition, the air quality monitoring station is close to the road. Dual peaks in CO happen daily in correlation with the OSV traffic activity between 8-10 am and 3-5 pm. At the Old Faithful station, CO peaks between 11 am and 2 pm when there is the most OSV activity in the parking area.

The CO at the West Entrance was lower in 2008-2009 than any previous year, based on all the statistical metrics of measurements. Total OSV traffic through the west entrance was also down from the previous year (Figure 1). The CO concentrations at the west entrance are now less than 10% of the National Ambient Air Quality Standard (NAAQS) set by the US Environmental Protection Agency. For CO, the NAAQS is 9 ppm for an 8-hour period (Table 1). For PM<sub>2.5</sub>, the concentrations are less than 15% of the NAAQS and have followed a similar trend to CO at the West Entrance (Figure 2). In most urban locations these conditions would be considered acceptable air quality, although CO is still higher than the summertime conditions for CO or the regional background concentrations of about 0.15 ppm (Ray 2007, 2008)

At Old Faithful, the hourly CO concentrations are now generally 1 ppm or less; 90 percent of the time the CO concentrations are 0.2 ppm or less. The PM<sub>2.5</sub> concentrations have remained nearly the same for the three previous winter seasons and are now close to the same as at the West Entrance station.

The timing in peak PM<sub>2.5</sub> at Old Faithful still differs from when the peak OSV traffic is present and in that regard differs from the observations at the west entrance. Both the CO and PM<sub>2.5</sub> at Old Faithful are well below the NAAQS.

Winter air quality at the West Entrance and Old Faithful is primarily influenced by emissions from 4-stroke snowmobile and snowcoach engines. Some smoke and pollutants are transported from town and the nearest housing units to the park entrance area when the winds are from the west. By contrast, the monitor in the town of West Yellowstone serves as a reference for conditions where 2-stroke snowmobile traffic dominates and there is a mix of wheeled vehicles and residential heating as additional CO and PM<sub>2.5</sub> sources. Note that the PM<sub>2.5</sub> concentrations are much closer to the NAAQS, possibly because of the greater emissions from 2-stroke engines in the snowmobiles. CO is elevated within the town of West Yellowstone and higher than at the park's west entrance, but does not approach the CO NAAQS.

## Conclusions

The air quality has stabilized at the monitoring stations in Yellowstone National Park over the previous 4-5 years. This is primarily from the requirement for Best Available Technology (BAT) snowmobiles (Federal Register 2007) and a much lower number of snowmobiles entering the park (NPS 2009). Air quality statistical indicators were lower this winter than in the previous winter at the West Entrance. This partly reflects the lower number of OSV traffic during the 2008-2009 winter season. The winter air quality remains below the health standards set by EPA for the locations where monitoring occurs.

Table 4. Statistical comparison of CO (ppm) between Yellowstone NP winter monitoring stations.

West Entrance								
Winter season	Max 1-hr	% of Std	Max 8-hr	% of Std	Average	90 <sup>th</sup> percentile	2 <sup>nd</sup> high 1hr CO	2 <sup>nd</sup> high 8hr CO
2008-2009	2.4	7%	0.6	6%	0.2	0.3	2.3	0.6
2007-2008	6.1	17%	1.6	18%	0.2	0.4	4.2	1.5
2006-2007	3.7	11%	0.8	9%	0.2	0.3	3.5	0.8
2005-2006	2.1	6%	0.9	10%	0.2	0.4	1.7	0.7
2004-2005	2.8	8%	1.0	11%	0.2	0.4	2.6	0.9
2003-2004	6.4	18%	1.3	14%	0.3	0.5	3.1	1.1
2002-2003	8.6	25%	3.3	37%	0.6	1.3	8.4	2.1
2001-2002	16.0	46%	5.4	60%	0.7	4.9	13.7	4.9
2000-2001	17.9	51%	6.1	68%	1.0	6.0	17.4	6.0
1999-2000	13.5	39%	5.4	60%	0.8	4.7	13.1	2.6
1998-1999	18.2	52%	8.9	99%	0.3	4.3	13.1	4.3
West Yellowstone, MT								
Winter season	Max 1-hr	% of Std	Max 8-hr	% of Std	Average	90 <sup>th</sup> percentile	2 <sup>nd</sup> high 1hr CO	2 <sup>nd</sup> high 8hr CO
2008-2009	7.9	23%	3.1	34%	0.5	0.9	5.9	3.0
2007-2008	6.7	19%	2.2	25%	0.4	0.7	5.7	2.2
2006-2007	5.0	14%	2.4	27%	0.5	0.9	4.3	2.4
Old Faithful								
Winter season	Max 1-hr	% of Std	Max 8-hr	% of Std	Average	90 <sup>th</sup> percentile	2 <sup>nd</sup> high 1hr CO	2 <sup>nd</sup> high 8hr CO
2008-2009	1.1	3%	0.4	4%	0.1	0.2	0.8	0.4
2007-2008	0.9	2%	0.4	5%	0.2	0.2	0.8	0.4
2006-2007	0.9	3%	0.4	4%	0.3	0.2	0.7	0.4
2005-2006	1.6	4%	0.5	6%	0.2	0.3	1.2	0.5
2004-2005	1.6	4%	0.8	7%	0.1	0.3	1.4	0.5
2003-2004	2.2	6%	0.9	10%	0.3	0.5	1.7	0.9
2002-2003	2.9	8%	1.2	13%	0.2	0.5	2.0	1.0

Table 5. Statistical comparison of PM<sub>2.5</sub> (µg/m<sup>3</sup>) between Yellowstone NP winter monitoring stations.

West Entrance					
Winter season	Max 1-hr	Max Daily (24-hr)	98 <sup>th</sup> percentile*	% of Std <sup>†</sup>	Average
2008-2009	53	5.1	4.8	14%	1.5
2007-2008	44	9.5	7.8	22%	2.6
2006-2007	40	8.8	8.7	25%	2.1
2005-2006	44	7.0	6.0	10%	1.9
2004-2005	21	6.0	6.0	9%	2.9
2003-2004	29	8.0	7.0	11%	4.0
2002-2003	81	15.0	17.0	26%	8.2
West Yellowstone, MT					
Winter season	Max 1-hr	Max Daily (24-hr)	98 <sup>th</sup> percentile*	% of Std <sup>†</sup>	Average
2008-2009	145	27.5	27	77%	12.3
2007-2008	167	24.7	22	63%	5.6
2006-2007	119	32.0	32	91%	12.9
Old Faithful					
Winter season	Max 1-hr	Max Daily (24-hr)	98 <sup>th</sup> percentile*	% of Std <sup>†</sup>	Average
2008-2009	23	5.7	5.2	15%	3.1
2007-2008	32	8.1	5.8	17%	3.2
2006-2007	20	6.6	6.4	18%	3.3
2005-2006	56	9.0	9.0	13%	3.5
2004-2005	38	6.0	9.0	14%	4.0
2003-2004	151	16.0	9.0	14%	4.9
2002-2003	200	37.0	21.0	33%	6.9

\* It is recognized that the PM<sub>2.5</sub> comparisons here are for only a 3-month winter period and not over 12-months as the PM<sub>2.5</sub> is normally calculated.

† PM<sub>2.5</sub> percent of standard are calculated based on the Oct. 2006 revised standard for consistency.

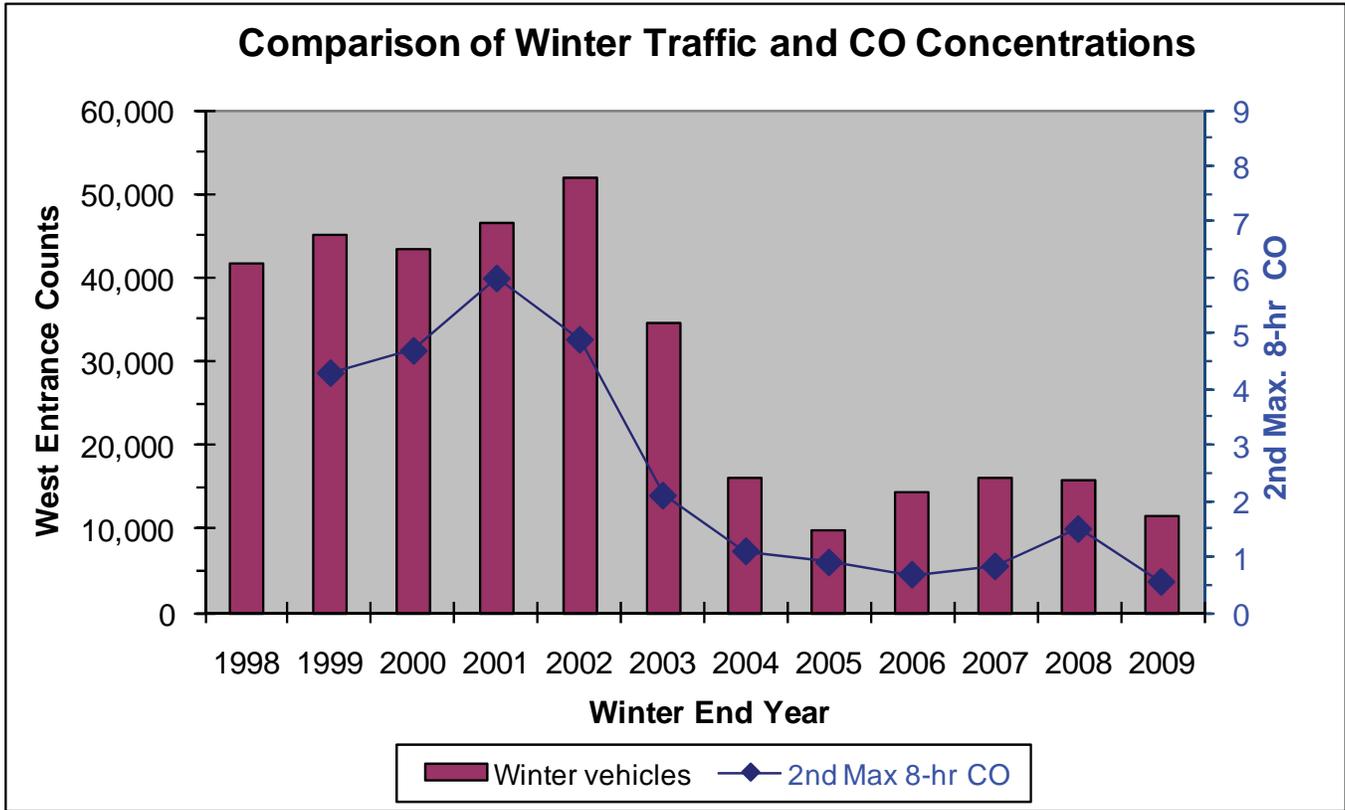


Figure 1. A comparison of the winter season OSV traffic volume through the west entrance and one metric for the air quality, the second highest daily concentration of the CO 8-hour average in ppm.

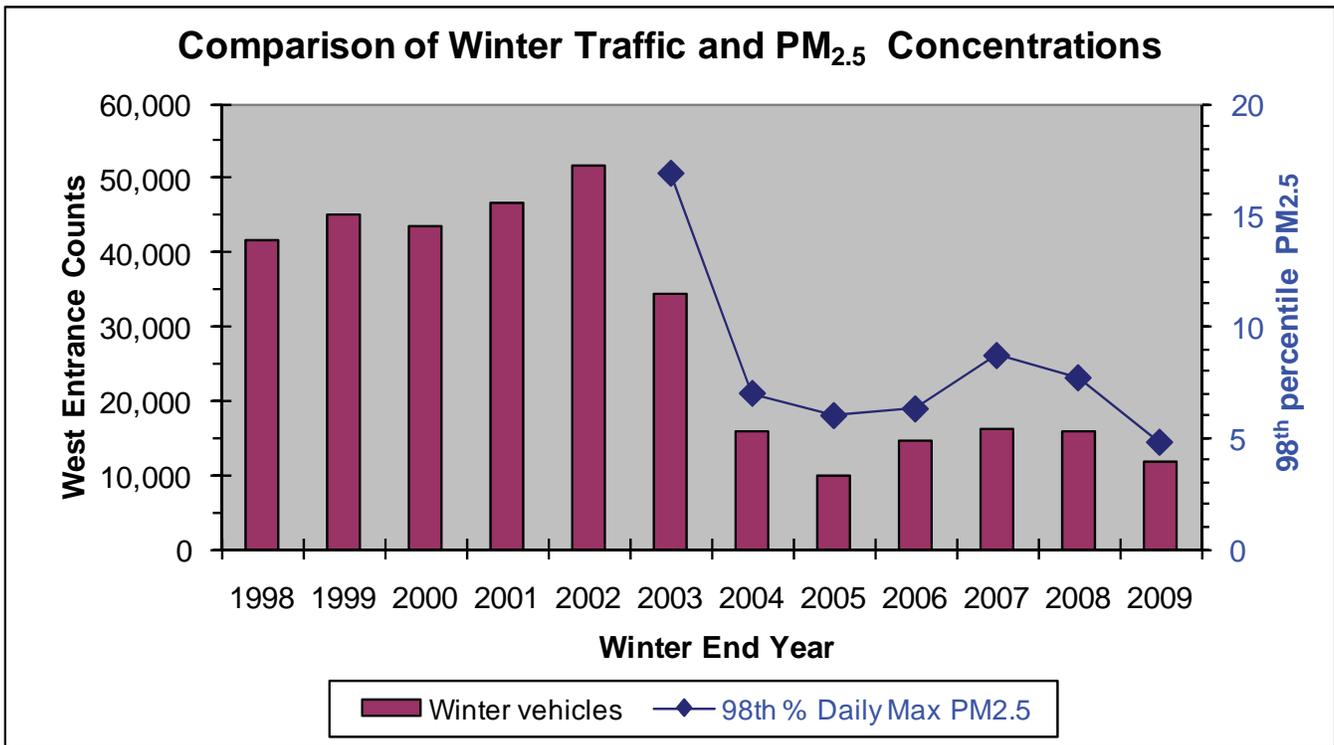


Figure 2. A comparison of the winter season OSV traffic volume through the west entrance and one metric for the particulate matter air quality, the 98th percentile of the winter season daily average concentration.

## Literature Cited

- Air Resource Specialists. 2009. Data transmittal report for the Yellowstone National Park winter use air quality study, 2008-2009. Air Resource Specialists, Fort Collins, Colorado. Available from <http://www.nature.nps.gov/air/studies/yell/yellAQwinter.cfm>
- Bishop, Gary A., R. Stadtmuller, D. H. Stedman, and John D. Ray. 2007. Portable emission measurements of snowcoaches and snowmobiles in Yellowstone National Park. *J. Air & Waste Manage. Assoc.* 59, 936–942 (2009). Available from <http://www.feat.biochem.du.edu>
- EPA. 2008. National Ambient Air Quality Standards (NAAQS). U.S. Environmental Protection Agency, Washington, D.C. Available from <http://www.epa.gov/ttn/naaqs/>
- Federal Register. 2007. Rules and Regulations, Final Rule governing the winter use in three parks. Vol. 72, No. 239 / Thursday, December 13, 2007/ page 70781. Available from <http://www.nps.gov/yell/parkmgmt/upload/finalrule13Dec2007.pdf>
- National Park Service, Public Use Statistics. 2009. Yellowstone visitor and vehicle count statistics. U.S. Department of Interior, National Park Service, Washington, D.C. Available from <http://www.nature.nps.gov/mpur/>
- Ray, J. D. 2007. Winter air quality in Yellowstone National Park: 2006—2007. Natural Resource Technical Report NPS/NRPC/ARD/NRTR—2007/065. National Park Service, Fort Collins, Colorado. Available from <http://www.nature.nps.gov/air/studies/yell/yellAQwinter.cfm>
- Ray, J. D. 2008. Winter air quality in Yellowstone National Park: 2007—2008. Natural Resource Technical Report NPS/NRPC/ARD/NRTR—2008/139. National Park Service, Fort Collins, Colorado. Available from <http://www.nature.nps.gov/air/studies/yell/yellAQwinter.cfm>



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 101/101071, February 2010

**National Park Service**  
**U.S. Department of the Interior**



---

**Natural Resource Program Center**

Air Resources Division  
PO BOX 25287  
Denver, Colorado 80225

[www.nature.nps.gov/air](http://www.nature.nps.gov/air)