Greater Yellowstone Area Air Quality Assessment Update

Prepared by the

Greater Yellowstone Clean Air Partnership

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Purpose of the GYA Air Quality Assessment Update

The Greater Yellowstone Area (GYA) Clean Air Partnership consists of air resource program managers and specialists for the National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, the Departments of Environmental Quality in Wyoming, Montana, and Idaho, and the Idaho National Energy and Environmental Laboratory. The primary purposes of the GYA Clean Air Partnership (GYACAP) are to serve as a technical advisory group on air quality issues to the Greater Yellowstone Coordinating Committee (GYCC), provide a forum for communicating air quality information and regulatory issues, and to coordinate monitoring between states and federal agencies in the GYA. The GYCC consists of Park Superintendents, Forest Supervisors, and Wildlife Refuge Managers and was created to allow better communication and more integrated management between the GYA land and resource management agencies.

The purpose of this assessment is to help GYA land managers maintain a basic understanding of air quality issues and use this periodic assessment to help address resources issues, foster partnerships, and secure funding. The assessment is NOT a decision document. It does NOT make resource management decisions, and does NOT replace analysis needed at the project level for NEPA. The focus of this assessment is to update the GYACAP (1999) Air Quality Assessment Document with a focus on new information on the four primary air quality issues within the GYA. These include:

- **Urban and industrial emissions**
- **Oil and gas development in SW Wyoming**
- **Prescribed and wildfire smoke**
- **Snowmobile emissions**

The GYACAP (1999) Air Quality Assessment Document was prepared to provide the GYCC with comprehensive GYA air quality information including an air quality legal framework, GYA air quality issues, current and potential impacts on GYA air quality, GYA air quality monitoring and summary of known information, and needs and recommendations. This assessment is intended to be useful in agency planning documents, National Forest Plan revisions, NEPA documents, facilitating air quality information exchange, and providing air quality information to the public and other agencies.

Urban and Industrial Emissions

Urban and industrial emissions consist of a variety of industrial, petroleum refining, gas transmission, agricultural processing, wood processing, mining, power generation, sand/gravel, and mining sources. Most of these sources produce emissions continuously, which can concentrate pollution in surrounding communities during inversions. The EPA AIRData base (EPA, 2004a) was queried for 1999 total permitted major stationary sources of industrial emissions in counties in Montana, Wyoming, and Idaho surrounding the GYA (Appendix 1). Many of these emissions, particularly the Wyoming, Idaho, and Gallatin County-Montana sources can be transported to GYA lands. Montana has the largest number of permitted stationary sources and the highest total emissions of NOx (nitrogen dioxides), PM_{10} (particulates), and VOC (volatile organic compounds). Idaho has the largest amount of permitted $S0_2$ (sulfur dioxide) and CO (carbon monoxide) emissions.

	Stationary Source Industrial Emissions near the GYA tons/year				
	CO	NOx	PM_{10}	SO_2	VOC
Montana	2,066	5,501	1,330	13,541	2,591
Wyoming	1,488	3,436	78	5,127	689
Idaho	11,438	1,733	1,465	14,880	51

The Montana sources are concentrated in the Billings/Laurel area where the largest concentration of petroleum refining and other industrial sources in Montana – Wyoming – Idaho area occur. The prevailing western winds disperse these emissions predominantly to the east and away from the GYA. Periodically east winds can cause “upslope” conditions which can carry these emissions toward the Beartooth and Absaroka Mountains on the Custer and Gallatin NF’s. These east winds, however, are usually associated with tight pressure gradients and are highly turbulent with robust mixing heights and dispersion energy. The Wyoming stationary sources are energy generation, mining/minerals, and natural gas processing and transmission in the southwestern (SW) part of the state and will be discussed in detail in the Oil and Gas

Drilling/Production section of this assessment. These Wyoming sources are directly upwind of the Wind River Range and Bridger and Fitzpatrick Wilderness Areas (Class 1), and Popo Agie Wilderness Areas (Class 2). These industrial emissions, in combination with minor sources and the extensive drill rig emissions in SW Wyoming are the major air quality concern in the GYA. The Idaho sources are dominated by chemical and fertilizer manufacturing facilities in the Soda Springs and Pocatello areas which can cumulatively combine with the energy related sources in SW Wyoming.

The EPA AIRData base (EPA, 2004b) was also used to query for currently listed non-attainment areas. These are geographic areas which have periodic violations of NAAQS (National Ambient Air Quality Standards). The non-attainment areas in proximity of the GYA include Billings, Montana for SO_2 and Pocatello, Idaho for PM_{10}. No non-attainment areas around the GYA occur in Wyoming as the only listed Wyoming non-attainment area is Sheridan for PM_{10}.

Greater Yellowstone – Teton Clean Cities Coalition

The formal "Clean Cities" designation for the Greater Yellowstone/Teton Clean Cities Coalition (GYTCCC) by the U.S. Department of Energy occurred on 9/18/2002. This event celebrated an important milestone in the energy and transportation direction of the Greater Yellowstone region. After nearly five years of collaborative effort, the achievements of regional public and private organizations were formally recognized by the U.S. Department of Energy. This designation made the GYTCCC the only designated "Clean City" in Idaho, Montana or Wyoming.

This coalition is distinguished by the scope and diversity of its stakeholders including three states, five national forests, two national parks, seven communities and six counties—not to mention dozens of private organizations. The majority of the existing U.S. Clean Cities are based in urban regions where air quality serves as a primary driver for the initiative. The Greater Yellowstone/Teton region does not represent a city but a focus on environmental protection and reduced energy consumption. The Coalition has coordinated a number of projects which would ordinarily be beyond the scope of a single community or organization.

The primary thrust of the Coalition is to reduce stationary and mobile air pollution sources. In 1999 YNP, and some surrounding communities, began the switch to cleaner burning, renewable fuels. All public and administrative re-fueling stations began dispensing only ethanol blended fuel (unleaded). The Montana DEQ estimates that since the switch, YNP has reduced carbon monoxide emissions by over fifty tons. In 2001, YNP switched its entire diesel fleet (over 300) to bio-diesel blend oil (canola). Additionally, all standby generators and boilers within the park have switched to the bio-diesel blend oil. A public bio-diesel pump has opened up in West Yellowstone, MT and another is slated to open in Belgrade, MT later this year.

In 2004, the YNP was the recipient of 4 donated hybrid vehicles from Toyota. The Toyota Prius vehicles are used for outreach and education purposes to help visitors understand the latest in hybrid technology. Several of the GYA National Forests are also beginning to use alternate fuel vehicles such as propane and hybrids.

Yellowstone National Park continues to seek funding to purchase more new "Yellow" buses. The first generation of yellow buses run on biodiesel and meet forthcoming EPA diesel emission requirements. Propane and natural gas versions are being developed and will be used in the future. The buses will be introduced into the Greater Yellowstone area (GYA) for mass transportation and a shuttling service. The buses will also play a pivotal role in the creation of a rural tour district in the GYA. Eventually the tour district will not only have the capability of moving visitors throughout the region, but also could be utilized to transport local residents. The first "leg" of the tour district will be a shuttle service from Driggs, Idaho to Jackson, Wyoming over Teton Pass. This will eliminate thousands of private commuter vehicles (and associated emissions) from that stretch of highway each day. More information on the Greater Yellowstone – Teton Clean Cities Coalition is available at http://www.eere.energy.gov/cleancities/

Oil and Gas Drilling/Production – SW Wyoming

Current and Future Field Development

Oil and gas development is rapidly expanding in south-central and southwest Wyoming. High demand and high market prices have stimulated considerable interest in additional natural gas development within the Upper Green River Basin. Development of new gas resources is consistent with the Comprehensive National Energy Strategy announced by the U.S. Department of Energy in April 1998, and meets the purpose and need of the Energy Policy and Conservation Act. Increasing energy development results in increased emissions. Managing these energy development emission increases is currently the most pressing air quality issue in the GYA.

The Upper Green River Basin has about 2,900 existing wells in the Pinedale District Field Office which is the most active BLM field office in the US for gas development activity. Recently the Pinedale office has processed 200-300 wells per year. About 425 new wells will be processed in 2005 and 475 in 2006 and 2007.

Current drilling activity levels in the Pinedale Anticline and Jonah II natural gas fields near Pinedale are higher than analyzed for either project during NEPA analysis. This has lead to some issues and concerns related to NO_x emission levels from the project areas as well as cumulative emissions and impacts. The BLM Pinedale Resource Management Field Office is preparing a revision of the Resource Management Plan. Up to 8,700 new wells may be proposed within the Pinedale area.

As long as natural gas and condensate prices remain high and technology advances to improve recovery, it is expected that development of current fields will continue, as will the exploration for other gas deposits in the Upper Green River Basin. Compliance with NAAQS and PSD increments and protection of AQRV's, particularly visibility, will require continued cooperation of the Forest Service, Park Service, BLM, Wyoming DEQ, and energy development companies.

Existing gas development projects and new proposed or anticipated projects are summarized in the following tables.

EXISTING SW WYOMING GAS DEVELOPMENT PROJECTS

Project Name	Project description	Analysis and/or Development Stage	Emissions Summary
Jonah II	Authorized the drilling of 450 wells over a 15 year period.	ROD (BLM, 1998) After five years of drilling, the project is almost drilled out at the 450 well level.	Emissions related to drilling with larger engines and at a faster pace have resulted in actual NO_x emissions greater than originally analyzed for the Jonah Project.
Pinedale Anticline	335 current wells	Pinedale Anticline Project EIS (BLM, 1999)	Emissions related to drilling with larger engines and at a faster pace have resulted in actual NO_x emissions higher than originally analyzed. In September 2005, the Wyoming Oil and Gas Commission approved 10 acre spacing in Questar's lease holds. This will likely lead to an infill proposal similar to the Jonah Infill project.
Questar Year-Round drilling on Pinedale Anticline	Allows Questar to winter drill in areas previously closed due to Mule Deer Winter Range stipulations.	BLM EA and FONSI (2004) Oil and Gas Commission approved 10 acre spacing for this project.	The Questar Year-Round Drilling EA estimated current NOx emissions (based on 2003 data) for the Pinedale Anticline field to be 1,895 tons per year. This is higher than the emissions level of 693 tons per year established within the Pinedale Anticline Project ROD (BLM, 2000) as a trigger for additional air quality analysis. The BLM has conducted supplemental modeling for the Jonah Infill Draft EIS (BLM, 2005b) to

			include the elevated NO_x emissions in the Pinedale Anticline area that were not considered in the original modeling in the Pinedale Anticline Draft EIS (BLM, 2000) and the Jonah Infill Draft EIS (BLM, 2005a). The BLM has indicated that they will resume the NO_x emissions tracking for 2004.
Anshutz, Shell and Ultra (ASU) Winter Drilling Pilot on Pinedale Anticline	One year pilot project. Allows ASU to winter drill in areas previously closed due to Mule Deer Winter Range stipulations as a one year pilot project.	BLM EA and FONSI (2005)	During the pilot project, the companies will implement new technology in the form of bi-fuel (natural gas and diesel) and selective catalytic reduction on drill rig engines andto evaluate NO_x emissions reductions.
Jonah Infill Project	Up to 3,100 additional wells within the Jonah Project Area over the next 15 to 20 years (BLM, 2005). Denser well sSpacing of 1 well every 5 to 10 acres is needed to extract natural gas.	The Jonah Infill Draft EIS (BLM, 2005a) and Air Quality Impact Analysis Supplement (BLM, 2005b). ROD target January 2006.	BLM modeled compliance with NAAQS and PSD increments for both the project and cumulative emissions. The analysis, however, indicates substantial visibility impacts from both the project and cumulative emissions in regional communities as well as Class I areas.
South Piney Coalbed Methane Natural Gas	Up to 210 deep (5,000 to 8,000 feet deep) coalbed natural gas wells over the next 15 years.	BLM DEIS anticipated at end of November 2005.	Drilling emissions per well are directly related to the well depth and drilling time, which may be less than that for drilling in the Jonah and Pinedale Anticline fields. Emissions in the production phase may be higher due to pumps operating to de-water the coalbeds so the gas can be released.

NEW PROPOSED SW WYOMING GAS DEVELOPMENT PROJECTS

Riverton Dome Natural Gas	Up to 336 wells. The wells will consist of a combination of conventional gas and coal bed natural gas wells. Located east of the Wind River Range.	BLM EIS is being conducted	Up to 9,000 hp of stationary engines at compressor stations and booster stations.
Pinedale Anticline Year Round Drilling	ASU and Questar are seeking to get a permanent release of winter drilling restrictions on the Pinedale Anticline.	A supplemental BL EIS will be prepared	
Atlantic Rim Natural Gas Project	Drill and develop up to 2,000 additional wells in the Atlantic Rim area of	Draft EIS due for public release aroundanticipated	

	Carbon County. 200 conventional natural gas wells and 1,800 coalbed natural gas wells as well as associated compressors.	December 2005	
BP Exploration and Production Co.	Proposed to drill some 2,000 additional wells in the Wamsutter area over the next 15 years. 1600 new well locations, 400 infill in existing developments.		

<u>Wyoming DEQ Air Resource Management</u>

In response to the rapidly changing oil and gas development in the Upper Green River Basin, the Wyoming DEQ is implementing multiple air resource management strategies.

- Permitting & Compliance The Wyoming DEQ has a program to ensure that all oil and gas production units are permitted and that Best Available Control Technology (BACT) is utilized to control or eliminate emissions. To guide oil and gas producers through the New Source Review (NSR) permitting process, the Wyoming DEQ developed the *Oil & Gas Production Facilities Chapter 6, Section 2 Permitting Guidance*. To address the increased activity and emission levels within the Jonah and Pinedale Anticline Gas Fields, the emission control requirements and permitting process were revised effective July 28, 2004 and result in more emissions being controlled earlier in the life of the well for single well facilities and control on startup of all wells at multiple well or PAD facilities. See *Jonah and Pinedale Anticline Gas Fields - Additions to Oil and Gas Production Facility Emission Control and Permitting Requirements*. Operators within the Jonah and Pinedale Anticline Gas Fields must also comply with permits issued by Wyoming DEQ for all well completions and re-completions, which emphasize the implementation of flareless completion technology. In addition, the Wyoming DEQ is evaluating the permitting of drill rig engines.

- Emissions Inventory & Modeling The Wyoming DEQ has undertaken an extensive analysis and modeling study designed to obtain the best possible estimate of the cumulative nitrogen dioxide (NO_2) prevention of significant deterioration (PSD) increment consumption from sources impacting southwestern Wyoming. The focus of the analysis are the Bridger and Fitzpatrick Wilderness Areas (which are federally designated Class I areas), along with the surrounding Class II areas. The preliminary results of the modeling analyses indicate that the allowable NO_2 Class I and Class II increment levels as well as the NO_2 ambient air quality standard, are not threatened. The final results of the modeling analyses will be available in early 2006. The Wyoming DEQ will continue to update the emissions inventory and modeling to evaluate cumulative NO_2 increment on a periodic basis.

- Monitoring Wyoming historically has required significant air quality monitoring of industrial activity. The Wyoming DEQ is furthering this legacy by expanding monitoring statewide, including the Upper Green River Basin in collaboration with industry. Since the fall of 2004, industry and Wyoming DEQ funded monitoring stations have been established in the Jonah Field, near Boulder, near Daniel, and in Pinedale. Monitoring stations are also being planned near Wamsutter, South Pass, Murphy Ridge, and in the Wyoming Range. The monitors are being strategically placed to assess actual ambient air quality impacts and will also serve as reality checks for modeling assumptions.

The Wyoming DEQ is increasing staffing and funding to expand upon and implement multiple air resource management strategies, as described above. The additional staffing and funding have been requested for the 2006-2007 budget as well as long-term funding from industry to directly support monitoring and modeling. Increased staffing in the Upper Green River Basin is also occurring as a direct result of mitigation commitments by industry in EA and EIS RODs.

Bridger-Teton and Shoshone NF Air Quality Monitoring Programs and Budgets

The SW Wyoming gas development activity is directly upwind of the Wind River Range which contains two Class I and one Class II Wilderness Areas, about 2000 lakes, very sensitive wilderness/air quality values, and very high wilderness recreational use. The Forest Service is mandated by the Clean Air Act and the Wilderness Act to protecting air quality (and AQRV's – air quality related values including visibility) in Class I Wilderness areas. Air quality monitoring within the Bridger-Teton and Shoshone NFs Class 1 areas has been ongoing since the early 1980s. The current program consists of:

- National Atmospheric Deposition Program (NADP) at two sites located at Gypsum Creek (BTNF) and South Pass (Shoshone NF).

- Interagency Monitoring for Protected Visual Environments (IMPROVE): An aerosol monitor and an optical monitor (transmissometer) located near Pinedale (above Fremont Lake) and at Dead Indian Pass northwest of Cody.

- Long-term lakes: Benchmark monitoring at five long-term lakes in the Bridger, Fitzpatrick, and Popo Agie Wilderness Areas in the Wind River Range (Hobbs, Black Joe, Deep, Ross and Lower Saddlebag lakes) sampled three times a year, and another lake very sensitive to atmospheric deposition, Upper Frozen Lake, sampled once a year. Lake sampling protocols include water chemistry, plankton, macro-invertebrates, and several physical parameters.

- Bulk Deposition: two bulk deposition collectors that collect snow, rain and dry deposition co-located with two of the long-term lakes (Black Joe and Hobbs). These sites are analyzed for chemical parameters.

The deposition monitoring data for the Wind River Range sites (NADP and bulk sites) indicates that sulfates are decreasing while nitrates are increasing. This is a common trend across the western US, which complicates directly relating the nitrate increases to accelerated energy development activities in SW Wyoming. The Wind River Range Lake chemistry data indicates a decreasing trend of acid neutralizing capacity (lakes becoming more acidic) in some of the long-term lakes. Some long term lakes are storing more nitrates which may lead to eutrophic conditions (Jill Baron, USGS, personnel correspondence). A rigorous analysis of the lake data is needed to determine the significance of these trends.

For 2005, funding for the air quality monitoring has been provided by the Forest Service, BLM, Wyoming DEQ, and industry contributions. A shift from energy industry contributions for NADP and bulk deposition funding ($135,000) and from the Forest Service WO for IMPROVE ($25,000) has created a need to identify $160,000 per year of new funding sources to continue the monitoring. An agreement between the Forest Service, Wyoming DEQ, and energy companies is currently being developed to cover this funding shortage for the next few years. A long-term funding solution is being sought by Wyoming DEQ and The USFS.

Prescribed Fire and Wildfire Smoke

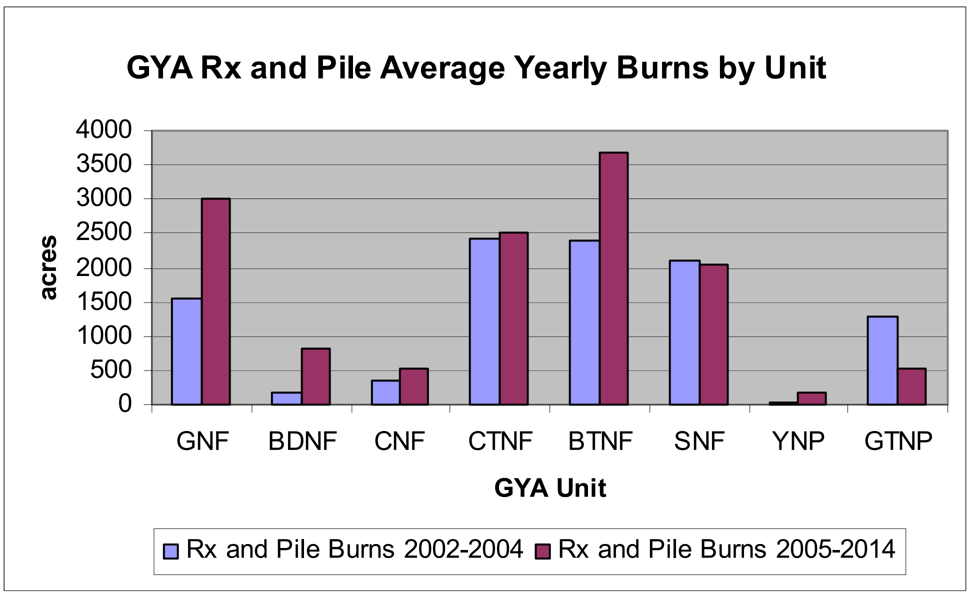
Wildfire smoke is the most dramatic air quality impact and prescribed fire is the predominant Forest Service and Park Service emission producing management activity in the GYA. Emissions from fire (wildland and prescribed) are an important episodic contributor to visibility impairing aerosols, including organic carbon, elemental carbon, and particulate matter. Wildfire impacts are increasingly difficult to manage due to excessive fuel loads, history of fire exclusion, and climate change (drought and increasing temperatures). Prescribed fire and fuel treatment projects, which include broadcast burns, understory burns, and pile burns) can reduce the size, frequency, and intensity of wildland fires and improve fire control, increase predictability of fire effects, and allow for smoke emission management.

The FOFEM5 model (Reinhardt, 2003) and the SIS - smoke impact spreadsheet which incorporate the CONSUME and CALPUFF models (Air Sciences, 2003) were used to estimate smoke ($PM_{2.5}$) emissions. Spring and fall broadcast and pile burning acres and $PM_{2.5}$ smoke emissions were tabulated by GYA units by SAF fuel code and vegetation type for an average of 2002-2004 for the GYA (Appendix 2). In addition 10 year (2005-2014) estimates of prescribed burning acres by GYA unit by vegetation type and wildfires acres (2000 – 2005) were also modeled for smoke emissions (Appendix 2).

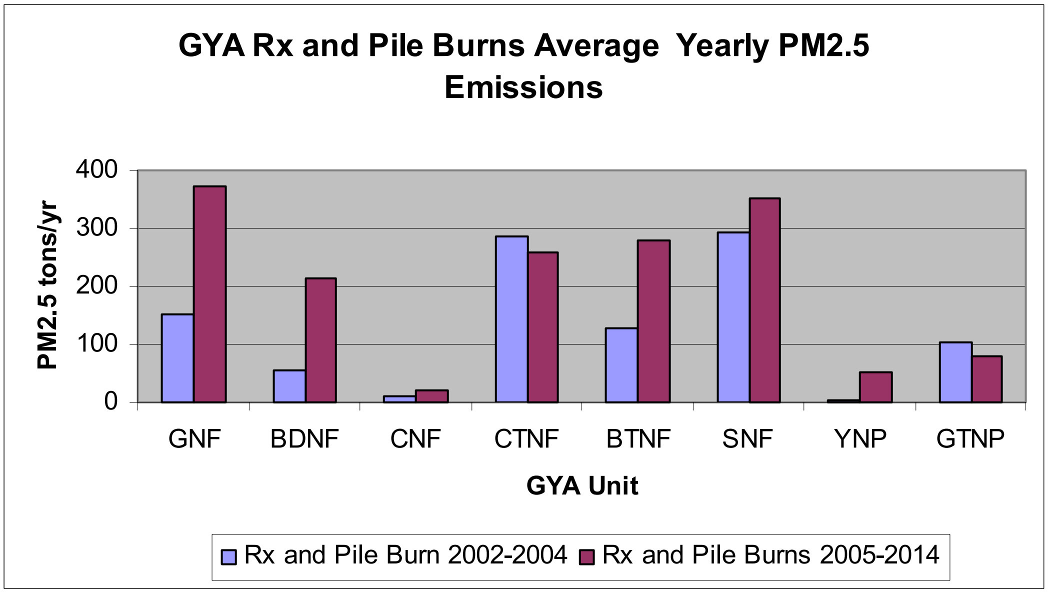
Prescribed burn and wildfire acres and smoke emissions ($PM_{2.5}$) by GYA unit						
Unit	2002-2004 average broadcast & pile burn acres	2002-2004 average broadcast & pile burn $PM_{2.5}$ tons/yr	estimated 2005-2014 Broadcast & Pile burning acres	estimated 2005-2014 Broadcast & Pile burning $PM_{2.5}$ tons/yr	2000-2004 average wildfire acres	2000-2004 average wildfire $PM_{2.5}$ tons/yr
Gallatin NF	1546	153	3000	374	11359	5498
Madison RD - BDNF	184	54	830	215	183	88
Beartooth RD - CNF	364	9.4	514	20	2091	1012

Targhee-Caribou NF	2416	287	2503	260	2672	1293
Bridger-Teton NF	2380	129	3670	279	11945	5782
Shoshone NF	2093	294	2040	351	9383	4541
Yellowstone NP	27	2.6	161	53	11397	5516
Grand Teton NP	1294	103	530	81	2471	1196
Total GYA	10304	1032	13248	1633	51501	24926

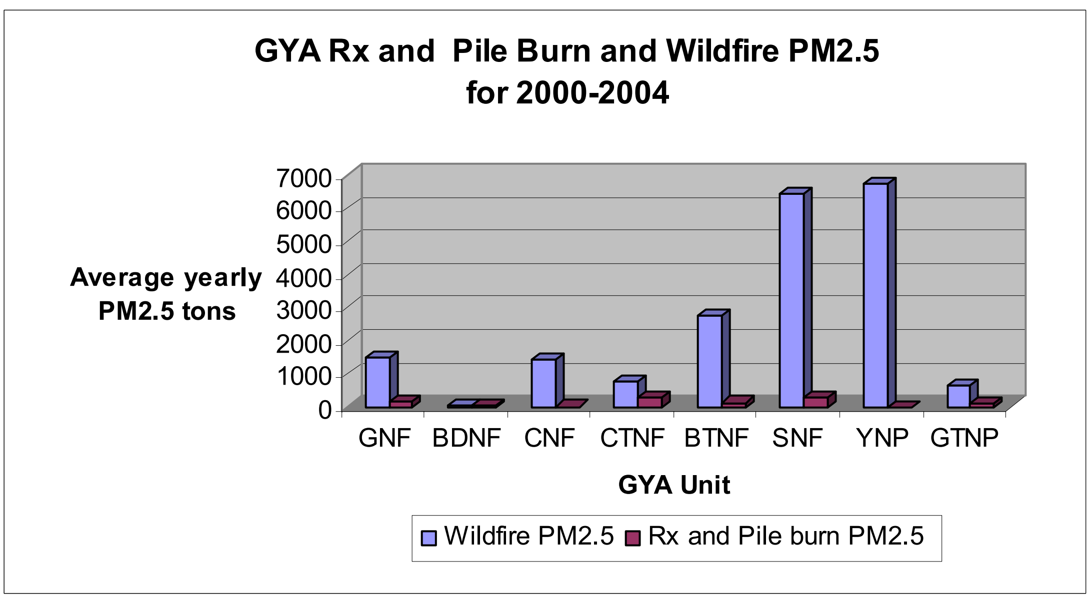
The Targhee-Caribou, Bridger-Teton, and Shoshone NF had the largest number of acres or prescribed fires in 2002-2004 due mainly to large sagebrush treatment acres. Estimated treatments for 2005 – 2014 add the Gallatin NF to the four largest prescribed fire treatment programs in the GYA. All GYA units plan to increase prescribed fire treatment acreages and prescribed fire smoke emissions during the next 10 years.



Estimated smoke emissions ($PM_{2.5}$) are similar to prescribed burn acres. Per acre smoke emissions are less for the Bridger-Teton NF due to a high percentage of sagebrush in the prescribed fire treatment which produce fewer per acre emissions than conifers (Douglas-fir, lodgepole pine, spruce-fir etc). All GYA units would increase prescribed fire smoke emissions ($PM_{2.5}$) during the next 10 years. The highest estimated emissions would be for the Shoshone NF where an average of 1000 acres per year each of Douglas-fir and lodgepole pine are anticipated during the next decade. Over the entire GYA, yearly average prescribed fire emissions are anticipated to increase during the next 10 years by about 58% (Appendix 2).



Wildfire acres and smoke ($PM_{2.5}$) emissions are much larger than prescribed fire emissions in all GYA units. On a per acre basis, wildfire emissions produce more smoke than prescribed fire due to increased combustion from more favorable burning conditions (fuel moisture and meteorology). During 2000-2004 wildfire acreage exceed prescribed fire acreage by five times and wildfire smoke emissions ($PM_{2.5}$) exceeded prescribed fire emissions by twenty four times (Appendix 2).



As prescribed fire treatment programs increase in the GYA the differences between wildfire and prescribed fire smoke would be expected to decrease although wildfire smoke will still be dominant in total smoke emissions. Total smoke emissions will depend largely on wildfire acreage which is managed primarily through fire suppression.

Wildfire smoke is considered a temporary “natural” source by EPA and the DEQ’s in Montana, Idaho, and Wyoming, and is therefore not directly regulated. Prescribed fire smoke, however, is subject to NAAQS (national ambient air quality standards) and is managed to minimize smoke encroachment on sensitive areas (communities, Class 1 areas, high use recreation areas, scenic vistas) during sensitive periods. In the GYA smoke dispersion is generally quite robust with strong ridge top, generally west to southwest, winds. The most sensitive areas are communities in valley locations such as Lander, Dubois, Jackson, Red Lodge, Big Sky, and West Yellowstone which are downwind of forested areas subject to wildfires and prescribed burning. During low dispersion times such as night and morning, smoke can concentrate and elevate $PM_{2.5}$ levels to nuisance concentrations but generally not in exceedance of the 24 hour $PM_{2.5}$ standard of 65 ueq/M^3. All of the highest smoke concentrations in the GYA in the last two decades have been due to wildfires, many from regional fires west of the GYA. The southern part of the GYA, particularly the Bridger-Teton and Targhee-Caribou NF’s and Grand Teton NP, are subject to smoke from agricultural burning in the Snake River valley. These impacts are cumulative with smoke emissions in the GYA. NEPA analysis for prescribed burning projects considers the sensitivity of smoke impacts and when appropriate the use of mitigation measures to minimize conflicts such as per day burn acreage limitations, burning during periods of good wind dispersion, and non-burning alternatives. A key factor in prescribed fire implementation is coordination with the DEQs in Montana, Idaho, and Wyoming, who have regulatory authority over smoke emissions and public health.

The Montana/Idaho Airshed Group – Smoke Monitoring Unit consists of USFS, State of Montana, State of Idaho, BLM, NPS, and private burners. The purpose of the group is to manage and limit the impacts of smoke generated from prescribed burning. Accumulation of smoke from controlled burning is managed through monitoring of weather conditions and formal coordination. Members submit a list of planned burns to the Smoke Monitoring Unit in Missoula, Montana. For each planned burn, information is provided describing the type of burn to be conducted, the number of acres, and the location and elevation at each site. Burns are reported by "Airshed" which are geographical areas with similar topography and weather patterns. The program coordinator and a meteorologist provide timely restriction messages for airsheds with planned burning. The Missoula Monitoring Unit issues daily decisions which can restrict burning when atmospheric conditions are not conducive to good smoke dispersion. Restrictions may be directed by airshed, elevation or by special impact zones around populated areas. The Monitoring Unit announces burning restrictions through 17 airshed coordinators located throughout Idaho and Montana. The operations of the Montana / Idaho State Airshed Group are officially recognized as Best Available Control Technology (BACT) by the Montana DEQ. The MT/ID Airshed Group Operating Guide is at http://www.smokemu.org/.

In 2004, the State of Wyoming revised the Wyoming Air Quality Standards & Regulations Chapter 10, and developed a new Section 4, Smoke management requirements. The new Chapter 10, Section 4 regulates large-scale vegetative burning, specifically vegetative burns in excess of 0.25 tons of PM_{10} emissions per day, for the management of air quality emissions and impacts from smoke on public health and visibility. Chapter 10, Section 4 is a permit-by-rule that succinctly lists the specific requirements of burners under a range of circumstances. The requirements of Chapter 10, Section 4 are effective for planned burn projects conducted and unplanned fire events that occur on or after January 1, 2005.

In support of Chapter 10, Section 4, the Wyoming Department of Environmental Quality – Air Quality Division developed a Smoke Management Program Guidance Document to assist burners in the implementation of the regulations. The Guidance Document contains a review and explanation of the regulation's requirements. The Guidance Document is structured to include comprehensive resource material into two major components: a Wyoming Smoke Management Program section and a Forms and Instructions section.

A copy of Wyoming Air Quality Standards & Regulations Chapter 10 is posted in the Standards and Regulations portion of the WDEQ-AQD website. The entire Smoke Management Program Guidance Document as well as portions of the Guidance Document, made available separately to provide quick reference, is posted in the Open Burning and Smoke Management portion of the WDEQ-AQD website. The WDEQ-AQD website address is http://deq.state.wy.us/aqd/smokemanagement.asp

Snowmobile Emissions

Snowmobile Emissions Detected in Yellowstone Snowpacks, 1996-2004

Seasonal snowpacks accumulate throughout the winter in the Rocky Mountains without significant melt, storing airborne pollutants deposited during snowfall until snowmelt begins. In cooperation with the National Park Service and the USDA Forest Service, the US Geological Survey (USGS) has been collecting seasonal snowpack samples each spring since 1993 in a network of 50 regular sampling locations throughout the Rocky Mountain region. Nineteen snowpack sampling locations in the GYA are listed in Appendix 3. Seasonal snowpack samples were analyzed for concentrations of major ions to establish background and elevated concentrations representative of the region (Turk et.al., 2001; Mast et.al., 2001). Within this regional network, the USGS also investigated local effects of snowmobile emissions of the acidifying ions ammonium and sulfate on snowpack chemistry at Yellowstone National Park during 1996, and 1998 through 2004. Results of sampling snowpacks at locations with variable snowmobile usage annually show clear patterns linking snowpack chemistry to snowmobile traffic.

Concentrations of ammonium and sulfate measured in snow samples taken directly from packed snowmobile routes in Yellowstone were substantially (up to 3 times) larger than concentrations of ammonium and sulfate measured in off-road snowpacks at least 30 meters away from snowmobile traffic. The relation between concentrations of these ions and volumes of snowmobile traffic was reported by the USGS in earlier studies of the 1996 and 1998 snowpacks (Ingersoll and others, 1997; Ingersoll, 1999). During these two years, concentrations of ammonium and sulfate and numbers of snowmobiles operating were highest near Old Faithful and the West Entrance. Concentrations of the two ions were lowest near areas with the least snowmobile usage at Lewis Lake Divide, the South Entrance, and Sylvan Lake. Similar patterns in concentrations of ammonium and sulfate were measured in snowpacks in subsequent years (1999, 2000, and 2001) using the same protocols. Thin snowcover and deteriorating snow conditions prevented sampling the snowpacked roadway at the West Entrance during the drier years of 2000 and 2001, so alternate locations were chosen at a low- and a high-traffic site at the South Entrance and the West Parking Lot at Old Faithful, respectively. In all cases observed from 1996 to 2002 concentrations of ammonium and sulfate in snowpacked roadways increased with proximity to snowmobile usage at the high-traffic locations of West Yellowstone and Old Faithful. At these two locations, off-road snowpack concentrations typically ranged from 5.1 to 14.0 microequivalents per liter (μeq/L) for ammonium and 3.5 to 7.6 μeq/L for sulfate. In-road sample concentrations at these sites ranged from 7.2 to 34.3 μeq/L for ammonium and 2.1 to 28.8 μeq/L for sulfate.

Decreases in concentrations of ammonium and sulfate began in 2002 and continued through 2004. Snow-sample concentrations from off-road and in-road sites for the winters of 2003, and especially 2004, showed smaller differences and were considerably lower than in previous years. All ammonium and sulfate concentrations for 2004 for samples from the paired off-road and in-road sites at West Yellowstone and Old Faithful were less than 10 μeq/L. The decreases in concentrations of ammonium and sulfate in 2003 and 2004 coincide with expanded use of four-stroke snowmobiles, limited use of two-stroke snowmobiles, and overall reductions in snowmobiles.

Snowmobile Use, Management, Air Monitoring, and Clean Technology Trends in Yellowstone NP and Grand Teton NP

The burgeoning popularity of snow machines in and around the Greater Yellowstone Area in the late 1980s and early 1990s led to concerns about air pollution, noise, wildlife harassment, and reduction in the quality of visitor winter experience. Snowmobile use generated the most widely publicized controversy concerning Yellowstone National Park. By the year 2000, visitors were making about 75,000 snowmobile trips and 1,300 snowcoach trips into the park during a 90 day winter period. Over 60 percent of these visitors entered the park through the West Entrance, from West Yellowstone. On peak days over 1,000 two-stroke snowmobiles used the West Entrance, where winter inversions often confine dense, cold, stable air that concentrates air pollution.

The traditional two-cycle engine snowmobiles being used released high hydrocarbon, carbon monoxide, and particulate matter emissions, as well as a variety of gases classified as “toxic air pollutants, ” including benzene, 1,2-butadiene, formaldehyde, and acetaldehyde. In addition, 20 to 33 percent of the snowmobiles' fuel was emitted as unburned aerosols.

Monitoring by the Montana Department of Environmental Quality documented that the air quality at the West Entrance was at times, very close to violation of the carbon monoxide eight-hour National Ambient Air Quality Standards, usually on calm winter days when there is little air dispersion.

The controversy about snowmobile emissions and access to U.S. National Parks and other public lands prompted studies, rulings, lawsuits, and technological innovations aimed at producing cleaner, quieter snowmobiles. One of the most significant technological changes has been the development of commercially available four-stroke snowmobiles, especially those that meet the National Park Service’s best available control technology (BACT) requirements. Laboratory testing of snowmobile emissions concluded that commercially-available BACT 4-stroke snowmobiles are significantly cleaner than 2-stroke snowmobiles. Compared to previously tested 2-strokes, these 4-stroke snowmobiles emit 95-98 percent less hydrocarbons (HC) 90-96 percent less particulate matter (PM), 85 percent less carbon monoxide (CO), 90 percent less toxic hydrocarbons, such as 1,3-butadiene, benzene, formadehyde and acetaldehyde than two-stroke engines. The 4-strokes engines, however, emit 7 to 12 times more oxides of nitrogen (NO_x) (Lela and White 2002).

To address the concerns of historic snowmobile use and types, including air quality, the NPS has adopted a multifaceted approach for Yellowstone and Grand Teton, which includes limiting snowmobiles numbers, requiring that snowmobiles use a commercial guide, and requiring that the snowmobiles be best available control technology (BACT), which are the cleanest and quietest four-stroke snowmobiles available. The commercial guide requirement helps assure that the snowmobiles meet the BACT requirements, comply with speed limits, and stay on the designated trail system. Reduction in overall snowmobile numbers also has resulted in fewer emissions and better compliance with winter air quality objectives.

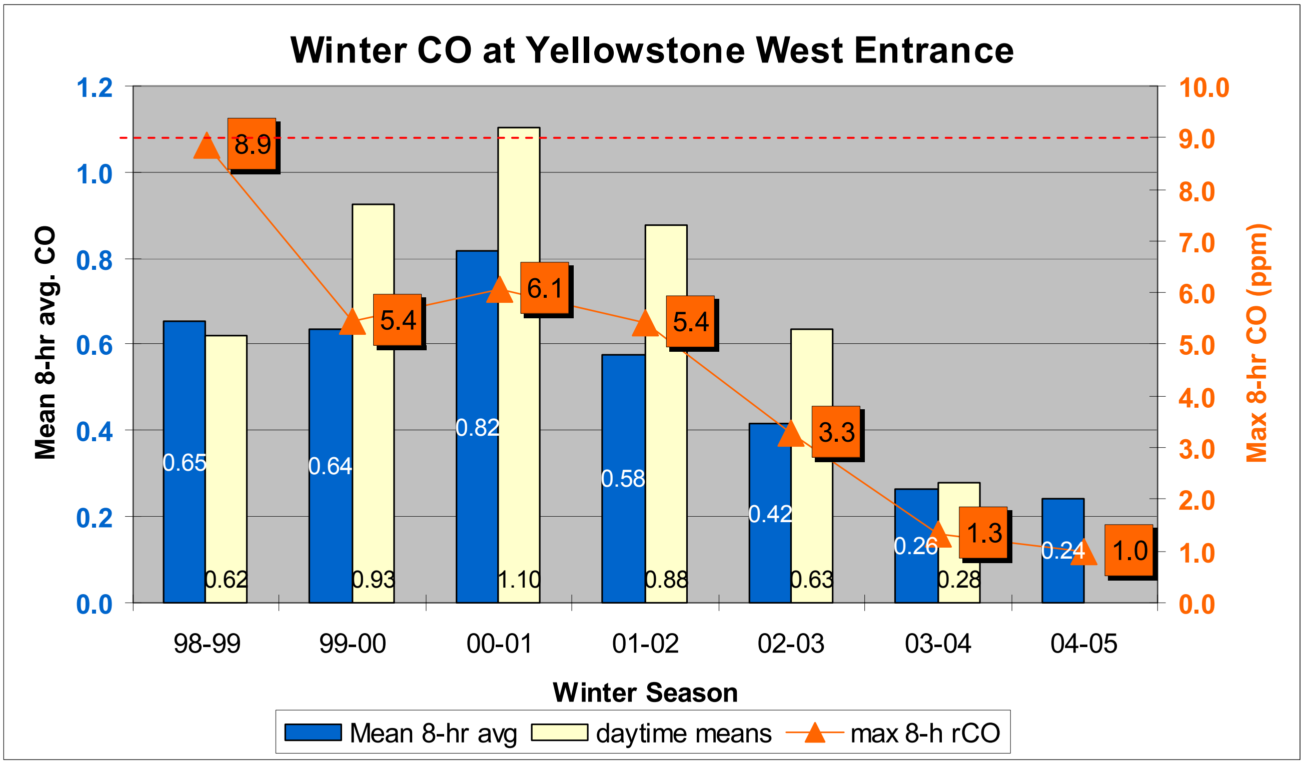
In November 2004, the National Park Service approved Temporary Winter Use Plans for Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr., Memorial Parkway. This decision allows 720 commercially guided recreational snowmobiles per day in YNP. In Grand Teton National Park and the John D. Rockefeller, Jr., Memorial Parkway, 140 snowmobiles per day are allowed. With minor exceptions, all snowmobiles are required to meet NPS best available control technology (BACT) requirements. The plan will be in effect for three winters, allowing snowmobile and snowcoach use through the winter of 2006-2007.

In addition to switching to BACT snowmobiles, YNP is using ethanol blend fuels and low-emission lube oils to further reduce emissions. Ethanol blend and biodegradable low emission lube oils in two-stroke engines reduces emissions of carbon monoxide by 7 to 11 percent, particulate matter by 25 to 70 percent, and hydrocarbons by 16 to 38 percent (MT DEQ web site www.deq.state.mt.us/CleanSnowmobile/faq/index.asp. March 9, 2005). Use of 10 percent ethanol blend requires no engine modifications or adjustments and is now the only unleaded "regular" fuel sold at the YNP gas stations.

Snowmobile and snowcoach rental operators in and around Yellowstone National Park have taken similar steps to protect air and water quality, using 10 percent ethanol blend fuel and synthetic lube oils in their machines.

Winter season gasoline sales in the park dropped 82 percent from 2001 to 2005 (J. Guengerich, Operations Manager, Yellowstone Park Service Stations, Inc., letter to M. Murphy, Yellowstone Business Management Office, March 9, 2005). The typical four-cycle engine snowmobiles get significantly better mileage (25-30 mpg) compared to the typical two-cycle snowmobile at 9-13 mpg (H.Haines, Chemical Engineer, MT DEQ, Pers. Communication, March 9, 2005). Snowmobilers can complete their trip in 1 tank of gas and typically no longer have to re-fuel in YNP.

Air quality monitoring began at the park's West entrance in the winter of 1998-1999 and at the Old Faithful development area in the winter of 2002-2003. A significant decrease in air pollutant concentrations for carbon monoxide (CO) and particulate matter (PM 2.5) has been measured at both sites. A 60 percent decrease in CO and a 40 percent decrease in PM 2.5 were recorded at West Entrance in 2003-2004 compared with the previous winter. A 23 percent decrease of carbon monoxide and a 60 percent decrease in $PM_{2.5}$ were recorded at Old Faithful for the same time period. This closely tracks with a 56 percent decrease in the number of snowmobiles entering the West Entrance and a 53 percent decrease in the snowmobiles counted at Old Faithful (Ray, 2005a).



Carbon monoxide (CO) data, shown above (Ray, 2005b), shows that CO has been decreasing at the West Entrance since 1998. The mean monthly CO at the West Entrance has an annual cycle with the highest concentrations in winter and summer and lowest in spring in fall. The winter CO is now similar to July and August which is a substantial change from 1998- 2002 when winter CO was much higher.

A substantial finding in winter of 2004-2005 monitoring (Bishop et.al. 2005) is that snow coaches have higher emissions than individual snowmobiles and that the increase in snow coach use is offsetting some of the snowmobile emission reductions. On a per passenger basis, snow coach emissions about equal 4 stroke snowmobile emissions. Bishop (et.al. 2005) measured emission rates and reports that older snow coaches, such as the carburetor fuel controlled Bombardier and gasoline van fuel injected Xanterra snow coaches, had high CO and hydrocarbon emissions. Newer snow coaches, such as the MPI fuel injected Bombardier by Alpen Guides and the NPS diesel van had CO and hydrocarbon emissions which were only 1-2% of the older snow coaches. Bishop (et.al. 2005) recommends discouragement of vintage fuel controlled carburetor engines in snow coaches. This could substantially reduce overall snow coach emissions.

Summary

Management Implications and Recommended Actions

Assessment Findings and Management Implications

Air Quality in the Greater Yellowstone Area remains generally excellent as GYA is largely undeveloped, with limited emissions sources, and predominantly robust dispersion. Internal sources of emissions within NPS and USFS lands in the GYA consist primarily of prescribed fire smoke, transportation/recreational sources, and management activity sources such as mining, road construction, ski areas etc. These sources are indirectly managed by the NPS and USFS and are usually not significant air quality issues except for snowmobile emissions at concentrated winter use areas such as the West Entrance. The NPS has greatly reduced in Park management related winter emissions with the use of "green" fuels and products, and requiring 4 stroke snowmobile engines in YNP and GTNP.

Wildfire emissions are the most spectacular emissions within and around the GYA but are not controllable by management except indirectly by fire suppression. During the last 3 years GYA prescribed fire emissions have increased with the Healthy Forests Initiative legislation and are anticipated to continue to increase by about 58% over the next 10 years. The overall smoke emissions (wildfire and prescribed) would be expected to remain about the same with the major variable of weather conditions. Much of the GYA, like most of the American west, has a wildfire suppression related accumulation of fuels with wildfire levels anticipated to be high during dry summer periods for the next several decades.

The greatest "threat" to air quality in the GYA is from anthropogenic sources upwind and adjacent to NP and NF boundaries. Urban and industrial air pollution, although moderate compared to much of the US, has a persistent impact since many of these emissions occur year long, including winter inversion periods. These sources are managed primarily by the DEQ's in Montana, Wyoming, and Idaho with collaboration from NPS, USFS, and BLM for major sources such as PSD. The largest cities around the GYA, such as Billings/Laurel, Bozeman, Cody, Lander, Jackson, and Idaho Falls are substantial sources of multiple emissions.

Currently the largest air quality concern the GYA is from gas field development in SW Wyoming and emissions from energy related industries. The SW Wyoming gas fields, primarily on BLM land, are expanding at a very high rate since this area provides a significant contribution to energy supply in the United States. The Clean Air Act requires the NPS and USFS identify, monitor, and protect AQRV's (Air Quality Related Values) in adjacent Class 1 areas. The Bridger Wilderness visibility, lake chemistry, and biota are being subjected to increasing levels of air pollution impacts from the upwind gas field development which is primarily on BLM land. The Fitzpatrick and Popo Agie Wilderness areas are also affected.

Compliance with NAAQS (National Ambient Air Quality Standards) and protection of AQRV's (Air Quality Related Values) will require continued close coordination between the NPS, USFS, BLM, and the DEQ's in Wyoming, Montana, and Idaho. The GYACAP has been a useful forum to facilitate coordination between the air quality management agencies in the GYA.

Grand Teton National Park personnel would like to establish NADP/NTN, CASTNet, and IMPROVE monitoring sites for at least 5 years in Grand Teton NP to compare with the network sites in Yellowstone National Park and determine if it is appropriate to augment the YNP air quality monitoring sites with more specific monitoring information from GTNP.

Recommendations

1. Comply with NAAQS, PSD increments, and AQRV thresholds.

2. Cooperate with the Wyoming DEQ, BLM, and energy companies to manage SW Wyoming oil and gas energy impacts.

3. Continue the system of air quality monitoring throughout the GYA. The AQRV monitoring in the Wind River Range (lakes, deposition, and visibility is critical).

4. Continue to encourage cleaner snowmobiles, snow coaches, and manage the winter use impacts.

5. Aggressively pursue fuel reduction projects and disclose smoke impacts and NAAQS compliance in NEPA.

6. Continue GYA-CAP annual meetings, coordination and information exchange.

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Appendix 1
Stationary Emissions Sources of Counties Surrounding the Greater Yellowstone Area

Montana Sources

	Pollutant Emissions tons/year								
	CO	NOx	PM_{10}	SO_2	VOC	Facility Name	Location	County	Industry Type
1	542	11.9	1.52	1,137	0.69	Montana Sulfur & Chemical	Billings	Yellowstone	Industrial Inorganic Chemicals
2	386	905	184	3,197	765	Centex	Laurel	Yellowstone	Petroleum Refining
3	293	697	155	1,222	534	Sonoco	Billings	Yellowstone	Petroleum Refining
4	205	1,504	127	2,698	20.4	Pal, Montana - J.E. Curette Plant	Billings	Yellowstone	Electric Services
5	191	324	60.3	74.7	14.9	Western Sugar	Billings	Yellowstone	Beet Sugar
6	149	41.5	63.3	2.21	68.1	Louisiana-Pacific - Belgrade	Belgrade	Gallatin	Sawmills & Planning Mills General
7	134	733	291	2,894	1,033	Exxon	Billings	Yellowstone	Petroleum Refining
8	42.5	3.12	40.0	24.4	19.8	Jell Group	Belgrade	Gallatin	Paving Mixtures And Blocks
9	31.0	685	213	192	2.64	Holman, Inc.	Three Forks	Gallatin	Cement, Hydraulic
10	29.8	448	22.8	2,073	9.36	Yellowstone Energy Limited Partnership	Billings	Yellowstone	Electric Services
11	23.9	55.4	46.4	6.03	4.04	Stillwater Mining Co - E.Boulder_Operatn	Mcleod	Sweet Grass	Metal Ores
12	12.5	2.49	10.5	7.06	4.69	Empire Sand & Gravel Company	Billings	Yellowstone	Highway And Street Construction
13	8.23	2.13			4.27	Mpc - Livingston Station 1&2	Livingston	Park	Natural Gas Transmission
14	6.62	23.4	22.8	0.48	0.80	Barretts Minerals Inc.	Dillon	Beaverhead	Minerals, Ground Or Treated
15	4.30	10.5	32.2	0.24	0.52	Luzenac America - Three Forks Plant	Three Forks	Gallatin Co	Nonmetallic Minerals
16	2.01	21.3	10.4	11.5	10.1	Park County Refuse District	Livingston	Park Co	Refuse Systems
17	1.31	6.08	9.83	0.37	0.31	RY Timber	Livingston	Park Co	Sawmills & Planning Mills General
18	0.94	3.23	9.67	0.15	0.19	Lorena America-Sappington Mill	Three Forks	Gallatin Co	Minerals, Ground Or Treated
19	0.51	20.0	1.92	0.09	0.88	MSU - Central Heating Plant	Bozeman	Gallatin Co	University
20	0.26	0.31	0.05	0.02	0.02	Laurel East Veterinary Service	Laurel	Yellowstone	Veterinary Services Specialties
21	0.18	0.42	0.34	0.04	0.03	TVX - Mineral Hill Mine	Gardiner	Park	Gold Ores
22	0.05	0.25	16.0		0.01	Cereal Food Processors, Inc.	Billings	Yellowstone	Flour & Other Grain Mill Prod

	Pollutant Emissions tons/year								
	CO	NOx	PM_{10}	SO_2	VOC	Facility Name	Location	County	Industry Type
23	0.01	0.02	0.03	0.04	0.06	Mt DOL Veterinary Diagnostic Lab	MSU - Marsh Laboratory, Bozeman	Gallatin	Testing Laboratorie
24			1.52			Egger, Inc.	Livingston	Park Co	Construction Sand And Gravel
25			3.35			Kantar Products	Three Forks	Gallatin Co	Clay Refractoriness
Total	2,066	5,501	1,330	13,541	2,591				

Wyoming Sources

	Pollutant EmissionsPollutant Emissions tons/year								
	CO	NOx	PM_{10}	SO_2	VOC	Facility Name	Location	County	Industry Type
1	434	7.80		1,383		Louisiana Land & Explor._Lost Cabin	Lost Cabin	Fremont	Crude Petroleum & Natural Gas
2	304	1,448			46.4	Williams Fld Svcs_Big Piney Comp Stn	Big Piney	Sublette	Natural Gas Transmission
3	142	52.4			193	Williams Field Services_Saddle Ridge	W/2 Se/4 S32 T28n R112w	Sublette	Natural Gas Transmission
4	103	60.7			45.5	Chevron Birch Creek	Big Piney	Sublette	Natural Gas Transmission
5	90.2	354		41.8	84.5	Santa Fe Snyder_Beaver Creek	Riverton	Fremont	Crude Petroleum & Natural Gas
6	82.1	93.8			29.4	Questar Pipeline _ Dry Piney	S11 T27n R114w	Sublette	Crude Petroleum & Natural Gas
7	79.8	556		1,872	52.6	Howell Pet Corp_Elk Basin Gas Plant	Powell	Park	Crude Petroleum & Natural Gas
8	42.8	139			36.1	Williston Basin Ipc _ Elk Basin Comp Stn	Cody	Park	Natural Gas Transmission
9	42.6	9.70			36.9	Williams Field Services_Hares Ear	Big Piney	Sublette	Natural Gas Transmission
10	39.6	249	77.2	3.70	0.50	Dakota Coal Co._Frannie Lime Plant	Bismarck	Park	Lime
11	39.4	93.3		193	61.6	Santa Fe Snyder_Riverton Plant	Riverton	Fremont	Crude Petroleum & Natural Gas
12	38.9	164			60.9	Wildhorse Energy_Pavillion Stn	Se/4 S5 T3n R3e	Fremont	Natural Gas Transmission
13	24.3	31.7			0.40	Colorado Interstate Gas_Lost Cabin/Madde	Lost Cabin	Fremont	Natural Gas Transmission
14	15.6	117			10.1	Colorado Interstate Gas _ Elk Basin	S31, T58n, R99w	Park	Natural Gas Transmission
15	5.90	36.5			6.40	Kn Energy _ Sand	Riverton	Fremont	Natural Gas

	Pollutant EmissionsPollutant Emissions tons/year								
	CO	NOx	PM_{10}	SO_2	VOC	Facility Name	Location	County	Industry Type
						Draw Plant			Transmission
16	2.60	10.9		403	14.4	Marathon Oil Co _ Oregon Basin Gas Plant	Cody	Park	Natural Gas Liquids
17	0.30	1.50		29.8	10.5	Marathon Oil_Pitchfork Battery	14 Miles W Of Meeteetse	Park	Crude Petroleum & Natural Gas
18	0.20	4.10			0.20	Montana Power Comp_Dry Creek/Heart Mtn	Cody	Park	Gas Transmission And Distribution
19		6.30	0.27	1,200		Koch Sulfur Products Company	Riverton	Fremont	Industrial Inorganic Chemicals
Total	1,488	3,436	77.5	5,127	689				

Idaho Sources

	Pollutant EmissionsPollutant Emissions tons/year								
	CO	NOx	PM_{10}	SO_2	VOC	Facility Name	Location	County	Industry Type
1	10,734	1,133	602	12,012	0.92	P4 Production Llc	Soda Springs	Caribou	Industrial Inorganic Chemicals
2	357	172	124	676	13.6	Nu West Industries	Soda Springs	Caribou	Phosphatic Fertilizer
3	202	75.3	206	10.3	22.8	Basic American Foods	Blackfoot	Madison	Dehydrated Fruits Vegs Soups
4	3.43	16.1	18.7	0.61	1.79	Kerr-Mcgee Chemical Llc	Soda Springs	Caribou	Industrial Inorganic Chemicals
	142	337	513	2,181	11.4	Jr Simplot Company Don Siding Complex	Pocatello	Power	Phosphate Fertilizer
Total	11,438	1,733	1,465	14,880	50.5				

Appendix 2 Acres of GYA Prescribed Burns, Pile Burns, and Wildfire and $PM_{2.5}$

Average of 2002-2004

SAF Fuel Code	veg type	Broadcast burning Spring acres	Broadcast burning Spring $PM_{2.5}$ tons/yr	Broadcast burning Fall acres	Broadcast burning Fall tons/yr	Pile burning acres	Pile burning $PM_{2.5}$ tons/yr	Total $PM_{2.5}$ tons/yr
210	Doug fir	2112	165.8	1099.0	196.2	413.0	166.0	528.0
206	Spruce/fir		0.0	33.0	19.1	4.0	0.1	19.3
208	Whitebark pine		0.0	385.0	58.7		0.0	58.7
218	Lodgepole pine	222	28.0	397.0	118.7	1120.0	109.4	256.1
402, 403	Sagebrush	1423	6.4	1542.0	6.9	100.0	3.0	16.3
16	Aspen	50	4.6	853.0	78.9	5.0	0.2	83.7
921	Willow	427	21.8		0.0		0.0	21.8
613	grass		0.0	167.0	0.7		0.0	0.7
total		4234.0	226.5	4476.0	479.2	1642.0	278.7	1032.0

Estimated Average of Next 10 years 2005-2014

SAF Fuel Code	veg type	Broadcast burning acres	Broadcast burning PM2.5 tons/yr	Pile burning acres	Pile burning $PM_{2.5}$ tons/yr	total $PM_{2.5}$ tons/yr
210	Doug fir	4030	440.7	416.0	167.2	607.9
206	Spruce/fir	450	261.0	120.0	4.0	265.0
208	Whitebark pine	230	35.1		0.0	35.1
218	Lodgepole pine	2044	474.2	583.0	57.0	531.2
402, 403	Sagebrush	3393	13.6		0.0	13.6
16	Aspen	1890	174.8	30.0	0.9	175.7
921	Willow		0.0		0.0	0.0
613	grass		0.0		0.0	0.0
219	Limber pine	5	0.8	5.0	0.5	1.3
		12042.0	1400.1	1154.0	229.6	1633.0

Wildfire

year	acres	$PM_{2.5}$
2000	76357	36957
2001	56599	27394
2002	41174	19928
2003	82151	39761
2004	221	107
total	256502	124147
average	51501	24926

Appendix 3 Greater Yellowstone Area air quality monitoring sites

National Atmospheric Deposition (NADP). These sites are part of the 2000 site NADP program which monitors wet deposition across the United States. The continuous monitoring stations are sampled weekly. Data is available at http://nadp.sws.uiuc.edu/

NADP site #	Location	GYA unit
WYO8	Tower Ranger Station	Yellowstone NP
WY98	Gypsum Creek	Bridger-Teton NF
WY06	Pinedale, Wyoming	BLM
WY02	Sinks Canyon	Shoshone NFState of Wyoming
WY97	South Pass City	BLM Shoshone NF

Interagency Monitoring of Protected Visual Environments (IMPROVE). Visibility monitoring sites which are part of a 110 sites nationwide. Protocols include nephelometers, aerosol samplers, and digital camera for some sites. The IMPROVE program includes the characterization of haze by photography, the measurement of optical extinction with transmissometers and nephelometers, and the measurement of the composition and concentration of the fine particles that produce the extinction and the tracers that identify emission sources. Sites are serviced every Tuesday. Data is available at http://vista.cira.colostate.edu/improve/

IMPROVE site #	Location	GYA unit
YELL2 (Yellowstone NP)	Lake Water Tank	Yellowstone NP
BRID1 (Bridger Wilderness)	White Pine Ski Area	Bridger-Teton NF
NOAB1 (North Absoraka)	Dead Indian Pass	Shoshone NF

Additional Air Quality Monitoring sites in or near Yellowstone NP.

The CASTNet site located in Yellowstone is part of a nationwide program to gather information on dry atmospheric deposition. The continuous monitoring station is sampled weekly.

The NPS GPMP concentrates primarily on documenting the levels of ozone and sulfur dioxide in parks because of their toxicity to native vegetation at or below the levels of the national ambient air quality standards (NAAQS). Yellowstone is one of 41 national parks continuously measuring ozone and one of 27 parks measuring sulfur dioxide on a weekly basis.

The National Mercury Deposition Network (MDN) is organized by the National Atmospheric Deposition Network (NADP) in the United States. The objective of the MDN is to measure the concentration of mercury in precipitation as well as wet deposition. MDN is a cooperative program between Canada, the United States and Mexico. Precipitation samples are collected at selected sites throughout North America.

Site	Location	GYA unit
Mercury	Tower Ranger Station	Yellowstone NP
CASTNet YEL 408	Lake Water Tank	Yellowstone NP
Ozone	Lake Water Tank	Yellowstone NP
Water Tank (gaseous pollutant monitoring)	Lake Water Tank	
West Yellowstone Park Entrance EPA 30-031-0013 Carbon monoxide	West Entrance	Yellowstone NP & Montana DEQ
West Yellowstone Firehole EPA 30-031-0012 $PM_{2.5}$	West Yellowstone	Yellowstone NP & Montana DEQ
CASTNet PND 165	Pinedale	Bridger Teton NF

Air quality monitoring at Yellowstone National Park's West Entrance and at Old Faithful addresses concern over vehicle emissions. Continuous Carbon monoxide and Particulate Matter (PM-2.5) are collected at both sites.

Site	Location	GYA unit
30-031-0013	West Entrance	Yellowstone NP & Montana DEQ
56-039-1012	Old Faithful	Yellowstone NP

Lake Monitoring sites provide chemical and biological trends of sensitive GYA lakes. The Bridger Teton NF (Bridger Wilderness) site protocols also include macro-invertebrates, phytoplankton, zoo-plankton, and physical measurements

Lake	Location	GYA unit
Hobbs Lake	Bridger Wilderness	Bridger Teton NF
Black Joe Lake	Bridger Wilderness	Bridger Teton NF
Deep Lake	Bridger Wilderness	Bridger Teton NF
Upper Frozen Lake	Bridger Wilderness	Bridger Teton NF
Saddlebag Lake	Bridger Wilderness	Bridger Teton Shoshone NF
Ross Lake	Fitspatrick Wilderness	Shoshone NF
Stepping Stone Lake	Absaroka Beartooth Wilderness	Gallatin NF
Twin Island Lake	Absaroka Beartooth Wilderness	Gallatin NF

Bulk deposition sites in the Bridger Wilderness are co-located at 2 lakes. Wet and dry deposition at these sites is collected and analyzed monthly and provides high altitude augmentation to the NADP network.

Bulk deposition site	Location	GYA unit
Hobbs Lake	Bridger Wilderness	Bridger-Teton NF
Black Joe Lake	Bridger Wilderness	Bridger-Teton NF

Snow chemistry sites are monitored in late winter in a cooperative program with the USGS- Water Resource Division (Colorado), NPS, and the USFS. The sites in YNP are focused on snowmobile impacts to snow chemistry. These “bulk deposition” sites provide a useful augmentation to the NADP network. An overview of the program is available at http://co.water.usgs.gov/projects/CO53100/CO53100.html

Site	Location	GYA unit
Daisy Pass	Above Cooke City	Gallatin NF
Big Sky	Big Sky Ski Area	Gallatin NF
Lionshead	Targhee Pass	Gallatin NF
Monida Pass	Monida Pass	Beaverhead NF
West Yellowstone (in and off road)	West Entrance	Yellowstone NP
Old Faithful (in and off road)	Old Faithful	Yellowstone NP
Lewis Lake Divide	Lewis Lake	Yellowstone NP
Sylvan Lake (in and off road)	Sylvan Pass	Yellowstone NP
Twenty One Mile	Divide Lake	Yellowstone NP
Canyon	Canyon	Yellowstone NP
Tower Junction	Tower Junction	Yellowstone NP
Garnet Canyon	Garnet Canyon	Grand Teton NP
Rendevous Mountain	Rendevous Mtn	Grand Teton NP
Four Mile Meadow	Four Mile Meadow	Bridger-Teton NF
Elkhart Park	Elkhart Park GS	Bridger-Teton NF
Teton Pass	Teton Pass	Bridger-Teton NF
Gypsum Creek	Gypsum Creek	Bridger-Teton NF
Togwotee Pass	Togwotee Pass	Shoshone NF
South Pass	South Pass	Shoshone NF