Estimating and Reducing Emissions from Within National Parks

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ABSTRACT

Air pollution is a serious threat to many of our national park units. While most of the pollutants impacting the parks are generated by human activities beyond the park boundaries, questions have arisen concerning the contributions of activities within the parks to air pollution concentrations in and near the parks. NPS has recently begun a series of inventories of anthropogenic air pollutant emissions generated within the parks to determine their origins, magnitudes, and compliance with state and local regulations. The results of those studies are presented in this paper. For example, in many National Parks, the three dominant sources of air pollution are automobile exhausts, road dust, and prescribed burning. The paper also discusses actions that could be taken to reduce those emissions, and the benefits that might result.

INTRODUCTION (Why do we care?)

The National park Service Organic Act of 1916 charges us "To conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of same in such manor and by such means as will leave them unimpaired for the enjoyment of future generations." At the same time, parks must be made accessible, not only to people, but also to their machines. However, wilderness and motors are incompatible. So, how to meet these objectives while hosting over a quarter of a billion visitors per year becomes a monumental problem.

For several decades the National Park Service (NPS) has been trying to estimate emissions of air pollutants from within the boundaries of the 384 park units that we currently administer. If NPS is to be a leader in protecting these national treasures with which we have been entrusted, we must exemplify the highest level of stewardship. We also believe that NPS should be an example to others, both in the private sector and in industry, by showing how new technologies and new approaches can be applied in a practical manner to solve common problems. Examples of these efforts are embodied in our "Environmental Leadership" initiative and our "Green Energy Parks" program.

NPS also believes that, if we are to be credible in working with other governmental entities to develop strategies to reduce air pollution across the nation, we must, at the same time, be taking a close look at our own "house" to ensure that our hands are clean. In addition, we want to know how our emissions compare to those from surrounding jurisdictions. Not only does this put us in a better bargaining position, but we

are also obligated to meet the same federal, state, and local regulations as any other citizen. So, compliance becomes another facet of our inventory effort. Unfortunately, reality has not always reflected these lofty goals.

BODY

What are some sources of park emissions?

NPS units range in complexity from a semi-barren plot of land with historical significance to something approaching a small city with its own infrastructure and school system. Many of the smaller park units have no stationary sources of emissions and rely upon outside suppliers for utilities. In some cases, no vehicles are allowed, and visitors arrive on foot or from nearby public transportation or roads; this is especially the case in our urban parks. On the other hand, some parks, by their nature, exist in magnificent isolation, and must be self-sufficient.

Having a few hundred million visitors in our "living rooms" every year presents some unique challenges if we are to be good hosts. Not only must we often provide food, security, and shelter, but also the other "necessities" of modern living. The large, isolated parks typically generate their own electricity and heat, and provide their own water supply and wastewater treatment, and must do so without spoiling the values that the visitors have come to experience. Our large fleets of vehicles and equipment require substantial maintenance efforts, in addition to our responsibilities to maintain roads and trails. And then, there is the pollution emitted by the vehicles used to transport our visitors around the often-vast expanses of our parks.

A particularly thorny issue is the matter of our prescribed burning efforts. After decades of suppressing wildfires in our national parks, we have come to understand that fire often plays a very important role in the natural functioning of an ecosystem. Now we are faced with the problem of "catching up" with nature in order to restore our wild areas to their natural condition. This may mean a very "unnatural" amount of intentional or "prescribed" burning in the meantime.

What are we doing now?

When I arrived at the Park Service a little over three years ago, one of my tasks was to begin inventories of parks with special concerns. For example, Rocky Mountain National Park (NP) was interested in quantifying its emissions in order to respond to criticisms from local officials about its contribution to regional air pollution problems. Yosemite Valley has been undergoing an extensive planning process aimed at reducing the impacts of human activity upon the Valley. Other parks expressed interest in assessing their relative impacts upon air quality in their areas, and in ways to reduce those impacts. (Parks in which I have conducted inventories are shown in Table 1.a.) It soon became apparent that this was more than a full-time job.

Table 1. Emission Inventories conducted by:

1.a. NPS	1.b. EAES&T (1)	1.c. CE-CERT
Acadia	Cabrillo	Arches
Grand Canyon (1)	Channel Islands	Black Canyon
Great Smokies	Death Valley	Bryce
Joshua Tree	Devil's Postpile	Canyonlands
Mesa Verde (1)	Eugene O'Neil	Capitol Reef
Mount Rainier (1)	Fort Point	Petrified Forest
North Cascades	Golden Gate	Glen Canyon
Olympic	John Muir	Zion (1)
Organ Pipe Cactus	Kings Canyon	
Rocky Mountain (1)	Lasen Volcanic	
Yosemite (1)	Lava Beds	
	Manzanar	
	Mohave Nat'l Pres	
	Muir Woods	
	Pinnacles	
	Point Reyes	
	Redwood	
	San Fransisco Maritime	
	Santa Monica Mountains	
(1) Included in report results.	Sequoia	
	Whiskeytown	
	Yosemite Valley mobile	

To allow us to better meet the needs of our client parks, NPS hired a contractor, EA Engineering, Science, and Technology (EAES&T—who had also been our prime contractor for a study of mobile source emissions in Yosemite Valley) to conduct inventories in 18 of our California parks (see Table 1.b.). Results from that project comprise a substantial portion of the results presented in this paper.

The Western Regional Air Partnership (WRAP) has been developing plans to improve visibility in the western US. One facet of WRAP's efforts has been to investigate emissions from sources "In and Near" Class I air quality areas on the Colorado Plateau. To that end, WRAP has passed through $50,000 from EPA to its "In and Near" forum to hire a contractor to inventory emissions from eight parks on the Colorado Plateau. In the fall of 2000, WRAP hired the University of California at Riverside's College of Engineering-Center for Environmental Research and Technology (CE-CERT) to conduct inventories at the parks shown in Table 1.c. (NPS administers that contract.)

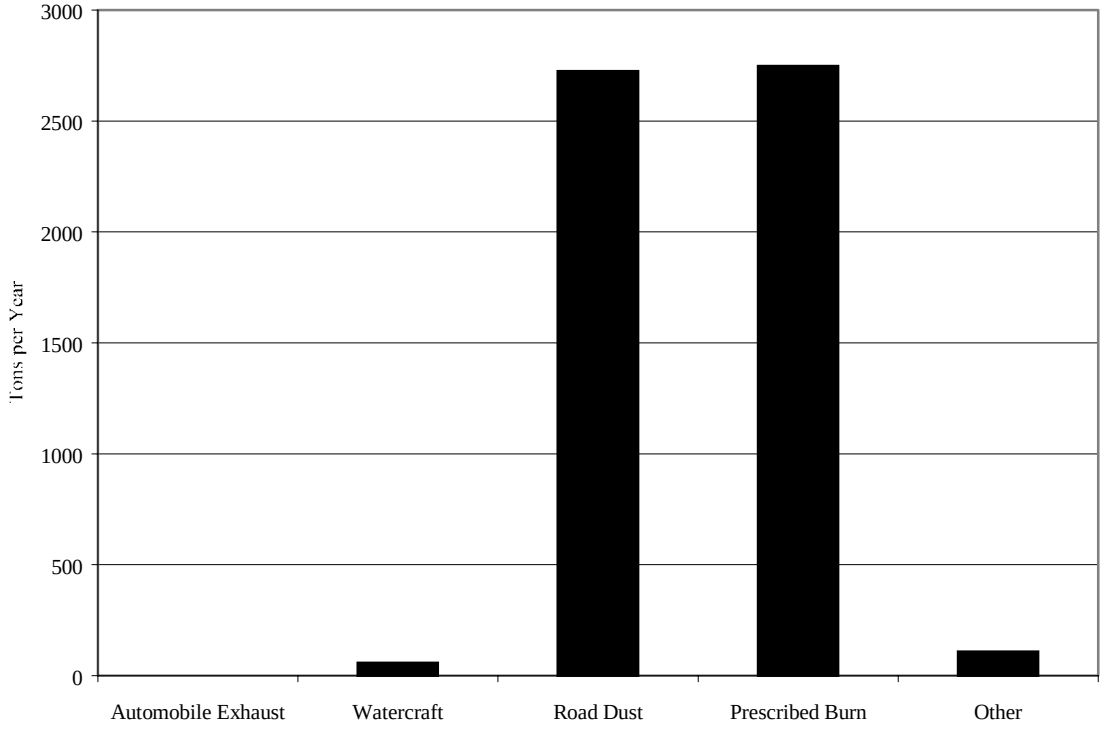
Most recently, the NPS Air Resources Division staff in Denver has been increased to include an engineer whose primary responsibility is to continue, expand, and coordinate our inventory efforts.

What have we learned?

Although we quickly discovered that our parks like change about as much as the civilian sector, for the most part they are observing good environmental practices, and some go well beyond. Several parks have installed photovoltaic systems that substantially reduce their dependence upon fossil fuels or the external power grid. ("Renewable Energy in the National Park Service," a comprehensive report by Sandia National Laboratories on these efforts, can be found at http://www.sandia.gov/pv/rnwprks.pdf.) At least one park has installed a fuel cell system to generate electricity, and some of the more-visited parks have instituted, or are planning, mass transportation systems. Many parks have replaced incandescent lights with energy-efficient fluorescents, converted paints and cleaning materials to "green" solvent bases, switched boilers and heaters to cleaner fuels, instituted recycling of motor oil, anti-freeze, car batteries and tires, and converted vehicles to alternative fuels (including one ship that burns "bio-diesel") or gasoline/electric hybrids. A more detailed listing of these "Success Stories" can be found in Appendix A at the end of this paper, and the relative benefits of various fuel conversions that have been accomplished in some parks are illustrated in Appendix B, Figures B.1. through B.4.

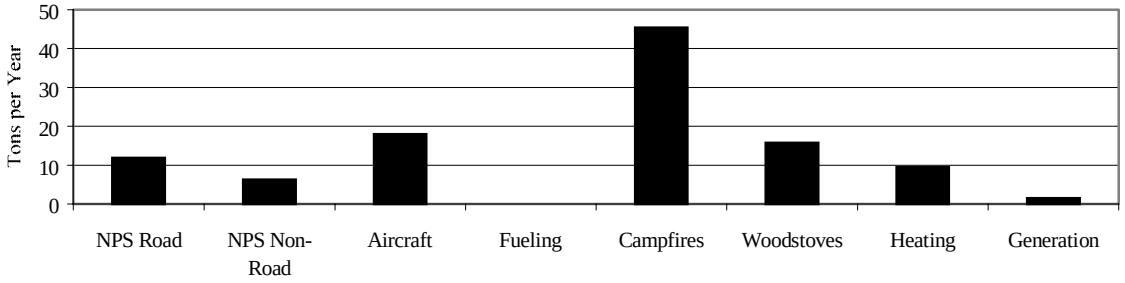
Despite the efforts described above, park emissions can be significant. Figure 1.a shows that particulate matter (PM_{10}) emissions in the parks surveyed are dominated by road dust and prescribed burning.

Figure 1.a. PM10



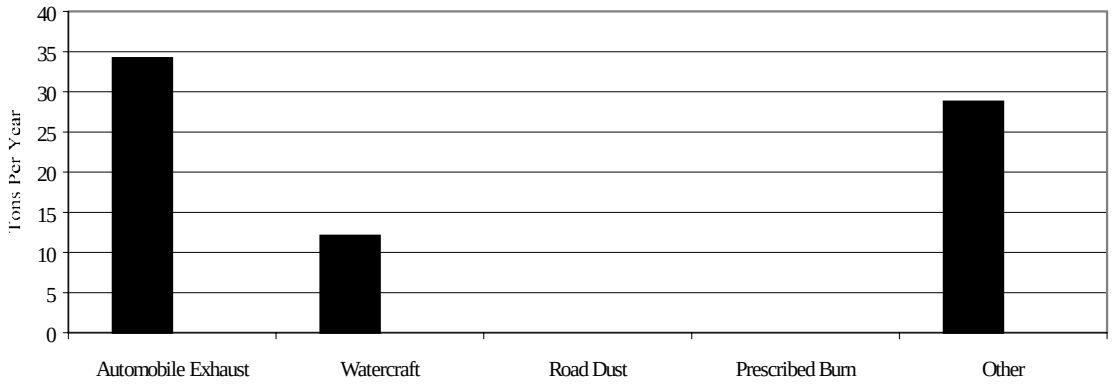
Campfires are the dominant sources of the "Other" category (Figure 1.b) of PM_{10}.

Figure 1.b. PM10 (other)



Sulfur dioxide (SO_2) emissions shown in Figure 2.a. are primarily the result of automobile exhausts and fuel combustion for heating. About half of the watercraft SO_2

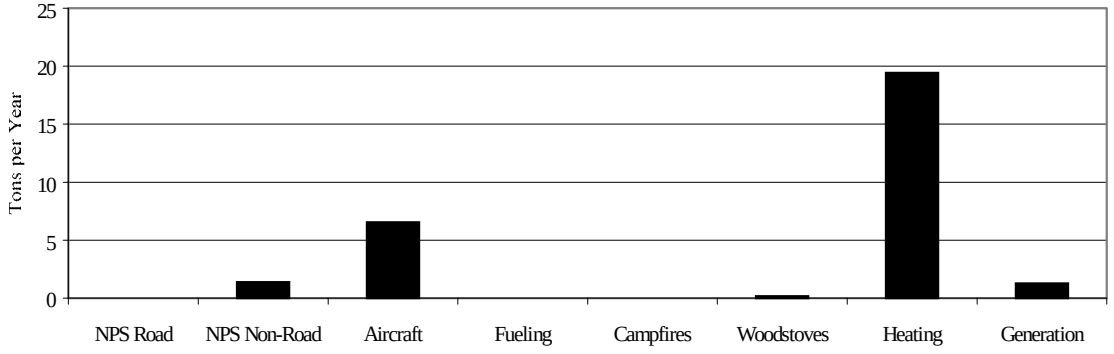
Figure 2.a. SO2



emissions occur in Golden Gate, with the remainder evenly split between Channel Islands and the Grand Canyon.

All of the aircraft emissions shown in Figure 2.b. are over the Grand Canyon.

Figure 2.b. SO2 (other)



Emissions of nitrogen oxides (NO_x) shown in Figure 3 are almost entirely due to automobiles.

Figure 3.a. NOx

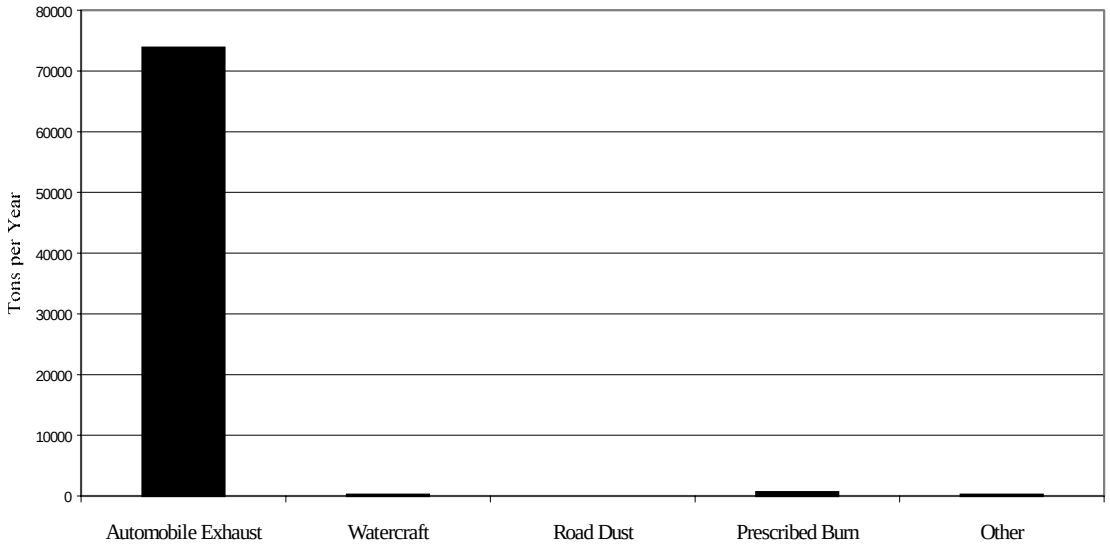


Figure 3.b. NOx (other)

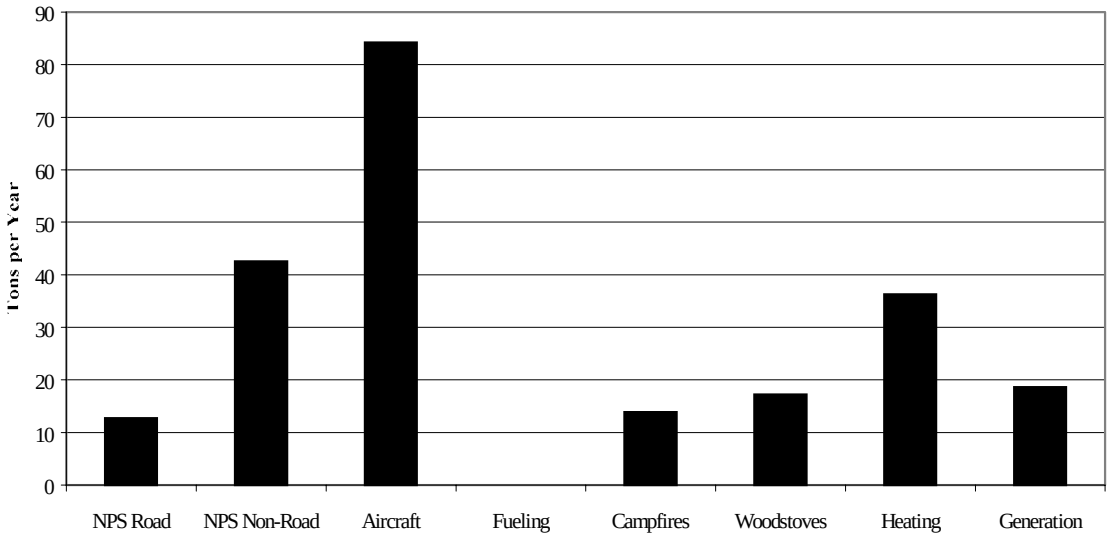


Figure 4 illustrates that prescribed burning is the largest source of emissions of volatile organic compounds (VOC), followed by watercraft (mostly in the Grand Canyon) and automobiles.

Figure 4.a. VOC

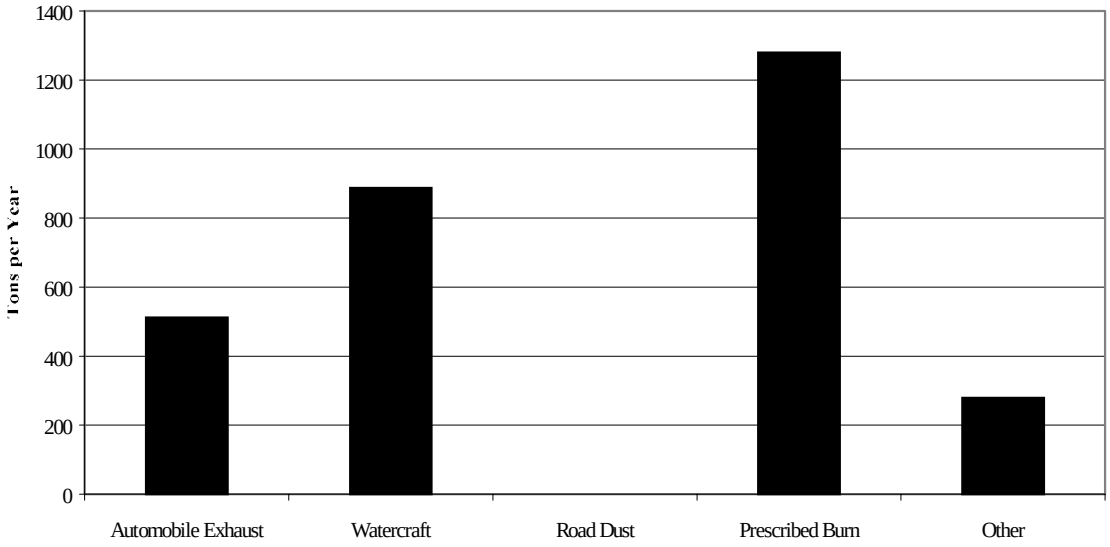
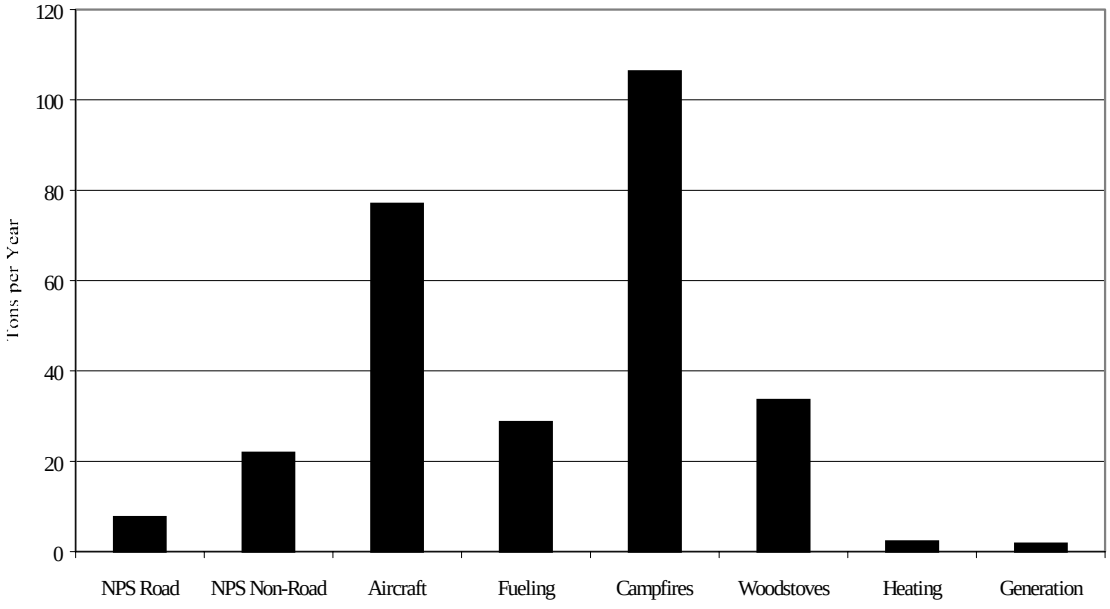
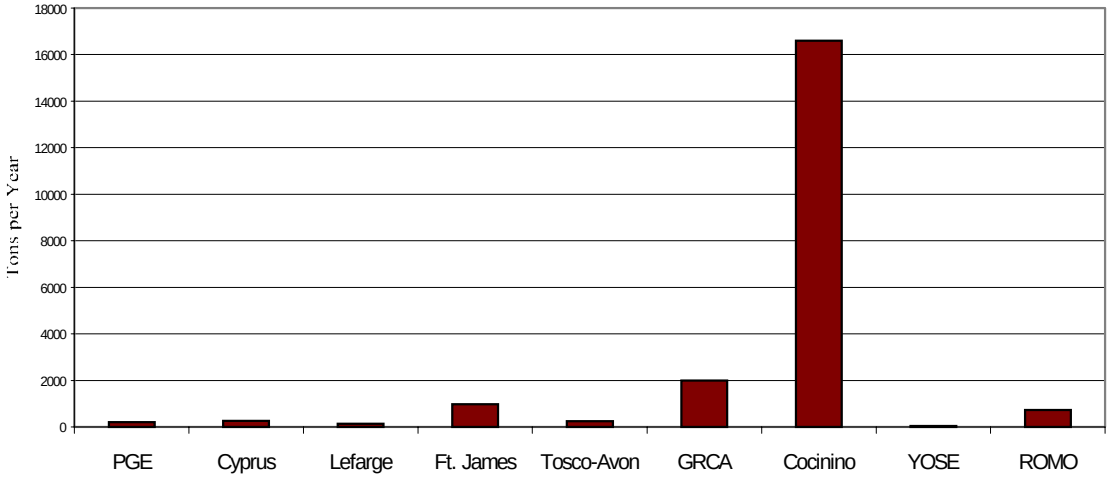


Figure 4.b. VOC (other)



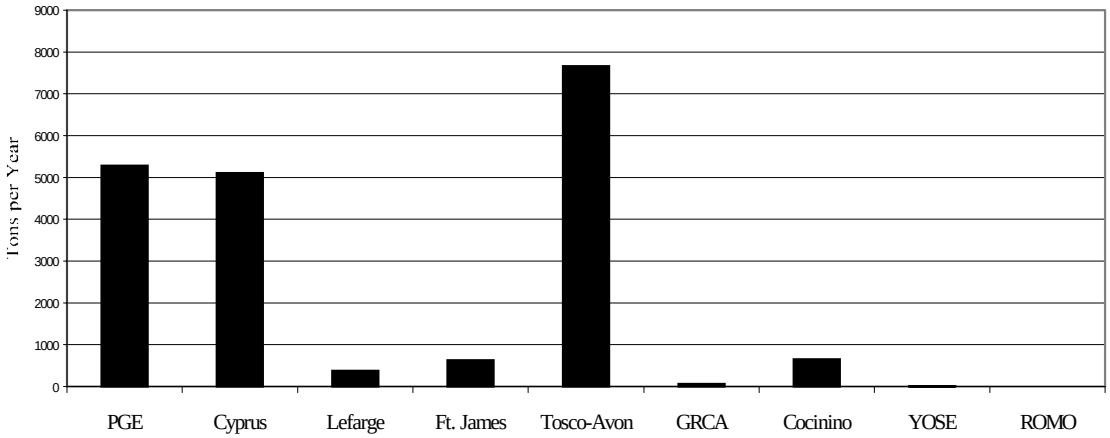
We are also interested in how emissions within our parks compare to those from industrial sources and from surrounding areas. The following Figures 5 through 8 illustrate how emissions from Grand Canyon (GRCA), Yosemite Valley (YOSE), and Rocky Mountain (ROMO) compare to the Boardman, WA power plant operated by PGE, the (formerly) Cyprus copper smelter in Miami, AZ, the Lefarge cement plant in Washington State, the Ft. James paper mill in WA, the Tosco-Avon refinery in CA, and Cocinino County, AZ next to the Grand Canyon. Figure 5 shows that only Cocinino County exceeds Grand Canyon NP for PM_{10} emissions, primarily due to road dust. Emissions from prescribed burning at Rocky Mountain NP are responsible for the bulk of its emissions.

Figure 5. PM10 Comparisons



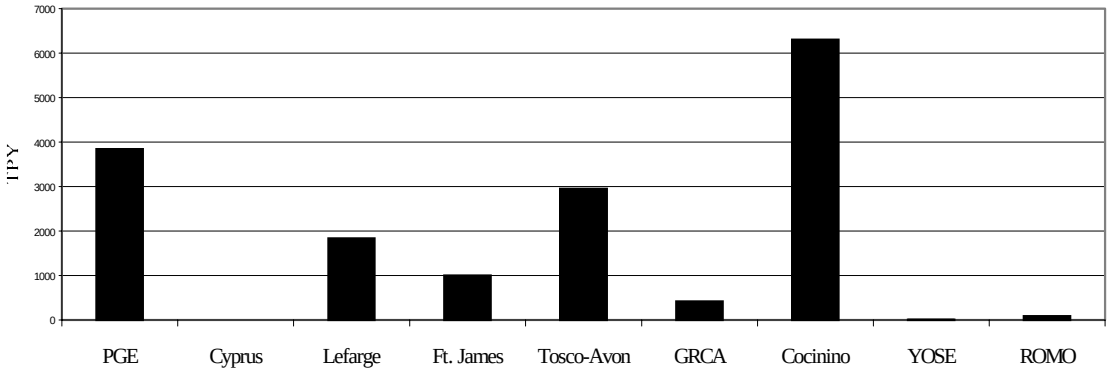
SO_2 emissions shown in Figure 6. are dominated by the power plant, copper smelter, and refinery; emissions from the parks are insignificant.

Figure 6. SO2 Comparisons



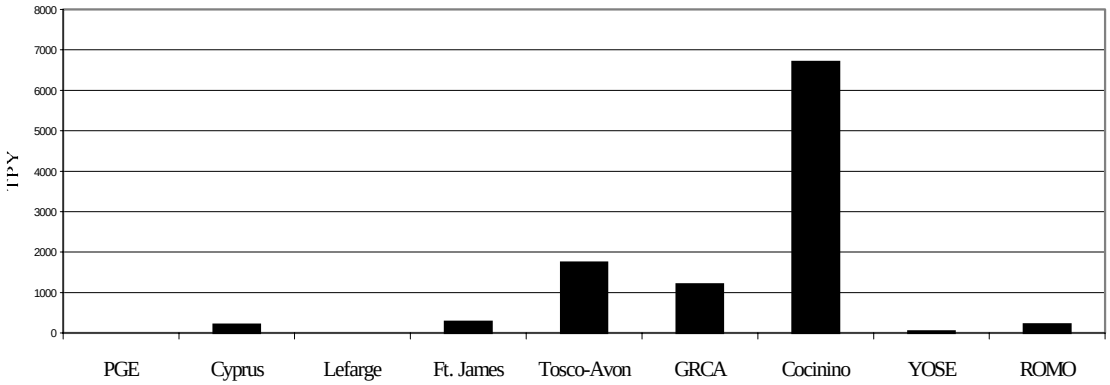
NO_x emissions from automobiles, watercraft, and aircraft in Grand Canyon NP are significant in Figure 7, but are still dwarfed by industrial and residential emissions.

Figure 7. NOx Comparisons



Watercraft in Grand Canyon NP, along with automobiles, result in VOC emissions that rival those of the refinery, but are still much less that area residential emissions, as shown in Figure 8.

Figure 8. VOC Comparisons



Complete compliance in our parks may be lacking. For example, because of their potential to emit more than 100 tons per year of one or more criteria pollutants (PM_{10}, SO_2, NO_x, VOC, CO), some of the larger parks may require either a Title V operating permit or a "synthetic minor" permit to avoid Title V. Beach fires are permitted at some parks which may allow burning of prohibited materials (pallets, treated lumber, rail ties, wood paneling, cabinetry, furniture, Christmas trees, and non-wood debris). Some parks open burn prohibited materials (treated lumber) as a routine disposal practice. Parks are also showing their age. Buildings are often poorly insulated and rely upon ancient and inefficient heating systems. Some are still using antiquated (dirty) woodstoves and incandescent lights. Landscape maintenance equipment is predominantly of the old two-stroke (dirty) variety.

CONCLUSIONS (What should we do?)

The two leading sources of emissions within the parks are automobiles (road dust and exhaust) and prescribed burning. While we can reduce the impacts of fires by controlling what is burned and under what conditions, it is likely that emissions from prescribed burning will increase as we step up our efforts to return wildlands to a more natural condition, as well as reduce the risk of catastrophic wildfires which result in even greater emissions. So, our most promising approach is to reduce visitor emissions, especially those from the automobile. But, the problem will not be easy to solve, as so eloquently stated by Edward Abee in his book Desert Solitaire:

> "Industrial Tourism is a threat to the national parks. But the chief victims of the system are the motorized tourists. They are being robbed and robbing themselves. So long as they are unwilling to crawl out of their cars they will not discover the treasures of the national parks and will never escape the stress and turmoil of the urban-suburban complexes which they had hoped, presumably, to leave behind for a while…How to pry the tourists out of their automobiles, out of their back-breaking, upholstered mechanized wheel chairs and onto their feet, onto the strange warmth and solidity of Mother Earth again? That is the problem which the Park Service should confront directly..."

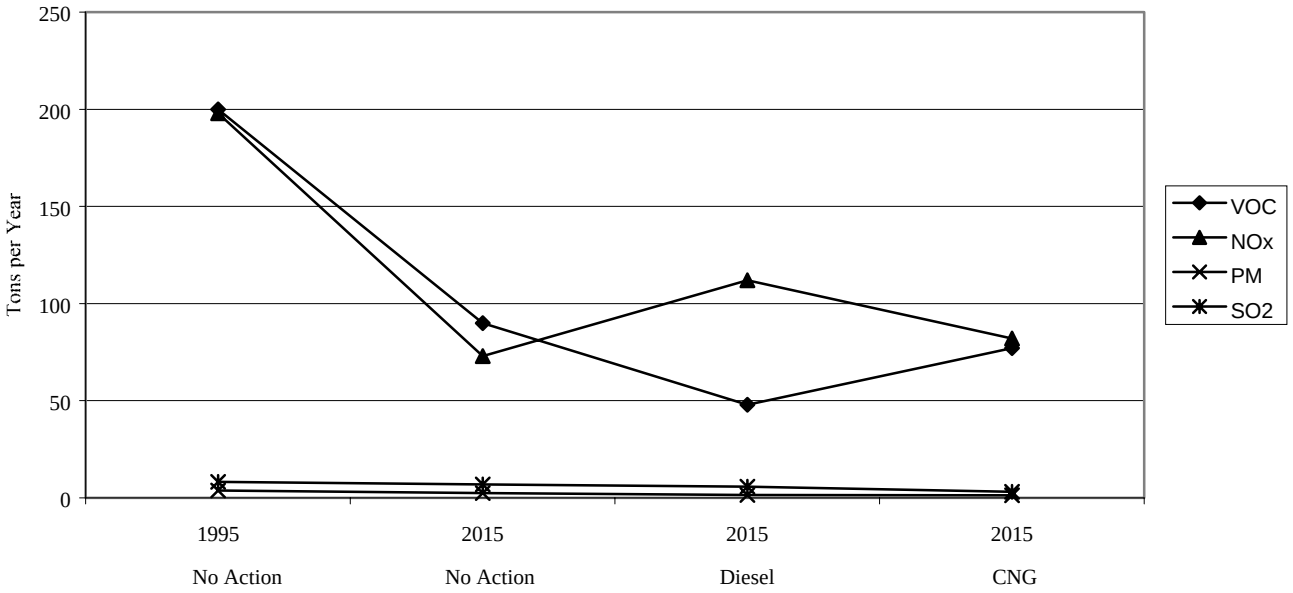
However, some parks such as Acadia and Zion are confronting the problem and have instituted mass transportation systems, and others such as Grand Canyon and Yosemite Valley are in the planing stages. One of the major problems, though, is that most mass transit systems work best where visitors are traveling around a loop and can return to their beloved autos at the end of the trip. In addition to reducing emissions from visitor vehicles, NPS and its concessionaires should explore the feasibility of the following:

- Replace diesel-fueled generators with natural gas/propane. Conversion to photovoltaic (as at Joshua Tree) would eliminate these (4.8 TPY) emissions entirely.
- Replace diesel-fueled heaters and boilers with natural gas/propane.
- Replacing old woodstoves with natural gas would reduce emissions.
- Creation of smoke-free campgrounds could alleviate complaints by sensitive individuals.
- Replace solvent-based cleaning agents with VOC-free cleaners.
- Substitute CNG (as at Zion) or diesel/electric hybrid busses for private automobiles.
- Replace gasoline-fueled park vehicles with natural gas/propane, or gasoline /electric hybrids.
- Replacement with electric vehicles would eliminate these (25 TPY) emissions entirely.
- Small parks may not find it cost-effective to install dedicated fueling systems for very small fleets. But, clusters of small parks may find it possible to establish a central fueling facility.

As noted above, several parks have already begun to reduce their emissions. For example, Joshua Tree NP in southern CA recently installed a photovoltaic system to replace diesel generators that had burned 14,000 gallons per year to supply electricity to its Cottonwood maintenance and residential area. In addition to reducing noise, air pollution emissions have been reduced as follows: PM_{10} 608 lb/yr, SO_2 568 lb/yr, NO_x 8644 lb/yr, VOC 706 lb/yr, CO 1862 lb/yr, and carbon dioxide 323,400 lb/yr. The CNG

bus system that began operation in Zion NP in 2000 is estimated to have reduced air emissions by 48 lb VOC/day (20% reduction) and 314 lb CO/day (27% reduction). PM emissions were reduced by 9%, and NO_x emissions increased by 20 lb/day (17% increase) due to the tenfold higher emisisons relative to passenger cars. This problem of balancing emissions increases and decreases among pollutants and between competing technologies is further illustrated in Figure 9 which is a plot of alternative emission scenarios for Yosemite Valley.

Figure 9. Yosemite Valley Shuttle



The natural evolution of the visitor vehicle fleet is such that, between 1995 and 2015, VOC and NO_x are expected to decline appreciably in Yosemite Valley, even if no action is taken to reduce vehicle miles traveled (VMT). However, in an effort to reduce both the human impacts upon Yosemite Valley and traffic congestion, NPS has been evaluating plans to reduce visitor VMT in the Valley. Two alternatives under review are to move visitors around the Valley in shuttle busses fueled by either diesel or compressed natural gas (CNG). The problem is that neither approach is a clear winner—use of diesel-powered buses would reduce VOC, PM, and SO_2 emissions relative to the "no action approach" passenger cars, but would produce greater NO_x emissions. Conversely, CNG busses would produce less VOC, PM, and SO_2 than "no action," and slightly more NO_x than the cars, but much less than the diesel busses. (CNG buses would also produce less PM and SO_2 than diesel buses.)

REFERENCES

Abbey, Edward, *Desert Solitaire; a season in the wilderness*, McGraw-Hill; New York, 1968, 269 p.

APPENDIX A. Success stories

- Acadia implementing an extensive bus system in cooperation with local communities.
- Badlands is operating two Toyota Prius gasoline-electric hybrid cars.
- The Ocean Ranger ship used to ferry passengers to Channel Islands burns "bio-diesel" fuel.
- Devil's Postpile has mandatory shuttle bus service June-September.
- Dinosaur operates shuttle system from the visitor center to the quarry.
- Visitors to Eugene O'Neill NHS must use the shuttle bus.
- Golden Gate replaced a fossil-fired electric generator with a fuel cell at Kirby Cove. Golden Gate operates 20 compressed natural gas (CNG) vehicles, including bi-fuel (CNG/gasoline) and dedicated fuel (CNG).
- Grand Canyon will institute a rail system to reduce auto use.
- North Cascades installed photovoltaic system at isolated ranger station near the Canadian border.
- Organ Pipe Cactus installed Stage I & II gasoline vapor recovery systems though not required.
- Pinnacles replaced a fossil-fired electric generator with photovoltaic system in west district resulting in 99% reduction in generator use. Pinnacles operates a 15-passenger shuttle van five weekends during peak season.
- Point Reyes provides shuttle bus service weekends and holidays January 1 - mid-April.
- Redwood operates photovoltaic systems at ranger's residence and Schoolhouse Peak fire lookout. Redwood operates several methanol fuel flexible fuel vehicles.
- During FY 1999, Sequoia/Kings Canyon installed photovoltaic/fuel cell/battery system with backup propane generator; completed retrofit of 5 buildings and shop area with low voltage fluorescent lighting; retrofit six restrooms with low voltage lighting fixtures; replaced two motors with energy efficient motors at the Wastewater Treatment Plant; installed 7 energy efficient water heaters in employee housing units; replaced five No. 2 oil heating units with propane heaters; purchased energy efficient refrigerators and ranges; and replaced 4 air conditioning units with swamp (evaporative) coolers.
- Whiskeytown NRA replaced all parking area lights with solar powered lights, and installed energy efficient lighting in the administrative offices. Whiskeytown was recently awarded DOE funding to advance the development of alternative fuels in NPS vehicles. Whiskeytown plans to build a propane refueling facility.
- Yosemite operates a free shuttle bus service in the eastern end of Yosemite Valley (year-round), and between Wawona and the Mariposa Grove of Giant Sequoias and from Tuolumne Meadows to Tenaya Lake (summer only).
- Several park maintenance shops have instituted recycling programs for used motor oil, oil filters, antifreeze, batteries, and tires. They have also converted parts cleaners to use cleaning agents that are free of VOC.
- Zion has instituted a mandatory shuttle bus program for use during the tourist season.

APPENDIX B

Figure B.1. Vehicle Conversion from Gasoline to CNG

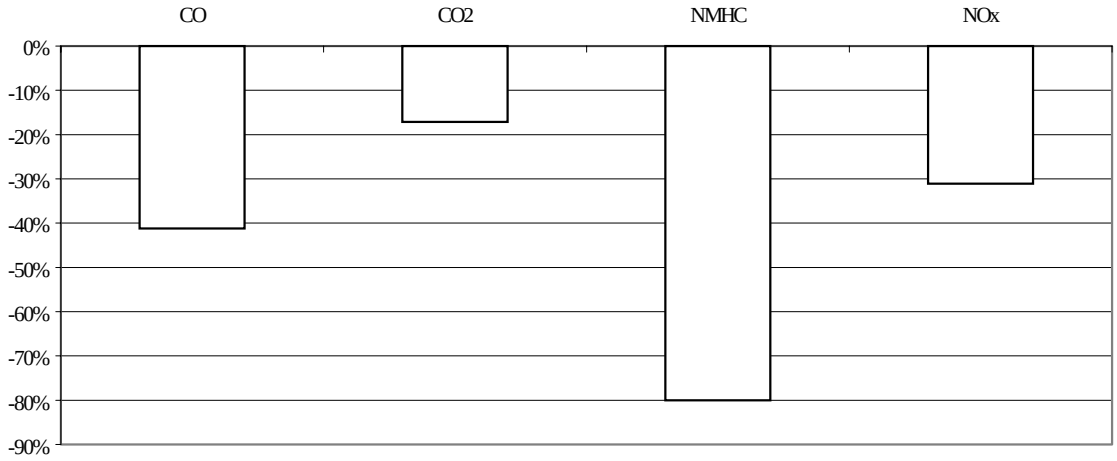


Figure B.2. Heater/Boiler Conversion from Oil to LPG

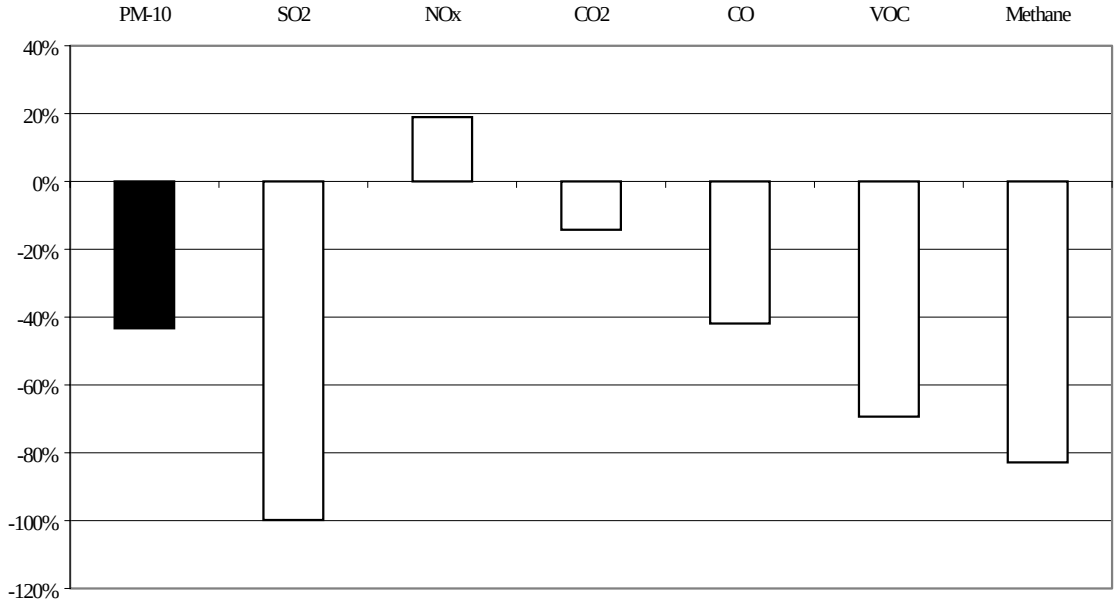


Figure B.3. Generator Oil to Gas Conversion

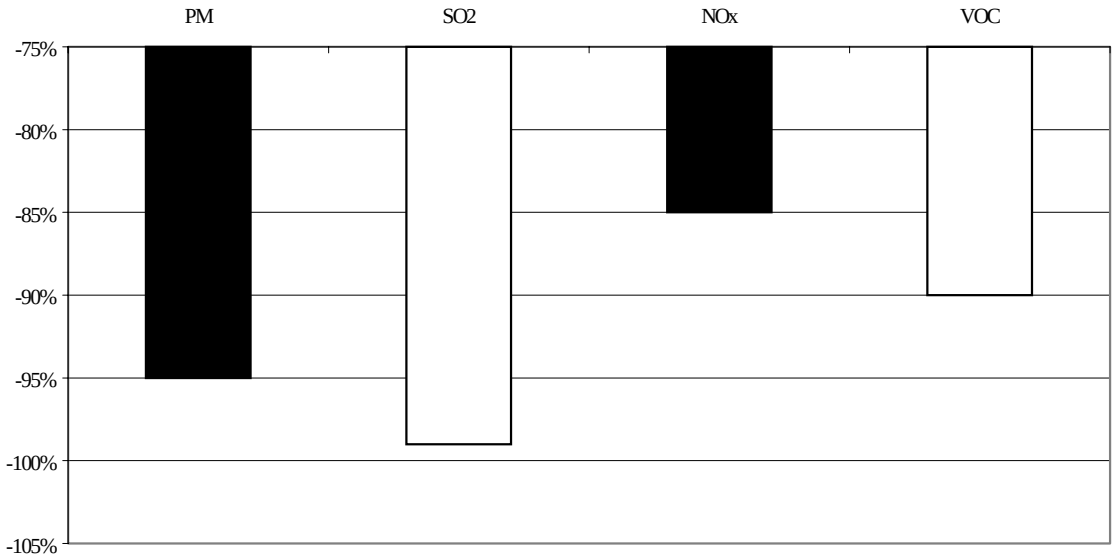


Figure B.4. Woodstove to Gas Conversion