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Portable emission measurements of snowcoaches and snowmobiles in Yellowstone National Park

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Yellowstone Winter Air Quality Study: Winter Vehicle Emissions



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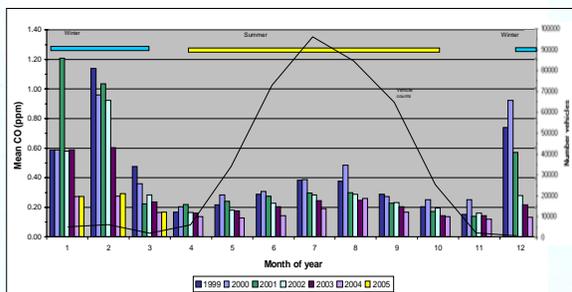
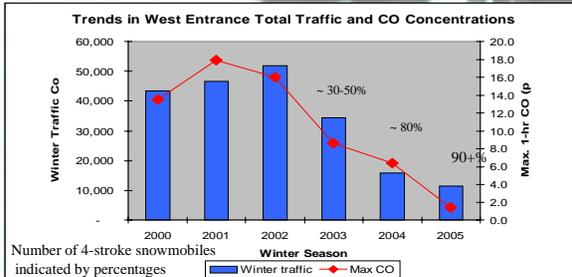
Introduction

Yellowstone National Park with its thermal features and abundant wildlife draws about 3 million visitors a year; less than 5 percent visit during the winter. Rapid increases in the number of snowmobiles using the park in the mid-1990's led to complaints about noise, odor, and air pollution. Measurements of air quality at the West Entrance found CO concentrations comparable to highly trafficked urban areas. Emission studies found that the 2-stroke snowmobile engines were many times dirtier than wheeled vehicles. Multiple law suites preceded the development of a Winter Use Plan that limited the number of snowmobiles, required the snowmobiles meet emission standards, and proscribed guided groups.

In recent years, the majority of snowmobiles visiting the park have switched to 4-stroke engines, more people are using the snow coaches, and the number of snowmobile visits has declined. Has the air quality improved? Are the emissions lower? What is the preferred mode of transportation from an air quality perspective?

Changes in Air Quality

Starting in 1999-2000, efforts were made to limit the number of snowmobiles queuing up at the entrance station. In 2002-2003 4-stroke snowmobiles became available as rentals and between one-third and one-half of snowmobile entrance traffic was 4-stroke sleds. In 2003-2004, 4-stroke snowmobiles and guided tours were initiated with the result that approximate 80% of snowmobiles were 4-stroke. During the winter of 2004-2005, greater than 90% of snowmobiles were 4-stroke. These measures appear to have been effective in reducing the high CO concentrations near the entrance station.



The CO concentrations are much higher during the winter months despite that fact that traffic is much higher during the summer. The decrease in CO in winter is due mostly to the reduced traffic, but also to an emission reduction of 61%. Summer mean CO concentrations have also been coming down in recent years. This due to newer vehicles with modern pollution controls that are slowly replacing the fleet of old vehicles.

Measuring Emissions in the Field

Ambient air monitoring was initiated at 2-3 locations. A remote sensing device was used to determine the emissions of CO, hydrocarbons, and NO for snowmobiles at the West Entrance station. Portable instruments were used to directly measure exhaust gases from a cross-section of snow coaches.



Above is part of the remote sensing equipment used at the West gate to measure snowmobile emissions. The snowmobile below is just going through the IR-light beam.



Snowmobiles emissions were measure on entry and exit. One sled was instrumented for direct exhaust emissions measurements.



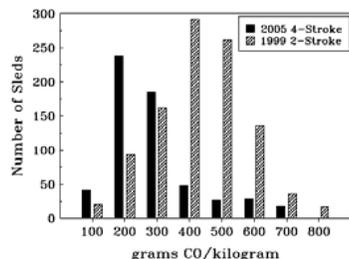
The compact emission analyzer was carried inside the vans and a hose run out to the exhaust pipe. Researchers traveled with the equipment.



The oldest snow coaches are Bombardiers. Most have older carbureted engines that have high emissions.

The snow coaches emissions on a round trip from Mammoth to Old Faithful are color-coded on this map. Higher CO emissions are seen with greater load, speed, and "off-cycle" excursions. The inset has shaded-relief of elevation to see the load effect.

Snowbuster 163 Emissions 2/15/05 - CO ppm
One Minute Rolling Average



Comparison of snowmobile CO emissions. There is a shift in the distribution of about 40% lower for 4-stroke sleds. Most of the tailing to higher values is from one brand of sleds.



Pictures are of the monitoring station at Old Faithful next to the parking lot and visitor facilities. Steam from the geyser is seen in the background. The close-in parking lot fills with snowmobiles and snow coaches during mid-day on busy weekends. Data at

Emissions over the route from Mammoth Hot Springs to Old Faithful is given in the figure for one of the conversion vans. The amount of CO vs NOx varies depending on engine load, terrain, and speed. Off-cycle excursions cause the engine to emit short periods of very high pollution. The snow coaches typically return at higher average speeds. The difference in the emissions on the return trip reflect the higher load.

Results of Emissions Studies

Emissions are presented in the table below as gm/mi/person. The change from 2-stroke to 4-stroke engines reduced CO by 40-60% and hydrocarbons by greater than 98%. The average snow coach emissions are slightly higher in CO and NO, lower for HC. However, snow coaches with modern pollution controls were much cleaner than the cleanest snowmobile measured. On a tons per season emitted basis, the 4-stroke snowmobiles and the current fleet of snow coaches are roughly even.

	Snowmobile	Snowmobile	Snowmobile	Snowcoach	Snowcoach
Pollutant	average 2-stroke	average 4-stroke	cleanest 4-stroke	average	cleanest
CO	65	28.0	25.0	42.0	0.7
HC	81	3.4	3.1	1.7	0.1
NO	--	2.4	2.8	3.1	0.2

Summary and Conclusions

- The historical decreasing trend in the number of snowmobiles is mimicked by decreasing CO concentrations and is the primary reason for the lower ambient CO concentrations.
- Both snow coaches and 4-stroke snowmobiles have lower emissions per person than the 2-stroke snowmobiles. Emissions reductions averaged 61% for CO and greater than -96% for hydrocarbons.
- The reduction in snowmobile hydrocarbons was significant (-96%) and readily observed. Visible exhaust plumes and odor were greatly reduced. The greater engine efficiency is reflected in an improved gas mileage by the 4-stroke snowmobiles.
- Snowmobile emissions were NOT observed to increase with speed on a gm/mile basis. Emissions are greatest during initial startup and idling, especially when the engine is cold.
- The Bombardier snow coach with an uncontrolled carbureted engine had the highest CO and HC emissions and operated in this high region 98% of the time. Vans and coaches with efficient fuel-injected engines and catalytic converters can be nearly as clean as modern wheeled passenger vehicles.