# Particulate Matter 2.5 (PM 2.5) Study: PM 2.5 Level When Exposed To Exhaust From Different Engine Sizes (cc)

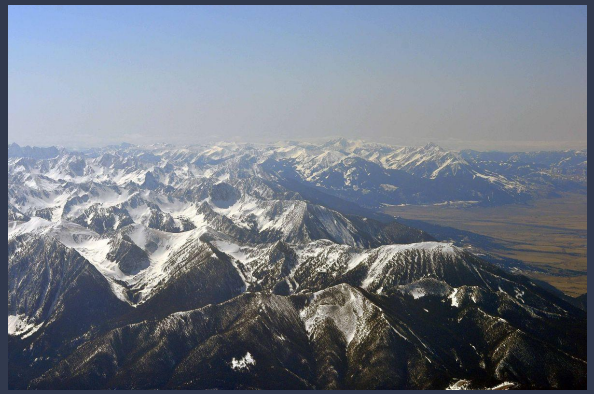
Tyler Andersen and Casey Rusdal

Libby Middle High School

Advanced Biology

Ms. Rose

# Background



**Relevancy:**

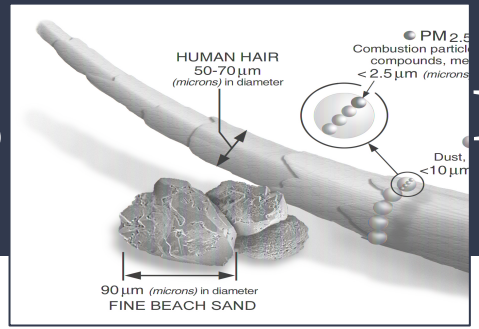
- Northwest Montana
  - Vast amount of time spent outdoors
  - Vehicle exhaust negative effects
    - Long term impact on our cardiovascular health
    - Inversion layer

**Question:** How does engine size impact Particulate Matter 2.5 (PM 2.5) output?

**Hypothesis:** The larger engine sizes will release more PM 2.5 due to the higher rate of fuel consumption.

**Null Hypothesis:** There will be no statistical correlation between engine size and PM 2.5 output.

# Intro to PM 2.5




- PM 2.5
  - Consists of particles of solids or liquids that are in the air
    - Airborne pollutants are a mixture of many chemicals
    - solid or liquid (CARB, 2023)
  - On-road vehicles are a significant source of harmful PM 2.5 air pollutant emissions
    - Vehicles burning fossil fuels emit PM 2.5
    - PM 2.5 can cause cardiovascular problems (Reichmuth, 2019)

# Federal Exhaust Standards

- Federal Exhaust Standards
  - Developed by the United States Environmental Protection Agency (US EPA) to lessen the consequences of PM 2.5 pollution
  - Tier 4 emission standards 2010 (the most recent of any exhaust standards)
  - More strict than Tier 2 and Tier 3 emission standards
  - Tier 5 emission standards are not set to come out until 2027

# Vehicles & Tools

125 cc

2007 Yamaha TT-R125

250 cc

2003 KTM 250 EXC-F

420 cc

2010 Honda Rancher

1000 cc

2007 Yamaha Vector

3400 cc

2000 Chevy Impala

5800 cc

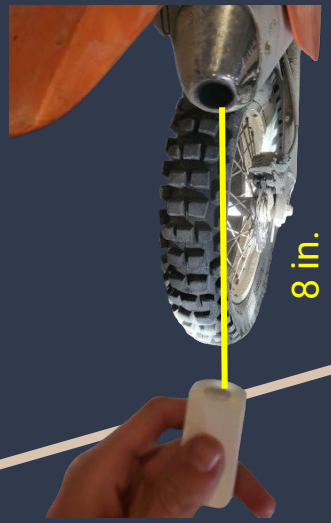
1997 Jeep Grand Cherokee

## Materials

- Wynd Air Quality Tracker
- 2007 Yamaha TT-R125
- 2003 KTM 250 EXC-F
- 2010 Honda Rancher
- 2007 Yamaha Vector
- 2000 Chevy Impala
- 1997 Jeep Grand Cherokee


Wynd Air Quality Tracker

# Experiment Methodology




## Methods

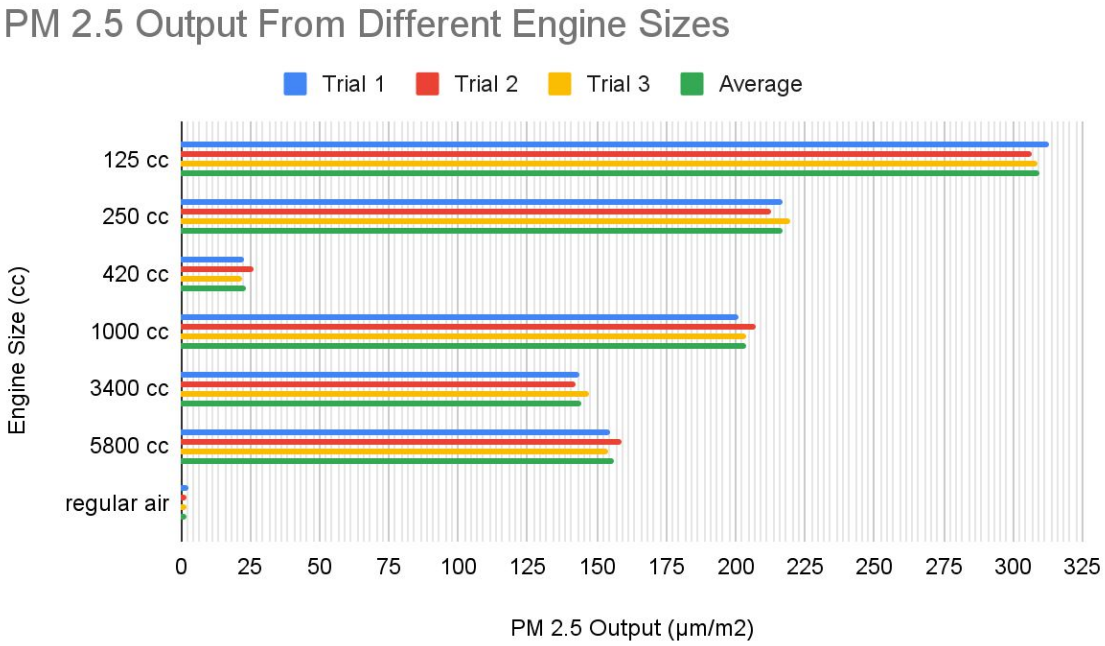
1. Wynd Air Quality Tracker was placed eight inches from the exhaust pipe
2. Reading began 2 seconds after engine start-up
3. Each reading lasted 10 seconds
4. PM 2.5 output was recorded
5. Each engine size was tested three times
6. All vehicles were tested in the same location and at around the same time of day

# Results

| Engine Size (CC) | Year Of Vehicle | Trial 1 | Trial 2 | Trial 3 | Average (significant figures) | Carbureted or fuel injected | Catalytic Converter (Yes/No) |
|---|---|---|---|---|---|---|---|
| **125 cc** | 2007 | 313 | 307 | 309 | 310 | Carbureted | N |
| **250cc** | 2003 | 217 | 213 | 220 | 217 | Carbureted | N |
| **420 cc** | 2010 | 23 | 26 | 22 | 24 | Fuel Injected | Y |
| **1000 cc** | 2007 | 201 | 207 | 204 | 204 | Fuel Injected | Y |
| **3400 cc** | 2000 | 144 | 142 | 147 | 144 | Fuel Injected | Y |
| **5800 cc** | 1997 | 155 | 159 | 154 | 156 | Fuel Injected | Y |
| **Regular Air** | N/A | 3 | 2 | 2 | 2 | N/A | N/A |

Trials in microns per square meter

# Results and Data Analysis




Difference between carburetor and fuel injected engines:

- Carbureted: All manual, has to be tuned to very precise conditions
- Fuel injected: Runs off a computer, can account for changes in the fuel air intake and environmental factors, making it more efficient

Catalytic converters were introduced in order to keep harmful pollutant out of the air

# Discussion

- Based on our data, our hypothesis was rejected
  - As motor size increased, for the most part, there was a decrease in PM 2.5 output
  - It can be assumed that larger engine sizes are more environmentally friendly
- *Exception of the 420 cc engine seemed to indicate otherwise*
  - Average output: 23.67 $\mu m/m^2$
  - Next lowest: 144.33 $\mu m/m^2$ (3400 cc)
  - Indicates that the 420 cc engine is the most environmentally friendly engine size studied

- Why might the 420 cc engine have a much lower PM 2.5 output?
  - Relative modernity compared to other engines
  - Newer catalytic converter
  - Under stricter emissions policies (US EPA)

# Conclusions and Error



There were several variables and possible errors that may have contributed to not completely accurate results:

Variables include:

- Fuel injected vs. Carbureted
- Whether or not a vehicle had a catalytic converter
- Human error in:
  - Length of test
  - Start time of test
  - Distance from exhaust
  - Exhaust pipe circumference
    - Affects dispersal fan

Null hypothesis:

Accepted due to no statistical correlation between engine size and PM 2.5 output

Steps for next time:

- More uniform sample set
  - All either fuel injected or carbureted
  - All or no catalytic converters
- Larger sample size
  - More extensive pool of engine sizes

In order to conclusively determine whether engine size is a factor were accurate or not, more similar experiments will need to be conducted.

# References

California Air Resources Board (2023). Inhalable Particulate Matter and Health (PM 2.5 and PM 10). Retrieved from the Web March 29, 2023. https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health#:~:text=What%20is%20Particulate%20Matter%3F,solid%20cores%20with%20liquid%20coatings.

David Reichmuth (2019). Air Pollution From Cars, Trucks, and Buses in the US: Everyone is Exposed, But the Burdens Are Not Equally Shared. Retrieved from the Web March 29, 2023. https://blog.ucsusa.org/dave-reichmuth/air-pollution-from-cars-trucks-and-buses-in-the-u-s-everyone-is-exposed-but-the-burdens-are-not-equally-shared/.