National Park Service Technical Comments

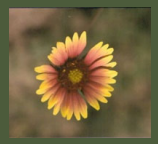
20.2.50 NMAC OIL AND GAS SECTOR-OZONE PRECURSOR POLLUTANTS RULEMAKING (EIB NO. 21-27 (R))

Synopsis

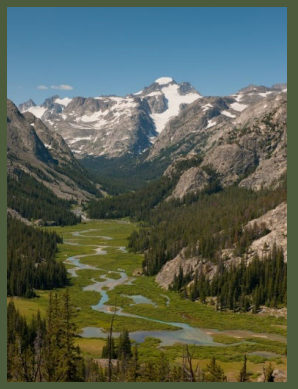
- Ozone concentrations exceed the level of the National Ambient Air Quality Standards (NAAQS) for ozone at Carlsbad Caverns National Park (NP) in New Mexico
- Volatile Organic Compounds (VOCs) measured at Carlsbad Caverns NP indicate the main sources of VOCs affecting ozone formation are from oil and gas activities
- Nitrogen oxide (NO_X) emissions that affect high ozone concentrations at Carlsbad Caverns NP are from local sources
- The measures proposed in this rule will help to reduce high ozone concentrations – more measures or more stringent measures are likely necessary to get below the NAAQS – this is a necessary step
- NO_x and VOC control measures are necessary to reduce ozone

The NPS and Air Resources—Why we Care

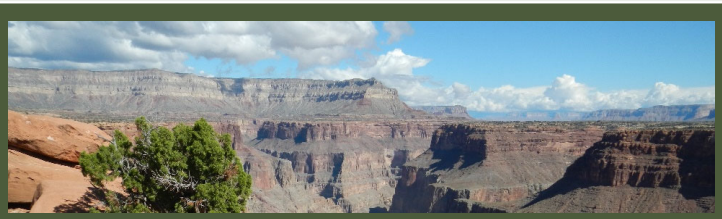
"…which purpose is to conserve the **scenery and the natural and historic objects** and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will **leave them unimpaired** for the enjoyment of future generations." (NPS Organic Act)



"Wilderness areas…shall be administered…in such a manner as will **leave them unimpaired** for future use and enjoyment as wilderness…" (Wilderness Act of 1964)



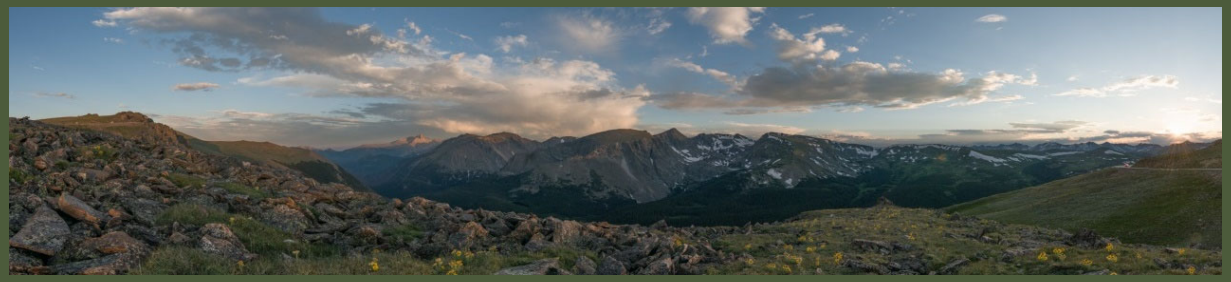
"…**preserve, protect and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores**…" (Clean Air Act as amended in 1977)



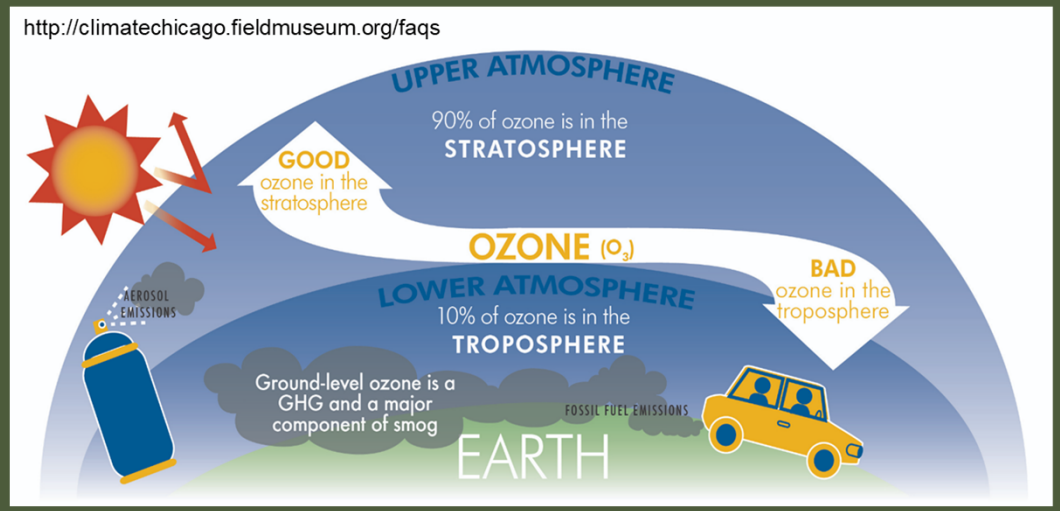
Regional Haze Rule, 1999

Requires state and federal agencies to work together to improve visibility in all 156 federal Class I national parks and wilderness areas

"In cases of doubt the land manager should err on the side of protecting the air quality-related values for future generations." (Senate Report No. 95-127, 95th Congress, 1977)



Ground Level Ozone

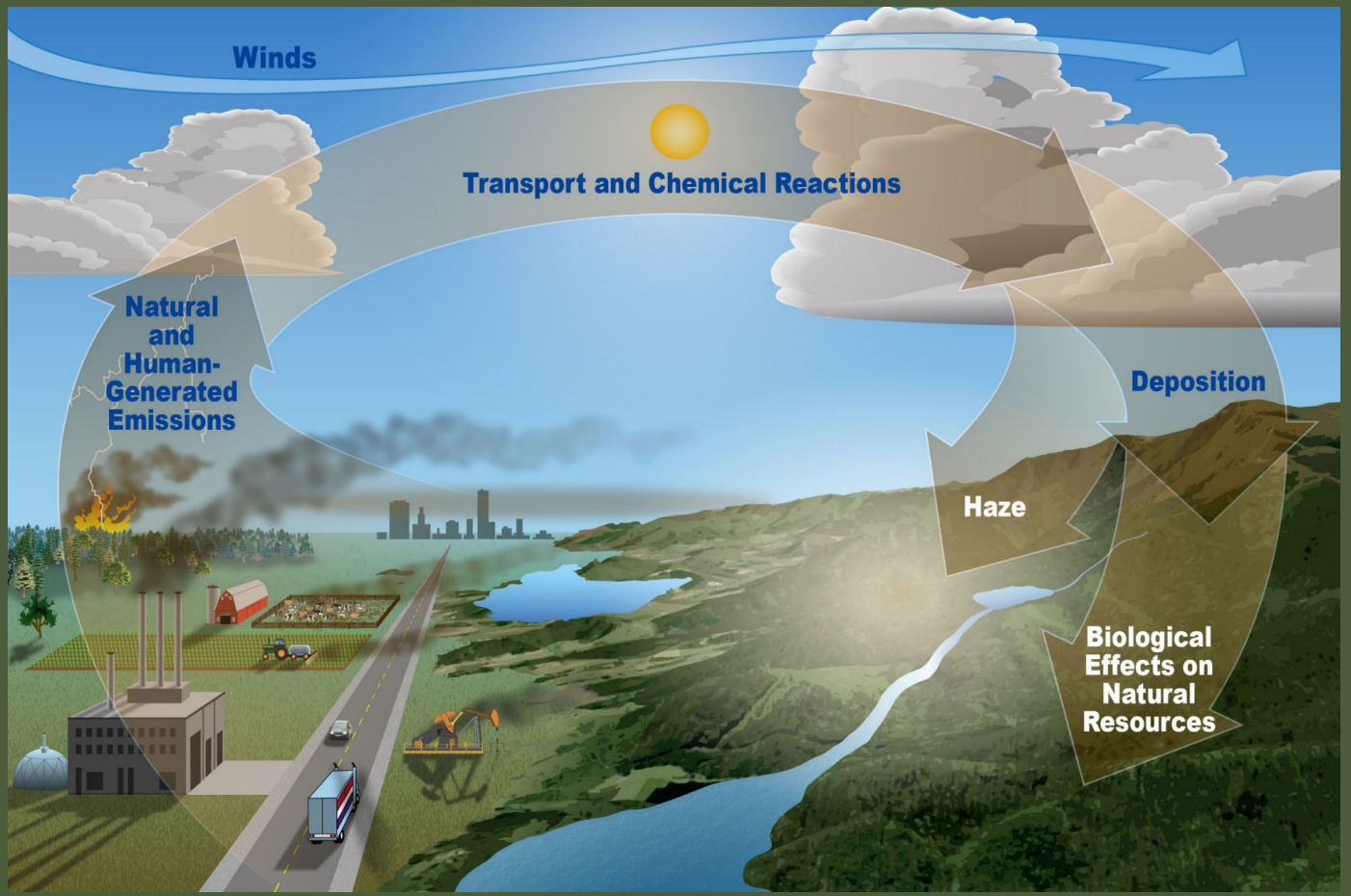


- Formed by reactions of NO_x and VOCs in the presence of sunlight
- Impacts vegetation and human health
- EPA Regulated Pollutant

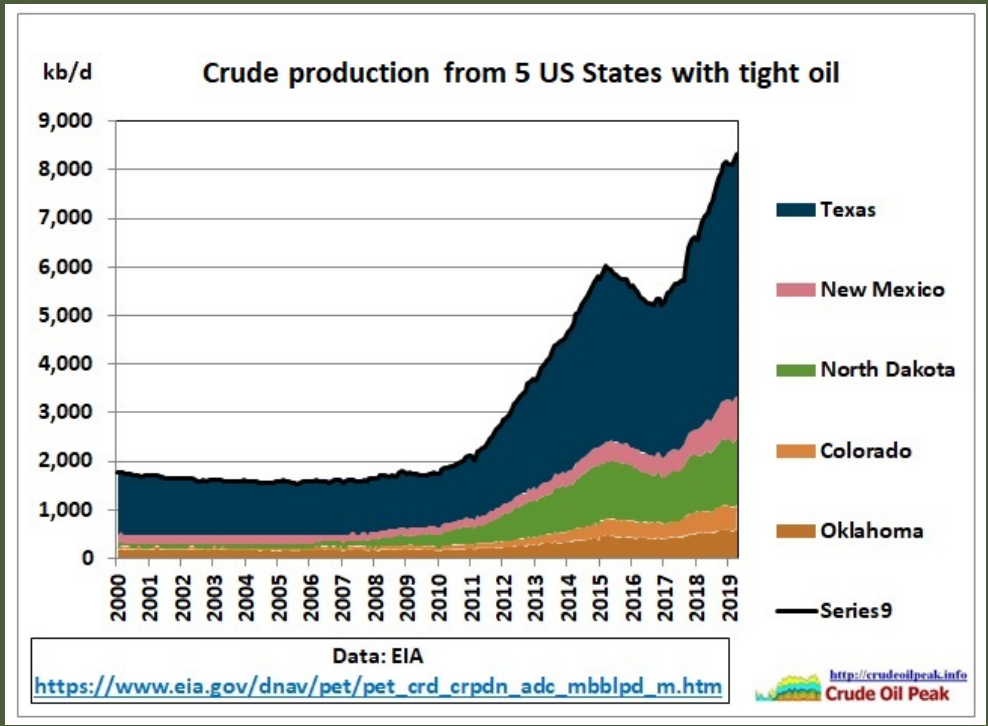
Lung Function

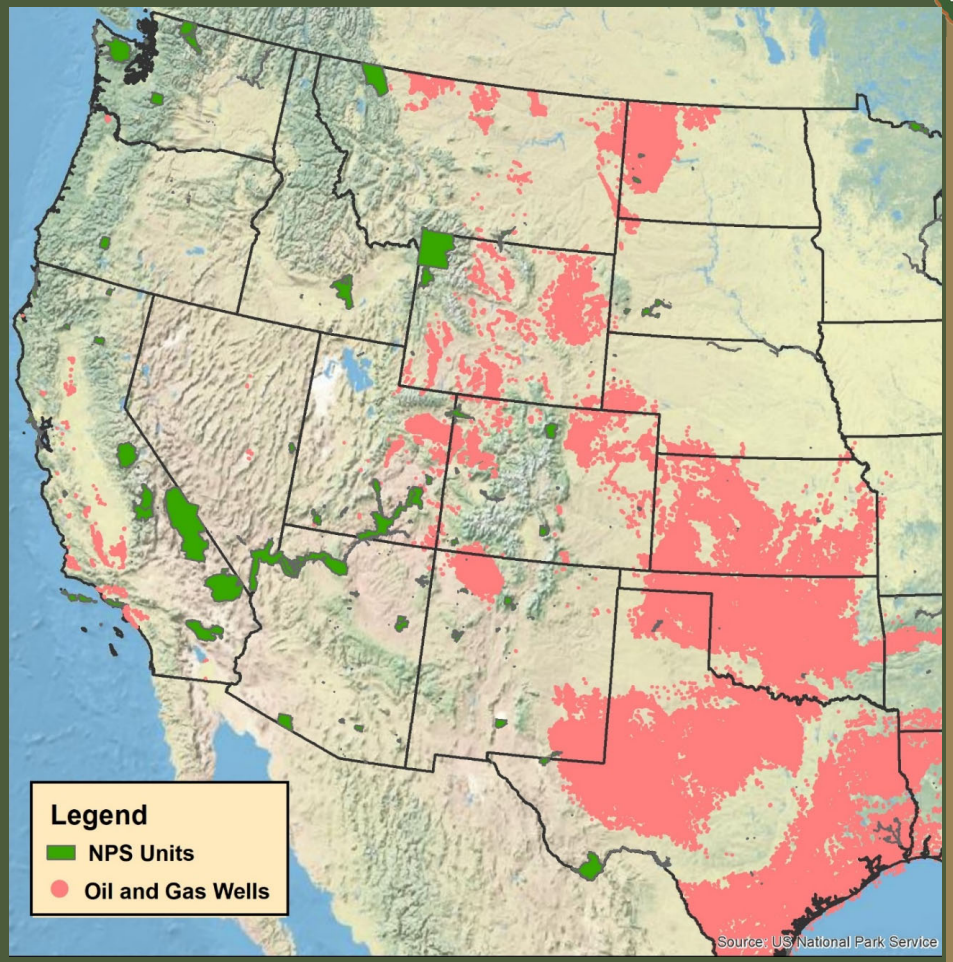
Foliar Injury

Pollutants Come from Outside Parks



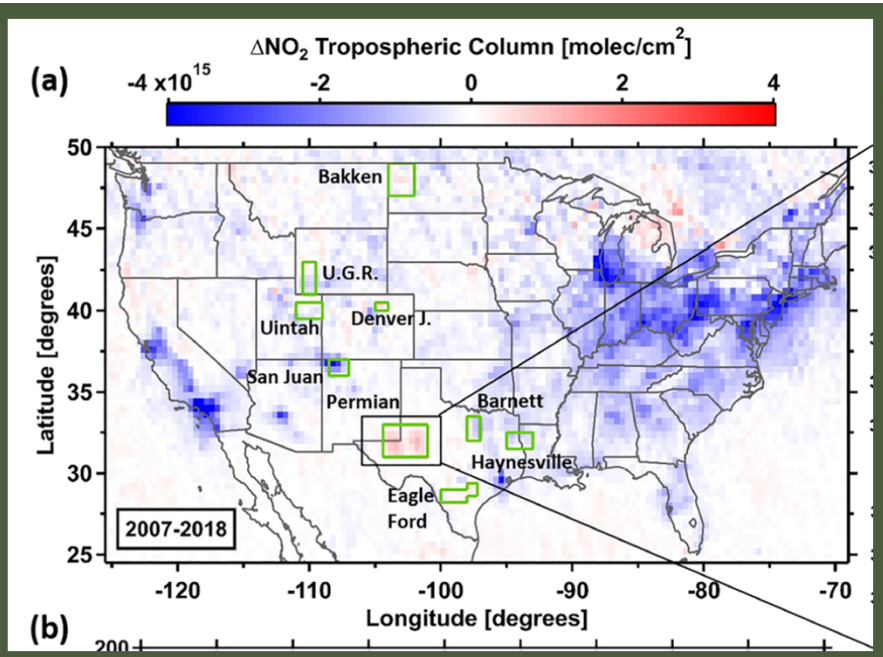
Extensive Oil & Gas Activities throughout Midwest and West





Increases in NO_x* and Ozone at Carlsbad Caverns National Park

*NOx = NO + NO_2



Trends in NO_x, from satellite data
(Dix et al., 2020)

Carlsbad Caverns Ozone

70 ppb is the national standard

Year	# Exceedance Days	Years	8-hr 4th high O_3
2016	None	2014-2016	67
2017	None	2015-2017	66
2018	10	2016-2018	**71**
2019	6	2017-2019	**74**
2020	9	2018-2020	**73**

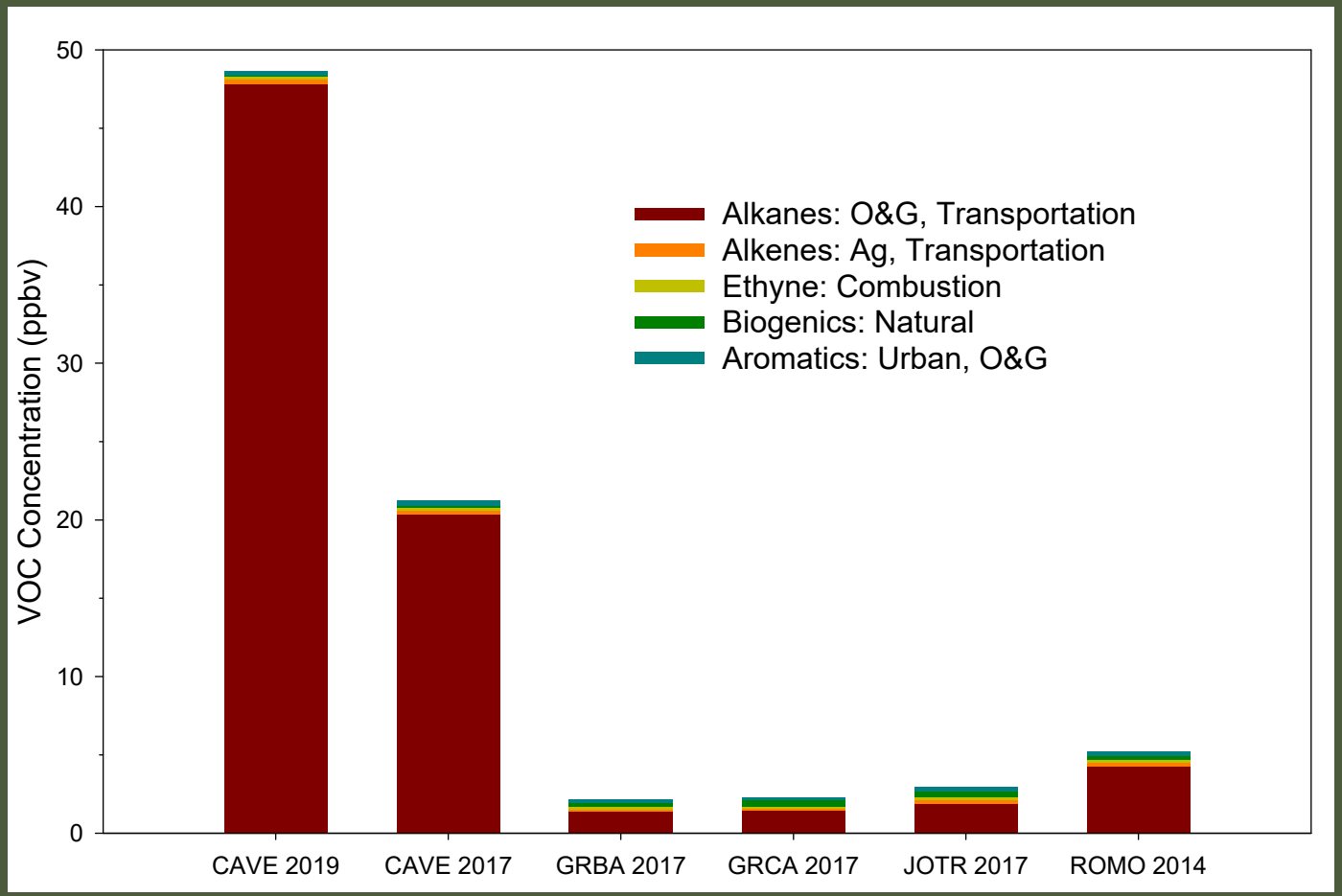
Measuring VOC markers (**70+**) to better understand sources affecting parks

- **Oil & Gas**
  - NMHCs: light alkanes C2-C6, i-butane/n-butane, i-pentane/n-pentane
- **Biomass Burning**
  - acetonitrile, methyl halides (CH_3Cl, CH_3Br, CH_3I), OVOCs (MeOH, acetone)
- **Urban**
  - industrial: benzene, toluene, xylenes
  - solvent evaporation: halocarbons (CH_2Cl_2, C_2Cl_4, C_2HCl_3, $CHCl_3$, CH_3CCl_3)
  - Waste water treatment: $CHCl_3$, $CHBr_3$
- **Agriculture**
  - crops: alkenes (hexenes, ethene, propene), DMS, $CHBr_2Cl$
  - animal husbandry: methanol, ethanol, acetaldehyde
- **Transportation**
  - Fuel Evaporation: i-pentane/n-pentane
  - fuel combustion: ethyne, ethene, propene, benzene,
  - exhaust: i-butane/n-butane, i-pentane/n-pentane, alkenes, ethyne
- **Biogenic/natural emissions:**
  - isoprene, monoterpenes
- **Stratospheric Intrusion:**
  - OCS, CFCs, HCFCs
- **Ocean/Marine:**
  - $MeONO_2$, $CH2Br_2$, $CHBr_3$, CH_2ClI, DMS, OCS
- **Oxidation/photochemical processing:**
  - $RONO_2$, OVOCs

VOC Survey Study
April – September 2017

- Mix of VOCs collected tell us about the sources impacting the parks.
- Park Natural Resource Staff at four parks collected VOC canisters over 5-month period.
  - Carlsbad Caverns NP (CAVE)
  - Great Basin NP (GRBA)
  - Grand Canyon NP (GRCA)
  - Joshua Tree NP (JOTR)

Average VOC Concentration



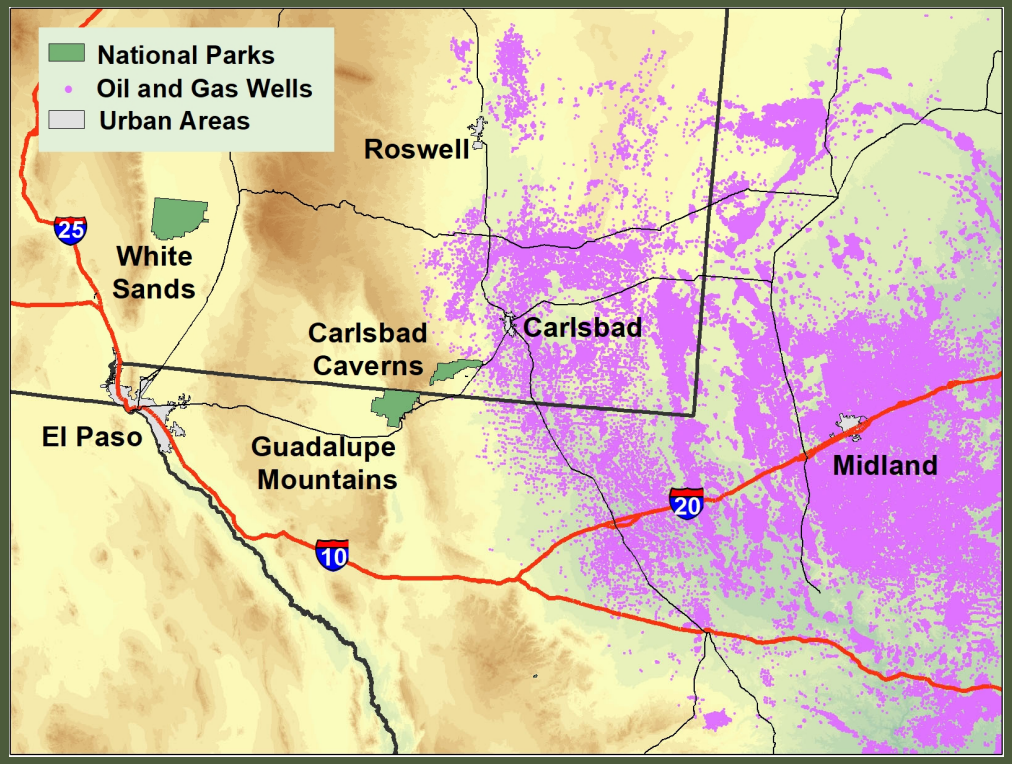
Carlsbad Caverns NP

VOC Mix Dominated by Oil &Gas

Carlsbad Caverns NP Sampling Notes

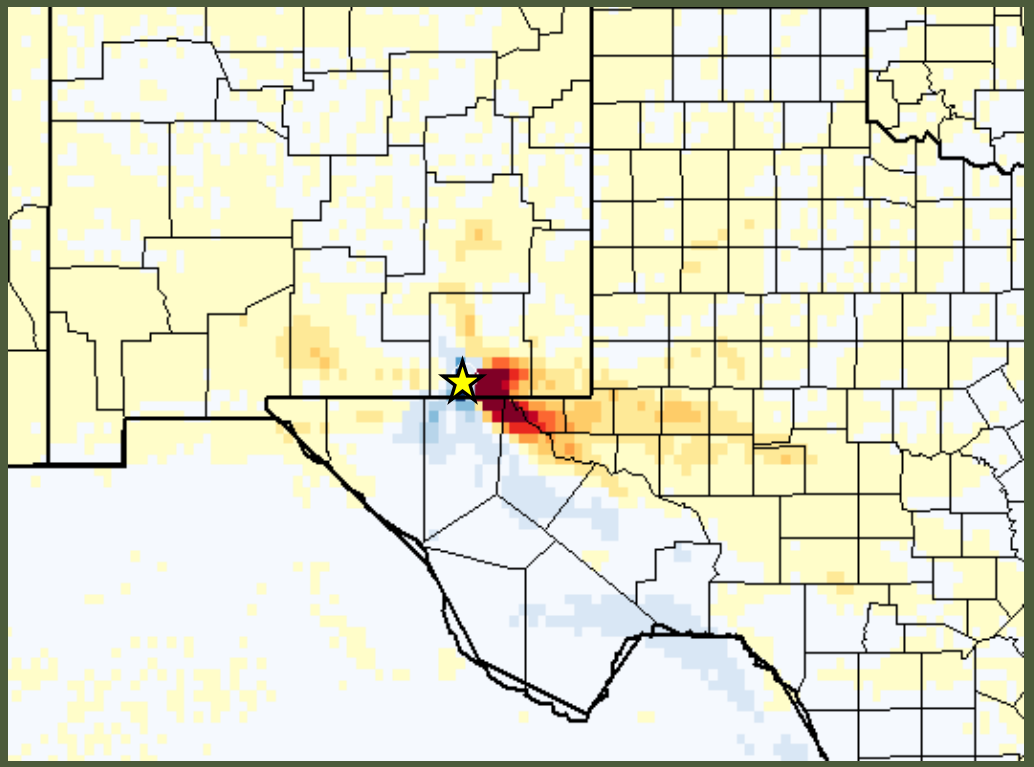
- 2017: Daytime only
- 2019: Hourly diurnal

Extensive Oil and Gas Development near Carlsbad Caverns NP



Where does air come from during periods of high ozone?

Where the Air Comes From When Ozone is High



Warm colors: ***More likely*** to come from these areas during high concentrations.

Cool colors: ***Less likely*** to come from these areas during high concentrations.

Carlsbad Caverns National Park 2019

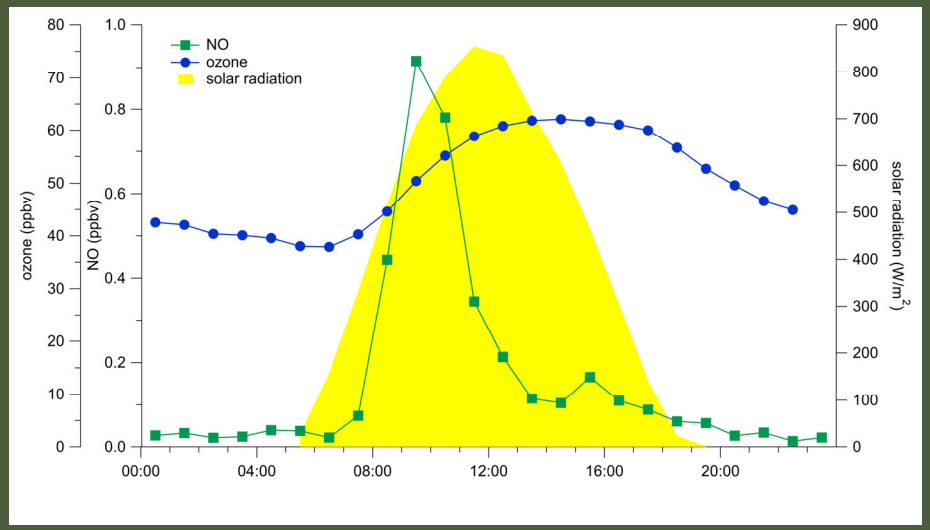
- Intensive 6-week study characterizing aerosol and gases at Carlsbad Caverns NP, with additional measurements in surrounding areas, including Guadalupe Mountains NP.
- Most extensive dataset to date

Carlsbad Caverns National Park Study 2019 - Objectives

1. What are the primary VOC drivers of regional ozone formation and how might future changes in VOC emissions affect peak ozone at Carlsbad Caverns National Park?
2. What is the nitrogen budget in the region and how sensitive is ozone formation to changes in NO_x concentrations?
3. What species, e.g. NO_x, H_2S, and VOC, contribute to or limit aerosol formation (which affects health standards and visibility)?

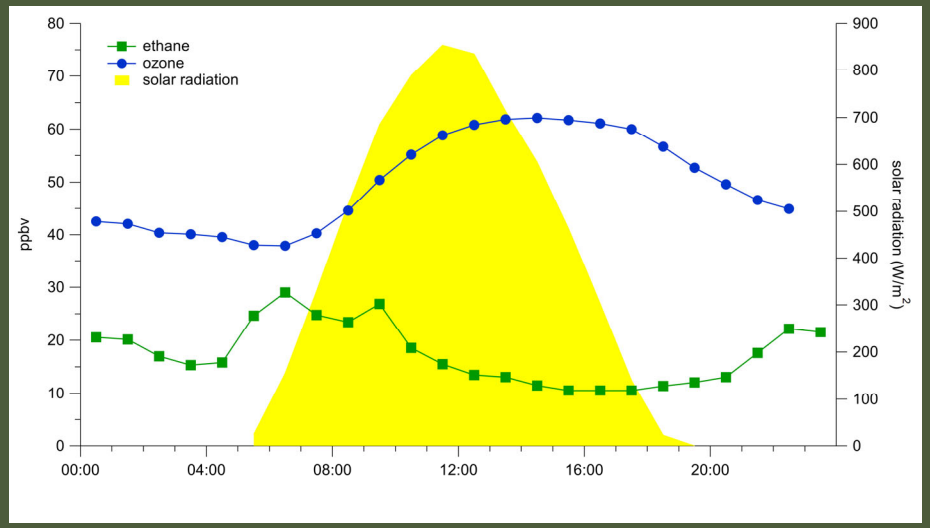
How do VOCs and NO_X interact?

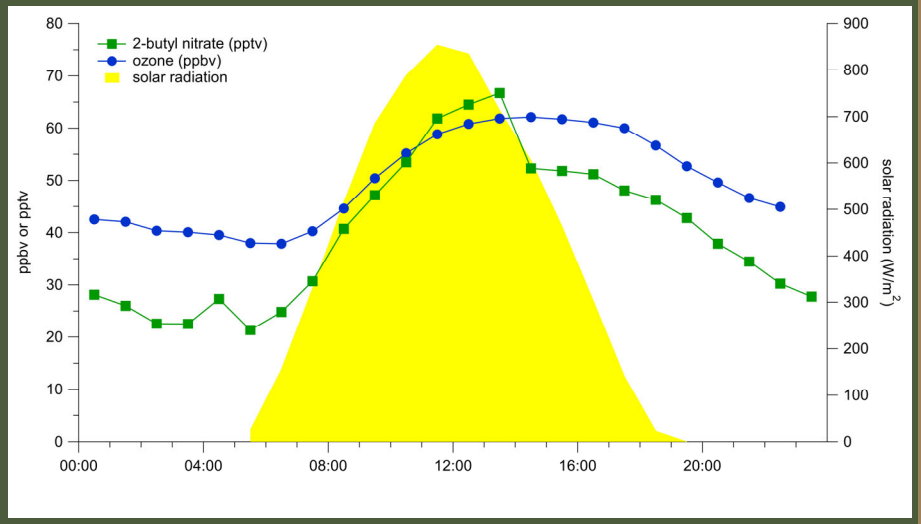
- The next slide shows the average concentrations of ozone, NO, and VOCs during the 2019 study
- Each figure shows the average ozone and the sunlight intensity for each hour of the day
- The three charts show the diurnal (daily) patterns of different compound classes:
  - How NO (unreacted NO_X) and ethane, one of the most abundantly emitted VOCs, build up and are reacted away
  - The formation of alkyl nitrates, one of the classes of VOCs formed through VOC + NO_x reactions in the atmosphere, has a similar pattern to ozone



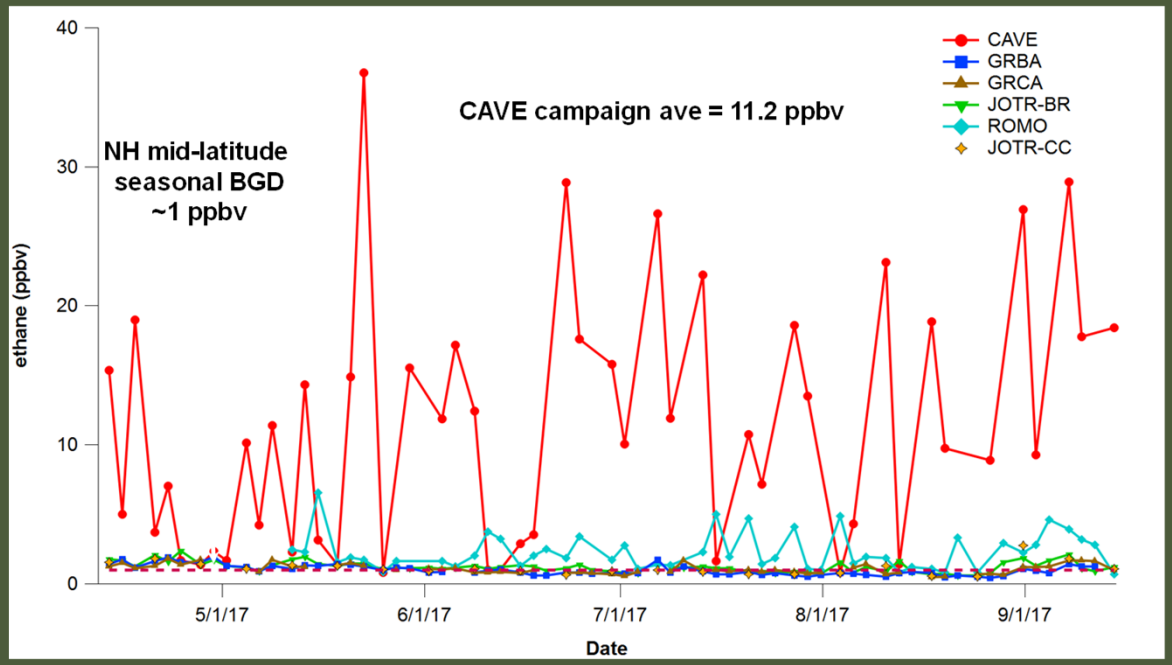
Diurnal Averages from 2019

- Ozone peaks in the late afternoon
- NO has a morning spike and emissions throughout the day
- VOCs (e.g., ethane) build up overnight and are reacted away during the day + mixing & dilution
- Secondary chemistry products, such as the alkyl nitrates (e.g., 2-butyl nitrate), have a similar diurnal distribution as ozone
- Alkyl nitrates are formed from parent n-alkane in the presence of NOx – high levels indicate abundant sources and local photochemistry





2017 and 2019 studies showed similar results at Carlsbad Caverns



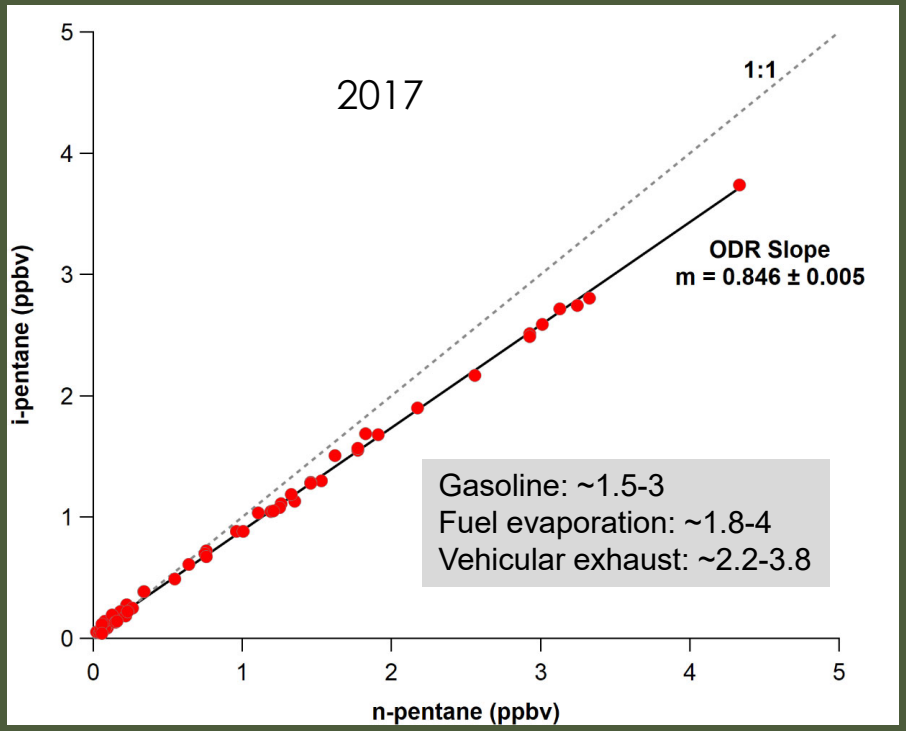
Ethane avg 2019 = 17.3 ppbv
Hourly sampling exhibited higher diurnal variability
Regularly observed levels >100 ppbv

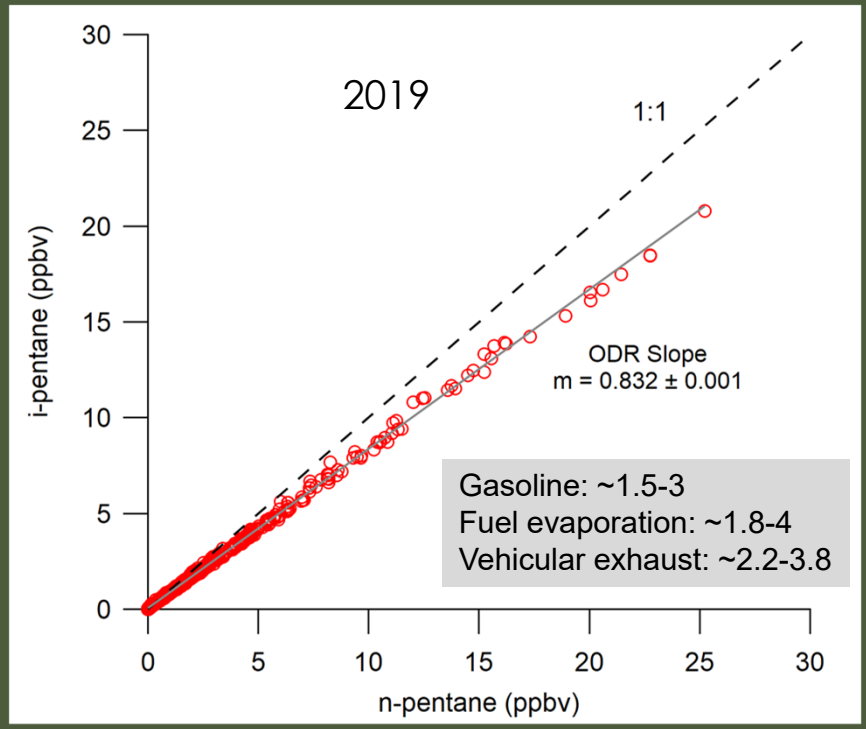
High VOC concentrations are all from oil and gas emissions.

Oil & Gas Emissions Tracers

The Pentane Ratio

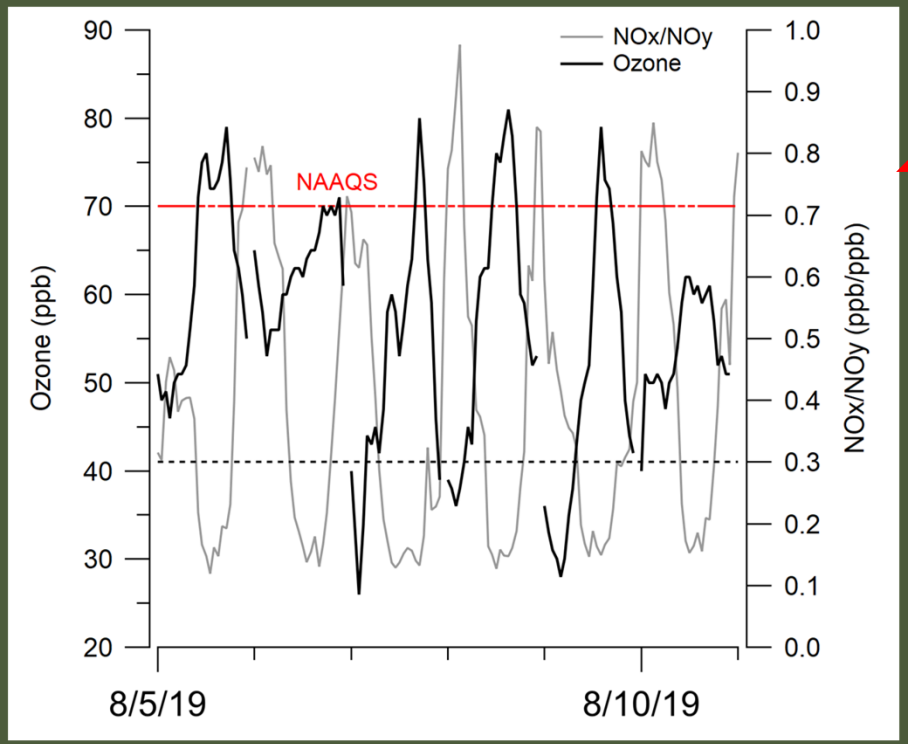
Carlsbad Caverns National Park 2017 & 2019





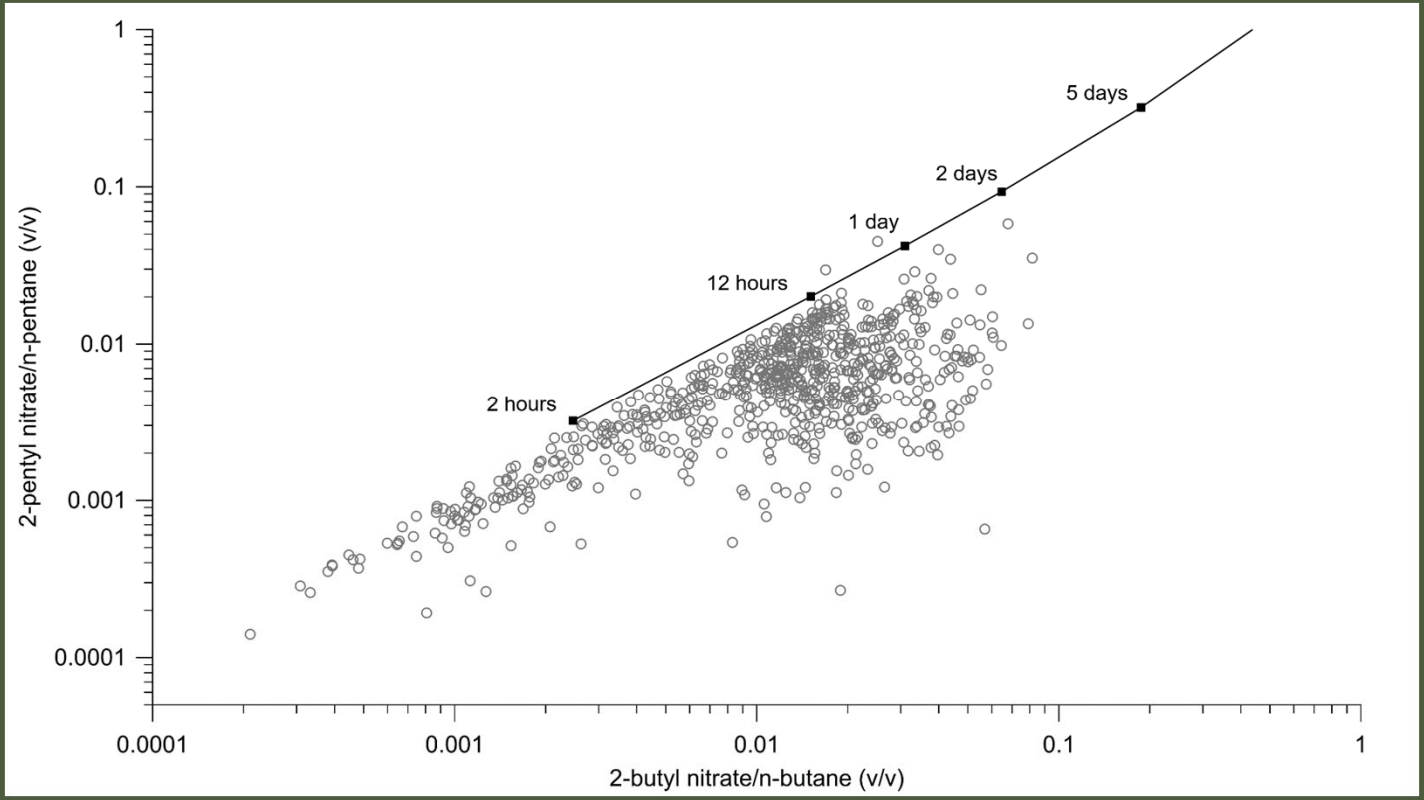
Fresh NO_x builds up at night and then reacts to form ozone

NOx/NOy > 0.3 → fresh pollution
NOx/NOy < 0.3 → photochemically aged (processed) air



Photochemical Age using Alkyl Nitrates

Air mass aging (photochemical age) from ratios of alkyl nitrates to parent n-alkanes illustrate that VOC and NO_x emissions are fresh and air masses are impacted by local sources.



The data support the need for this rule

- Ozone concentrations at Carlsbad Caverns National Park frequently exceed the national ambient air quality standard for ozone.
- The information presented highlights the need for both NO_x and VOC reductions and supports the proposed engine & turbine standards.
- NMED's proposed NO_x limits for engines and turbines are similar to on-the-books standards in other states including Texas and Pennsylvania.
  - Note: California engine NO_x limits are significantly more stringent than NMED's proposal—our recommended changes are based on Pennsylvania's Best Available Technology limits.

Recommended changes (1)

- Based on examples from Pennsylvania's state requirements, we recommend the following changes be incorporated to strengthen the proposed rule.

→ **Rich-burn Engines**

- Require all *new* and *existing* rich-burn engines >500 HP to meet a limit of 0.2 g NO_x/hp-hr
  - NMED proposal is 0.5 g NO_x/hp-hr
- Require all *new* and *existing* rich-burn engines >100 HP and ≤500 HP to meet a limit of 0.25 g NO_x/hp-hr
  - NMED is not proposing limits for this class size
- Require all *new* rich-burn engines ≤100 HP to meet a proposed limit of 1.0 g NO_x/hp-hr
  - NMED is not proposing limits for this class size

Recommended Changes (2)

→ **Lean-burn Engines**

- Require all *existing* lean-burn engines ≤100 HP to meet a proposed limit of 2.0 g NO_x/hp-hr
  - NMED is not proposing limits for this size class
- Require all *existing* lean-burn engines >100 and ≤500 HP to meet a proposed limit of 1.0 g NO_x/hp-hr
  - NMED is not proposing limits for this size class
- Require all *existing* lean-burn engines >500 HP to meet the proposed limit of 0.5 g NO_x/hp-hr
  - NMED is proposing this limit for all existing engines greater than 1,000 HP
- Require all *new* lean-burn engines ≤ 500 HP to meet a proposed limit of 1.0 g NO_x/hp-hr
  - NMED is not proposing limits for this size class

Recommended Changes (3)

→ **Existing Turbines**

- Require all *existing* turbines ≥1,000 and <5,000 HP to meet a NO_x limit of 25 ppmvd @15% O_2
  - NMED is proposing a limit of 50 ppmvd @15% O_2 for all turbine size classes
- Require all *existing* turbines ≥ 5,000 HP and < 60,000 HP to meet a NO_x limit of 15 ppmvd @15% O_2
  - NMED is proposing a limit of 50 ppmvd @15% O_2 for all turbine size classes
- Require all *existing* turbines ≥ 60,000 HP to meet a NO_x limit of 9 ppmvd @15% O_2
  - NMED is proposing a limit of 50 ppmvd @15% O_2 for all turbine size classes

National Park Service Summary

- Ozone concentrations exceed the level of the National Ambient Air Quality Standards (NAAQS) for ozone at Carlsbad Caverns National Park
- The NPS has studied ozone formation at a number of parks. Carlsbad Caverns National Park stands out as being most affected by oil and gas sources.
- Two studies have been done at Carlsbad in 2017 and 2019, during times when peak ozone concentrations are measured there. The two studies show consistent results.

Summary (continued)

- Volatile Organic Compounds (VOCs) measured at Carlsbad Caverns NP indicate the main sources of VOCs affecting ozone formation are from oil and gas activities
- Nitrogen oxide (NO_x) emissions that affect high ozone concentrations at Carlsbad Caverns NP are from nearby sources
- The measures proposed in this rule will help to reduce high ozone concentrations –this is a necessary step
  - More measures and/or more stringent measures are likely necessary to get below the NAAQS
- NO_x and VOC control measures are necessary to reduce ozone

Questions?