INVESTIGATING OVERSIGHT OF OIL & GAS DEVELOPMENT IN NEW MEXICO

UCLA Institute of the Environment and Sustainability
for WildEarth Guardians

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Photo by Barbara am Ende

Foreword

This report was created by nine environmental science students in the Institute of the Environment and Sustainability (IoES) at the University of California, Los Angeles. The work was produced at the request of WildEarth Guardians.

We recognize that the University of California, Los Angeles resides on the land of the Gabrielino/Tongva peoples, the traditional land caretakers of Tovaangar. We pay our respects to Honuukvetam (Ancestors), elders, and 'Eyoohiinkem (our relatives/relations) past, present and emerging.

We thank all of those who have made this project possible, including, but not limited to: our advisor, Noah Garrison; our clients, Jeremy Nichols and Rebecca Sobel of WildEarth Guardians; the 2020 WildEarth Guardians Practicum Team for their advice, technical assistance, and graphic layouts, particularly Shelby Slaughter and Christopher Reed; Felicia Federico and William Boyd, who provided feedback on our final report; and Noam Rosenthal, for GIS advising.

Disclaimer: The views and positions expressed in this report are those of the authors, and do not necessarily reflect those of WildEarth Guardians or any of the other parties identified here.

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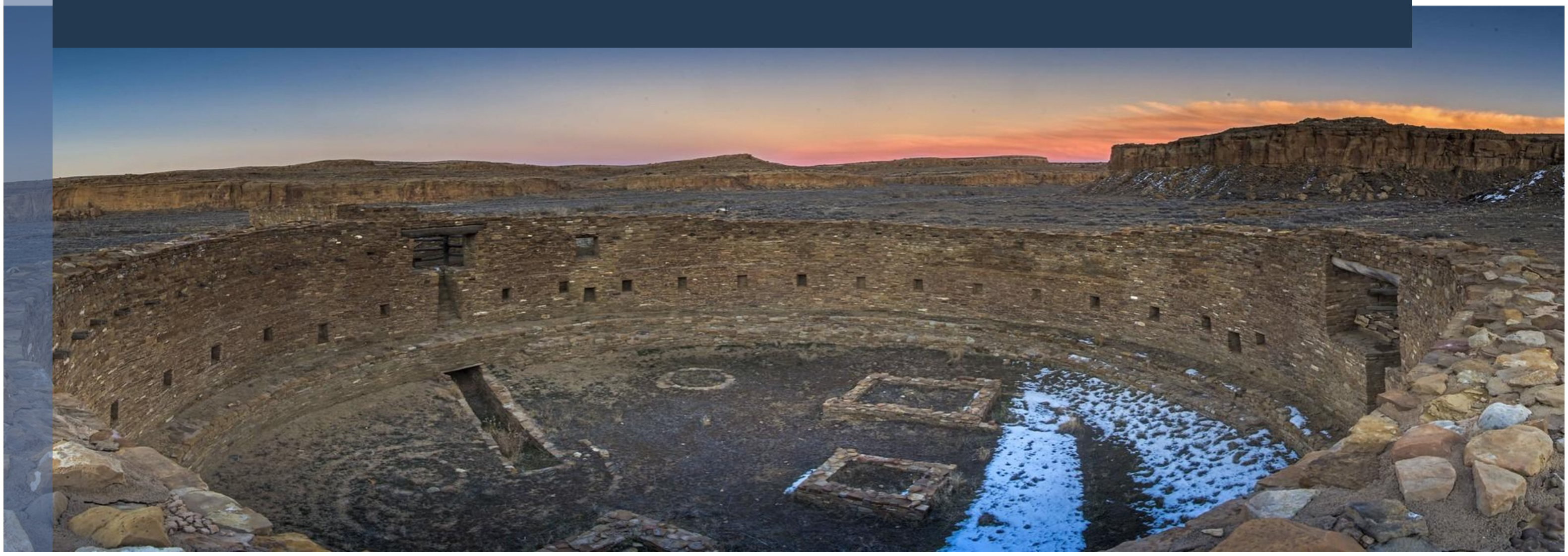


Photo by Andrew Kearnes

In the Permian and San Juan Basins of New Mexico, which are dominated by oil and natural gas production, there is an alarming threat to public health that is invisible to the naked eye: ground-level ozone. This pollutant is formed when nitrogen oxides (NOx) and volatile organic compounds (VOCs) emitted during oil and gas production subsequently react in the presence of sunlight to form ozone. Ozone can cause serious damage to respiratory functions even in healthy individuals (Rodriguez et al., 2009). Coughing, difficulty breathing, increased frequency of asthma attacks, and damage to airways are all health problems caused by ozone at even relatively low concentrations.

Currently, one county in New Mexico is in violation of National Ambient Air Quality Standards (NAAQS) for ozone under the federal Clean Air Act (CAA). Sensors in other New Mexico counties show violations that could lead to that designation. Despite the threat to public health, New Mexico officials continue to issue permits for oil and gas facilities, which only increases already unhealthy air pollution. Although the state is currently undertaking a plan to address ground-level ozone, the Ozone Attainment Initiative (OAI), the original proposed draft includes language that will potentially enable extensive exemptions and loopholes for oil and gas production.

Ozone is also just one piece of a much larger problem. Oil and gas drilling, including increasingly common well stimulation practices such as fracking, industrialize landscapes, fragment wildlife habitat, contaminate water supplies, and release toxic pollutants into the air that are associated with serious health impacts, including respiratory problems, cancer, and cardiovascular disease. Tribal communities, particularly in the San Juan Basin in northwest New Mexico, are often disparately impacted by oil and gas development, increasing their risks of acute and chronic health risks.

Building off the work of a 2020 IoES Environmental Science Practicum Team that investigated possible federal Clean Air Act permit violations and illegal drilling in New Mexico, our research indicates that oil and gas producers may be operating without proper air quality compliance and permitting throughout the San Juan and potentially Permian Basins of New Mexico. Although the drilling of new wells and pollutant emissions from supporting infrastructure are directly related, in New Mexico, the state's Oil Conservation Division (OCD) regulates oil and natural gas production, while a separate agency, the New Mexico Environment Department (NMED), is responsible for enforcing Clean Air Act permitting and air quality standards. This division of regulatory authority in New Mexico creates the potential for drilling and other oil and gas operations to evade proper oversight.

Photo by Andrew Kearnes

Facilities, such as tank farms, compressors, and other infrastructure necessary for production and which process the oil and gas extracted from one or more wells must receive a determination from NMED of whether a permit is or is not required prior to any construction. We interpret "construction" to include the drilling of new, associated wells (NMED, 2016). But well drilling and monitoring is overseen by OCD, and there is no centralized database connecting wells to facilities; therefore, wells may be drilled before their associated facility obtains required permits, and there is no direct way to tell if wells are being drilled lawfully.

Based on spatial analysis of wells in San Juan County, we estimate that 35% of the oil and gas wells drilled between 2010 and 2020 that we assessed had potentially violated the federal Clean Air Act by being drilled prior to permits for their associated facilities being issued. However, we were unable to pair a substantial number of wells to specific facilities in the San Juan Basin, or pair the vast majority of wells to facilities in the rapidly developing Permian Basin. Nor were New Mexico state agencies able to do this when we contacted them — the New Mexico Environment Department (NMED) stated that they do not have any way of assessing what wells are associated with the facilities they issue permits for with the information they collect. This means that the state is effectively unable to determine whether operators are violating the Clean Air Act.

Based on spatial analysis of wells in San Juan County, we estimate that 35% of oil and gas wells drilled between 2010 and 2020 that we assessed had potentially violated the federal Clean Air Act by being drilled prior to permits for their associated facilities being issued.

History of Oil and Gas Production in New Mexico

After oil was first discovered in Nem w Mexico in 1924, production reached a peak in 1969 before declining until the early 2010s (New Mexico Bureau of Geology & Mineral Resources [NMBGMR], n.d.). As seen in Figure 1, New Mexico oil production has increased again significantly in the past decade and reached a record high in 2020 (New Mexico Energy, Minerals, and Natural Resources Department [EMNRD], 2021a). Currently, there are more than 57,000 active wells in New Mexico (EMNRD, 2021b). Gas production, which has historically been more volatile than oil, also reached a new high in 2020. This increase in production is a result of the increased use of unconventional oil and gas production methods, such as hydraulic fracturing, or "fracking" (NMBGMR, n.d.).

New Mexico ranks third in crude oil production and eighth in natural gas production in the United States (EIA, 2020a; EIA, 2019). As shown in Figure 2, the two major oil basins in the state are the Permian Basin, located in the southeast corner of the state and extending into Texas, and the San Juan Basin in the northwest corner. In these two regions, oil and gas are extracted on a mixture of federal, state, private, and Tribal lands (EMNRD, n.d.).

New Mexico is home to 23 federally recognized Tribes, each with their own traditions and culture. In addition to public health threats, Indigenous cultural and environmental resources are at risk of encroachment by the oil and gas industry. The San Juan Basin is located in the Greater Chaco Region, which is the ancestral home of Puebloan peoples and is a sacred pilgrimage site inhabited by the Diné people of the Navajo Nation (Van Dyke & Heitman, 2021; McAlpine, 2019). Historic, cultural and sacred sites have been crisscrossed by pipelines and roads linking oil and gas infrastructure (Van Dyke & Heitman, 2021), and Tribal communities are at risk from the air pollution emitted from oil and gas operations. Drilling in the Permian Basin additionally has the potential to pollute residential aquifers and to harm delicate cave systems and the Native artifacts and fossils contained within them (Oldham, 2021).

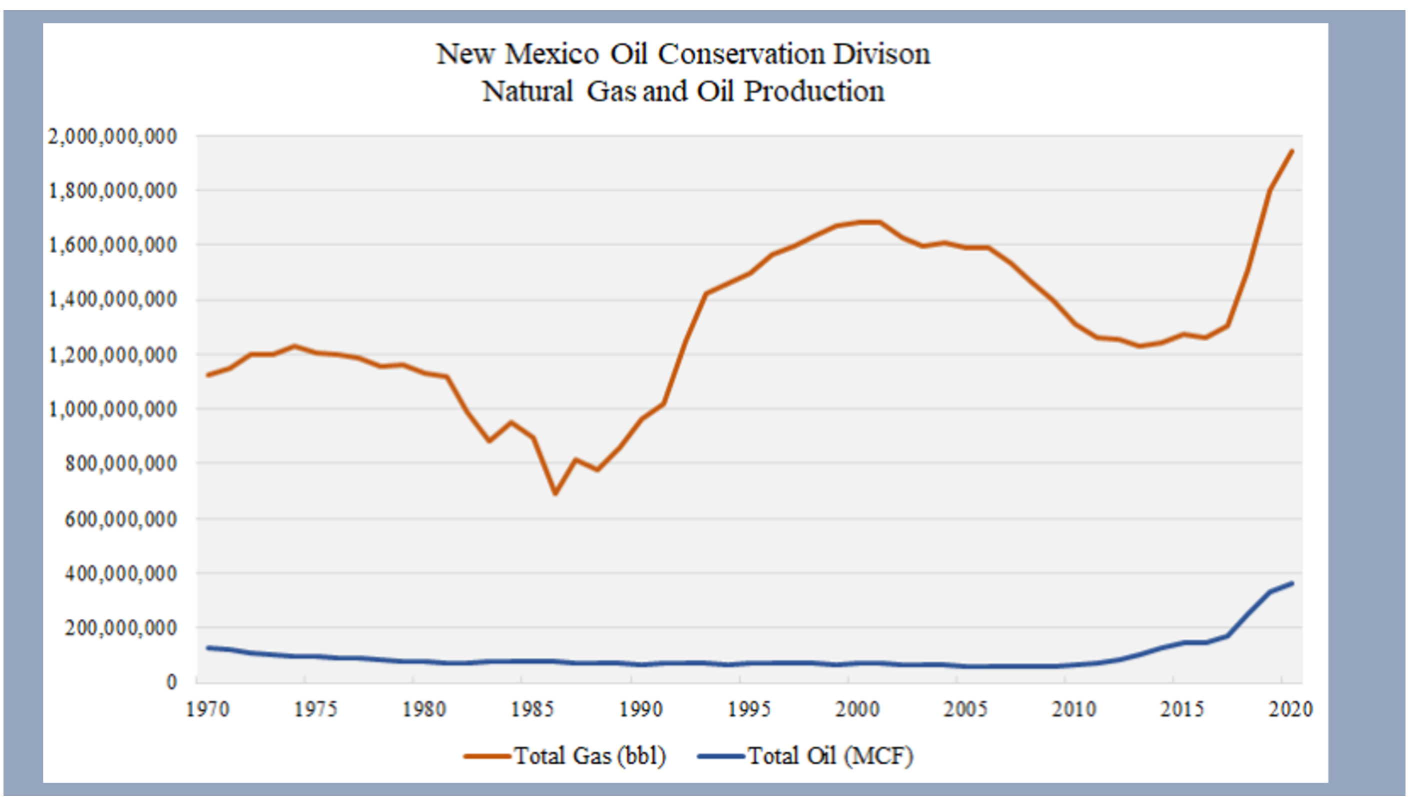
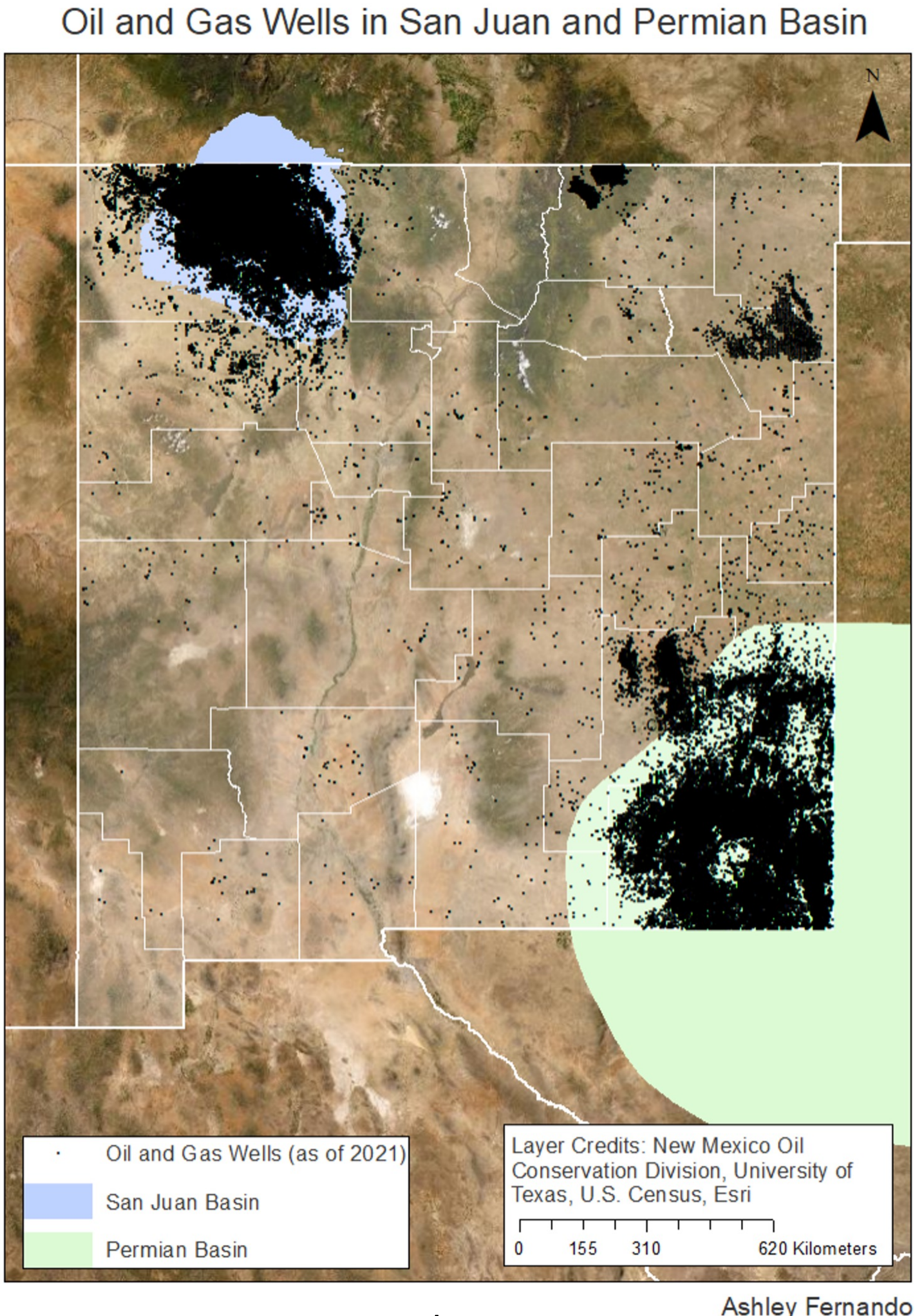
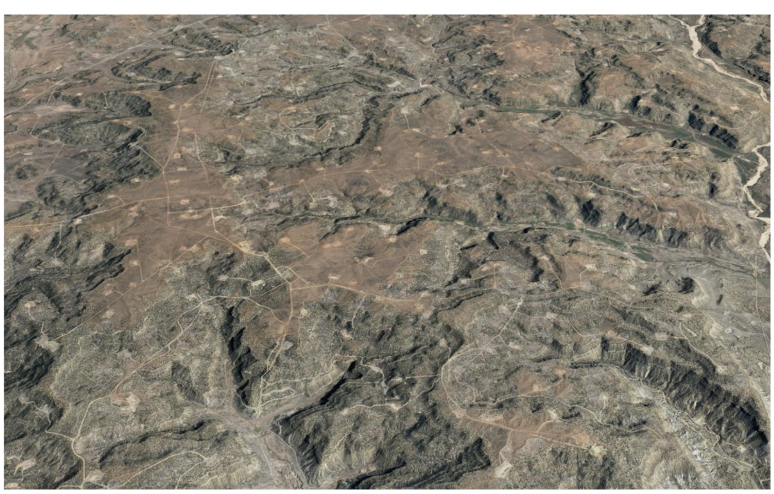


Figure 1: Total oil production (MCF) and gas production (bbl) in New Mexico reached new highs in 2020.



A.

Figure 2: A. Permitted oil and gas wells in New Mexico. The two main regions for oil and gas production in the state are the San Juan Basin in the northwest and the Permian Basin in the southeast. B. Distribution of wells in the San Juan Basin. C. Distribution of wells in the Permian Basin.



B.

C.

The Science of Oil and Gas Drilling

Oil and natural gas production can be categorized as either conventional or unconventional. In conventional operations, wells are drilled into a rock formation where the oil and natural gas in the reservoir easily flows to the wellbore (EIA, n.d.). Usually, conventional wells are drilled vertically into highly permeable formations, where the fluids are contained in a geological trap, or rock formation that allows the oil and gas to accumulate in an underground reservoir. The primary stage of production relies on the reservoir's natural pressure to extract oil and gas, but once production declines, particularly for oil production, additional production techniques such as flushing oil from the reservoir with water or injecting steam or carbon dioxide are commonly used (Scanlon et al., 2014).

Unconventional oil and gas production techniques are somewhat loosely defined, and the exact technologies that fall under this umbrella term vary and fluctuate over time (EIA, n.d.). Generally, in unconventional operations, the oil and gas is extracted from tight geologic formations that have low permeability, such as shale deposits found in New Mexico's Permian Basin. To access more of the deposit, wells are commonly drilled vertically until they near the target layer and are then curved and horizontally, or directionally, drilled as much as thousands of feet further (FracTracker Alliance, 2020). Most unconventional production then requires well stimulation to open new pathways for oil and gas to flow through before it can become commercially viable. Hydraulic fracturing, acid fracturing, and matrix acidizing are three common types of well stimulation, each of which improve the flow of oil and gas from the reservoir by increasing the permeability of the formation (Shafiq & Mahmud, 2017).

Hydraulic fracturing, or "fracking," involves injecting fluids and solid proppants at a high pressure into a rock formation to create and prop open fractures, which allow oil and natural gas to flow into the wellbore (EIA, n.d.). Hydraulic fracturing of even a single well can require millions of gallons of water, a variety of chemicals, including hazardous or toxic fluids, and proppants such as sand or ceramics (Environmental Protection Agency [EPA], 2016). The exact chemical mixture of fracking fluid can vary greatly and is often considered to be a trade secret. Biocides, scale inhibitors, solvents, friction reducers, additives, corrosion inhibitors, non-ionic surfactants, and other chemicals provide lubrication and prevent corrosion, clogs, or bacterial growth. The chemical mixture comprises around 1% of the total fluid injected; approximately 50,000 gallons of chemicals are required per well (American Chemical Society, 2020).

Once the fluid and proppant mixture is prepared, it is injected through perforations in the well at a high enough pressure to cause the desired rock layer to fracture (FracTracker Alliance, 2020). Oil, natural gas, and hydraulic fracturing fluid then flow through the newly created fractures, which are held open by the proppant. Once it reaches the surface, the recovered flowback fluid is treated, recycled, or disposed of, commonly by re-injecting it underground in deep injection wells, though in some cases requiring tanker trucks for removal offsite. However, over 90% of the fluid used for fracking generally remains underground (Hansen et al., 2013).

Although considered unconventional, hydraulically fractured horizontal wells have been the most common type of well drilled since 2014, and in 2016, they accounted for 69% of all wells drilled in the U.S. (EIA, 2018).

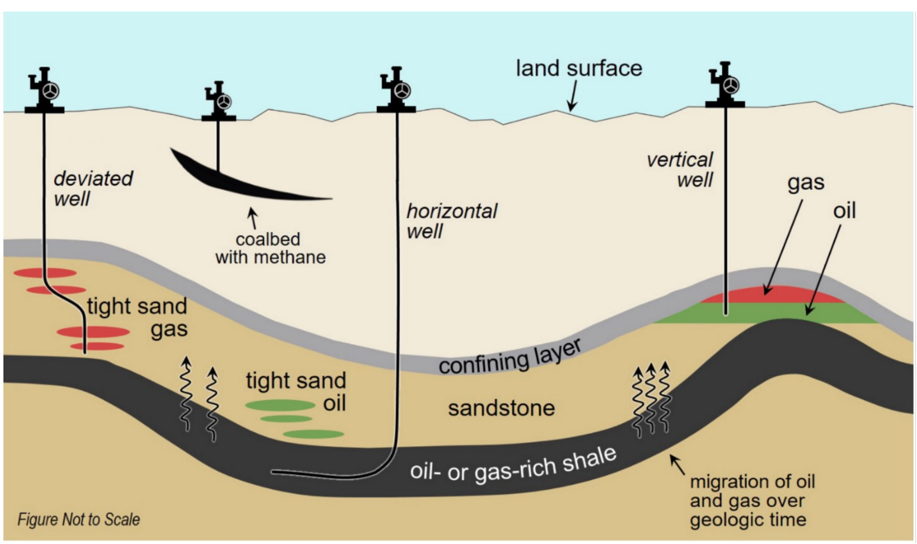


Figure 3: Oil and gas from conventional reservoirs easily flow to the wellbore. Unconventional production is required when oil and gas are trapped in tight geologic formations. **Image source:** EPA**, 2016**

Public Health and Environmental Impacts of Oil and Gas Drilling

Oil and gas production present multifaceted harms to communities and the environment. Exploration and extraction industrializes landscapes, threatens the quality and quantity of water supplies, and pollutes the air. Moreover, the extraction and combustion of these fossil fuels releases carbon dioxide, methane, and other potent greenhouse gases that contribute to climate change (NASA, n.d.). This can occur either through intentional combustion or as fugitive releases of gases.

Fossil fuel exploration, extraction, and production operations alter natural landscapes. Substantial machinery is brought to construct expanses of concrete well pads that can span several acres each and to build new roads to reach these sites. In fact, 4.2 million acres of public land alone in New Mexico are leased for oil and gas development (Center for Western Priorities, 2021). This alteration leads to habitat loss and fragmentation for native plants and animals, increasing their vulnerability to invasive species and ecosystem collapse (Meng, 2016). An estimated 37,000 species globally are at risk due to present and future oil and gas development (Harfoot, 2018).

Oil and gas extraction threatens local water quality and quantity. Hydraulic fracturing in particular is water intensive, potentially exacerbating regional water shortage issues that will worsen over time due to climate change (Meng, 2016). Water usage can be anywhere from 1.5 to 16 million gallons per well (U.S. Geological Survey, n.d.). Fracking fluids that return to the surface as flowback in the produced water often contain potentially hazardous chemicals. Approximately 15 barrels of wastewater are produced for every barrel of oil, requiring substantial resources for wastewater management and disposal to avoid leakage in groundwater and surface water (Grinberg, 2014). Further, poor well construction, such as improperly cased production or injection wells, can allow fracturing fluid to migrate into aquifers and contaminate drinking water (see Figure 4). Fluids can also reach aquifers through surface spills and via natural fractures or neighboring wells that were improperly plugged.

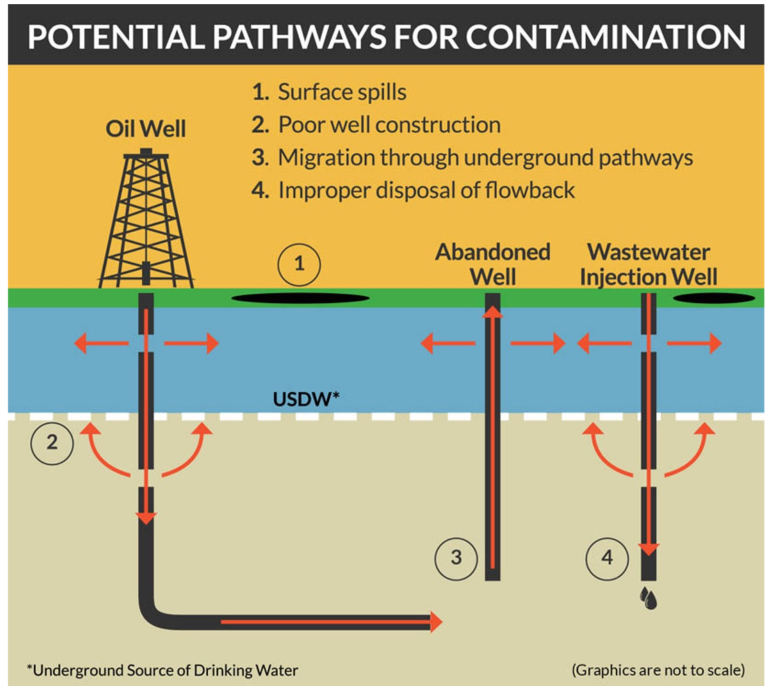


Figure 4: Well stimulation operations have the potential to reach and contaminate underground sources of drinking water as a result of surface spills, poor well construction, migration of fluids through abandoned wells or natural underground fracture pathways, and when the flowback fluid is improperly disposed of. Image Source: Conservancy of Southwest Florida

Moreover, the chemical additives used in hydraulic fracturing include compounds such as methanol and ethylene glycol that are hazardous to human health (Denchak, 2019). Equipment failure, corrosion, human error, and even normal operations can result in spills of crude oil or produced water. In New Mexico in 2020, a total of 1,217 different spills released 13,401 barrels of oil and 64,116 barrels of produced water (Center for Western Priorities, 2021). These spills have contaminated water and soil. For instance, in January 2020, a pipeline operated by the Williams Production and Exploration Energy, Inc. burst, spouting produced water onto a private residence and contaminating the land to the extent that the family can no longer eat food grown on their property (Jamail, 2020).

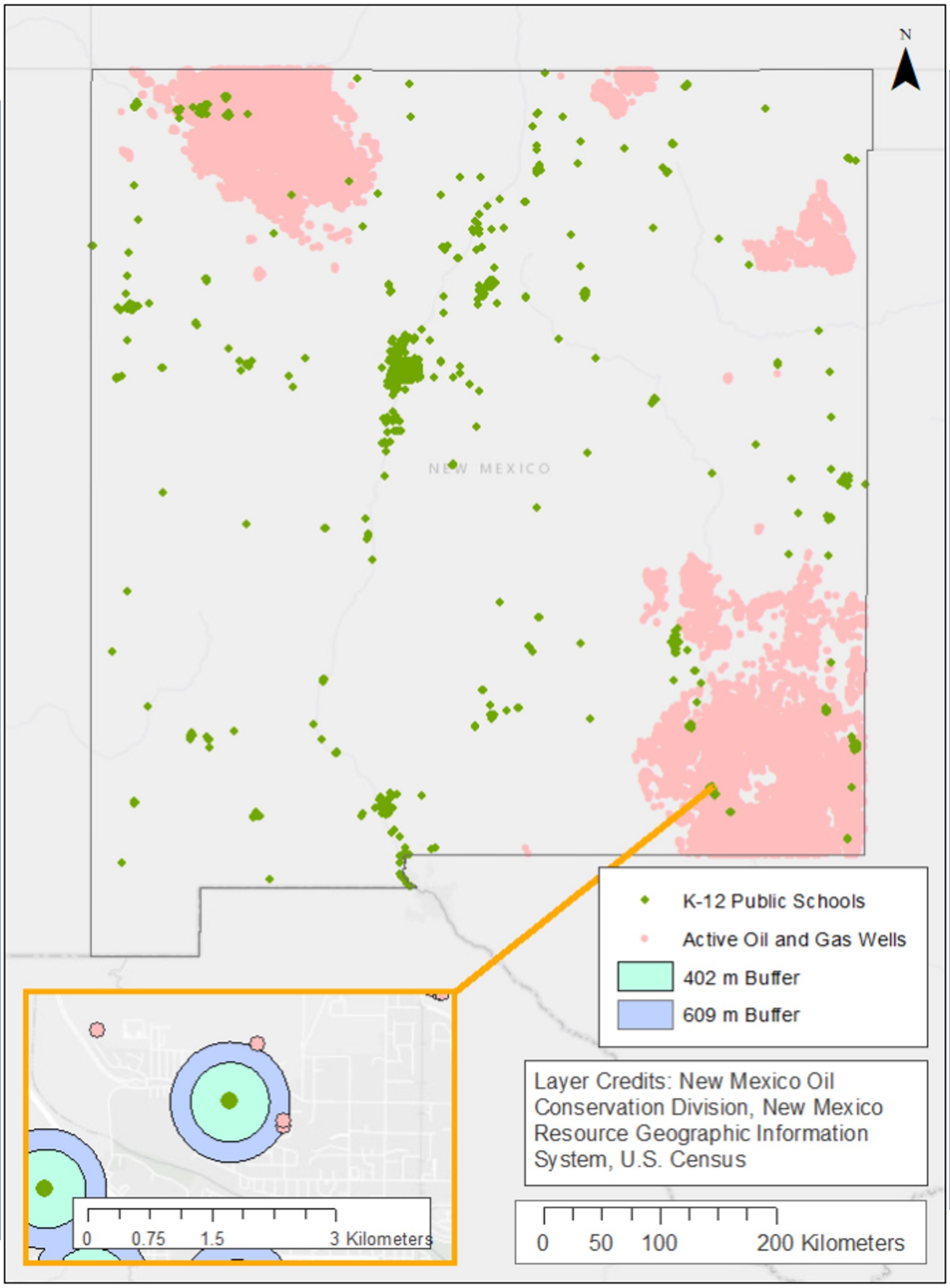
Exhaust fumes and their reaction products reduce air quality and contribute to climate change. Exhaust fumes from extraction equipment typically include volatile organic compounds (VOCs), nitrous oxides (NOx), particulate matter (PM), sulfur oxides (SOx), and various toxins, carcinogens, and metals (Thompson, 2017). In general, these air pollutants can cause a host of respiratory illnesses, cancer, and reproductive and developmental harms. For instance, inhaling SO2 causes shortness of breath and constricts the passage of air in the lungs, and carcinogens like benzene have been linked to increased cancer incidence in multiple studies (Johnston et al., 2019). PM2.5 is linked to premature death, bronchitis, asthma, and other respiratory issues.

Furthermore, VOCs and NOx are known precursors to ground-level ozone, meaning they undergo chemical reactions with sunlight to produce the gas. Ozone is known to cause long-term issues like chronic obstructive pulmonary disease (COPD), increased frequency of asthma attacks, and even early mortality upon inhalation. Even at low concentrations, ground-level ozone can damage lung function (Rodriguez et al., 2009). Additionally, long-term ozone can cause abnormal lung development in children. As the oil and gas industry is the largest industrial source of VOCs in the United States, it is a major contributor to ozone pollution and related illnesses in oil-producing regions (EPA, 2020b).

In addition to the controlled exhaust fumes, fugitive gases, usually methane, can escape through breaks in pipes and from exhaust fumes from engines and other extraction equipment (Earthworks, n.d.), or from poorly sealed well casings. As methane is 25 times more potent than carbon dioxide as a greenhouse gas, fugitive gas from oil and gas extraction operations can contribute significantly to climate change (EPA, 2020b).

Photo by Sam Rubright

ARE NEW MEXICO SCHOOL CHILDREN AT RISK?



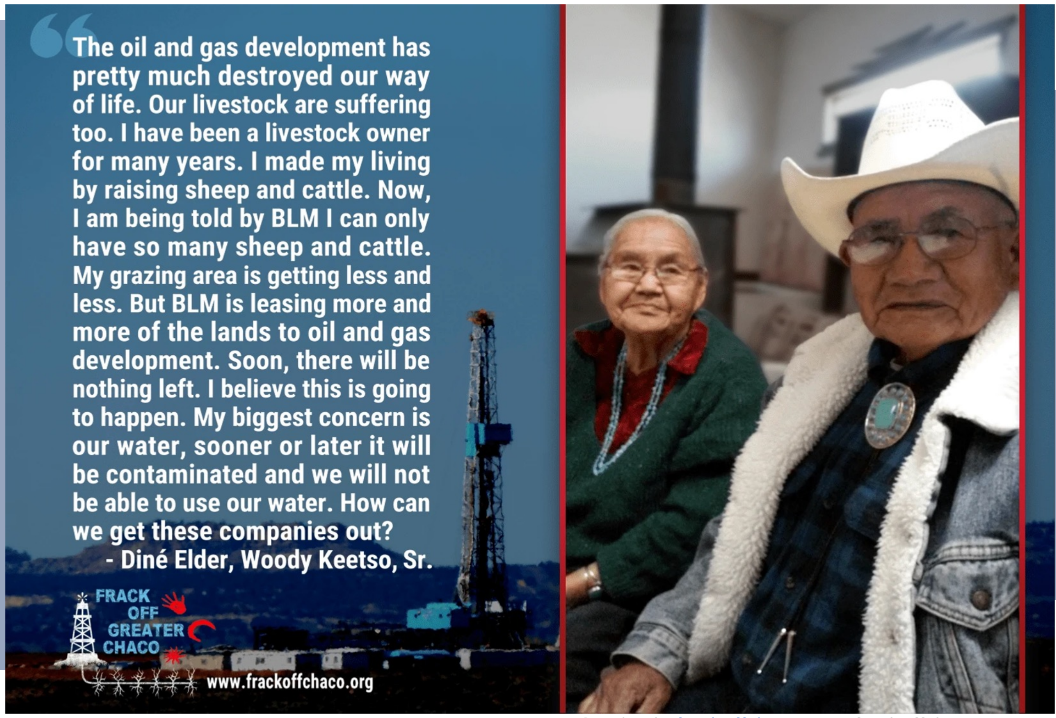
Ashley Fernando

Figure 5. Active oil and gas wells operate within one-quarter-mile and 2000-foot radii of public schools in the state of New Mexico. The inset map framed in orange spotlights a school with two active wells operating less than 2000 feet (609 meters) away.

Oil and gas wells in the Permian and San Juan Basins are often drilled near schools, many at distances subjecting children and adolescents to harmful emissions. What constitutes a "safe" distance or setback from oil or gas operations is often debated, but distances of between one-quarter mile (1,320 feet or 402 m) and 2000 feet (609 m) from wells are supported by recent research and surveys by environmental and health professionals (Tempus, 2020). From a GIS analysis, we found that **127 active wells in the state of New Mexico are operating within 2000 feet of a public school, and 45 active wells are operating within one-quarter mile of a public school** (see Figure 5).

Disproportionate Impacts on Indigenous Communities

Increased oil and gas development could further harm Indigenous communities in the Greater Chaco Region.



Graphic by frackoffchaco.org #frackoffchaco

In the United States, Indigenous people often disproportionately bear the burdens of both climate change and the fossil fuel production that accelerates it. Navajo community members are two times as likely to live within half a mile of an oil and gas facility as other residents of New Mexico (Clean Air Task Force, 2018). Figures 6.A and 6.B show the location of active oil and gas wells in relation to Tribal lands in the state. Located within the oil-producing San Juan Basin, the Greater Chaco region is pockmarked with oil and gas extraction operations, which are often approved despite inadequate Tribal consultation or environmental review (Iallonardo, 2020). Oil and gas operations also frequently risk disturbing cultural features that are deeply connected to the Indigenous heritage and traditions. In Chaco, the land around the national park contains numerous artifacts and ruins that could be lost to oil and gas production (Iallonardo, 2019).

Additionally, the Navajo Nation has inadequate access to running water and electricity due in part to federal treaty violations, as well as a lack of access to federal funding for healthcare (Lakhani, 2020). In fact, thirty percent of the nation lives without electricity, and forty percent are without clean drinking water (Lakhani, 2020). These burdens combine with the dangers of climate change and with the ecosystem degradation, air pollution, and water contamination from fossil fuel production near Tribal lands to expose Indigenous people to a greater risk of public health crises.

Oil and gas operations may also disproportionately risk the safety of Indigenous women and girls. For example, in the Bakken oil production region between Montana and North Dakota, attacks on Native American women have increased as male transient oil workers have increasingly taken up residence in temporary housing units, known as "man camps," on and near Tribal lands. During one particular oil boom in 2014, sexual assault cases tripled (Bleir & Zoledziowski, 2018). Indigenous women are murdered and assaulted at much higher rates than other American women in general, primarily by white and other non-Native men; a study from 2016 found that more than half of all Native women have been sexually assaulted (Rosay, 2016).

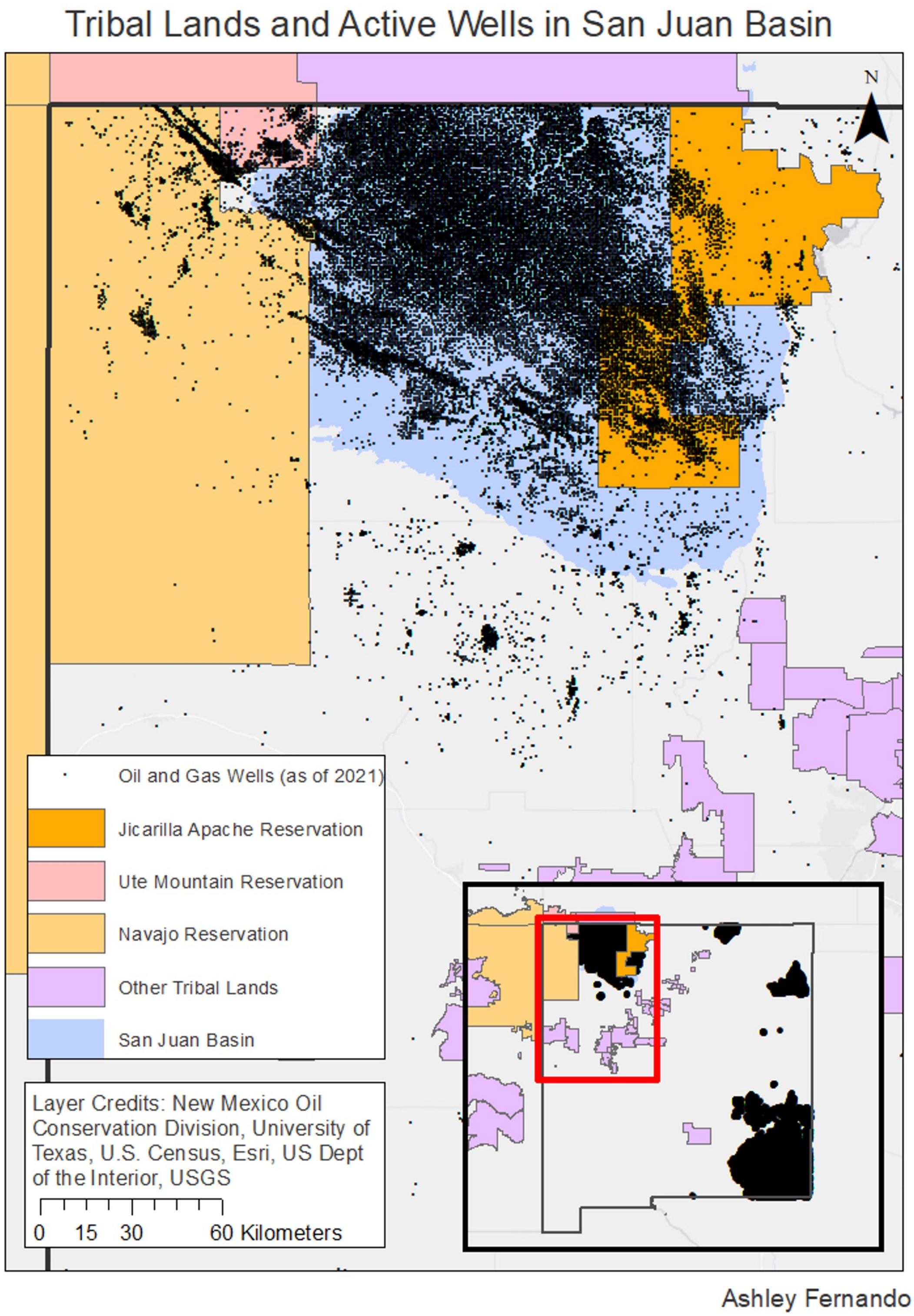


Figure 7. Tribal lands and active wells in the San Juan Basin. The three reservations most impacted by drilling in the San Juan Basin are those of the Navajo, Jicarilla Apache, and Ute Mountain Tribes.

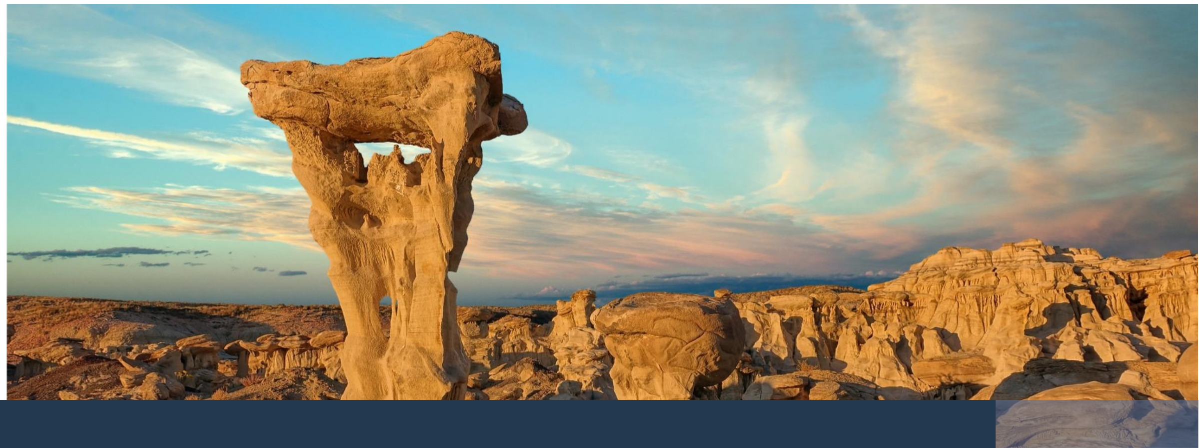


Photo by John Fowler

Regulating Oil and Gas in New Mexico

The various state and federal systems that govern oil and gas production across New Mexico result in a complicated web of regulation. In general, state law regulates the drilling aspect of oil and gas production while federal law regulates water quality, air quality, and worker protection related to oil and gas activities (Allison & Mandler, 2018). However, jurisdiction, and determining what laws or regulations apply, can depend on whose land the drilling occurs on, the specific type of activity being conducted, and a host of other factors. As described below, application of various laws and regulations may transcend these designations.

Federal Law

The federal Clean Air Act (CAA) is the primary law responsible for controlling air pollution and protecting human and environmental health from oil and gas development. The CAA regulates air pollution "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population" (42 U.S.C. § 7401(b)(1)). It primarily achieves this through establishing National Ambient Air Quality Standards (NAAQS). The NAAQS set primary standards, to protect public health, and secondary standards, to protect public welfare more generally, limiting the ambient air concentration of six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate pollution – split into PM2.5 and PM10. States are generally responsible for implementation of the NAAQS program, while the EPA oversees state action and the program more generally; the CAA in fact requires states to develop State Implementation Plans or "SIPs" for meeting the NAAQS within their borders. When regions do not reach attainment with the NAAQS, emission sources of criteria pollutants in the area are subject to additional regulation (EPA, 2020a). In New Mexico, administration of the CAA and permitting is managed by the Air Quality Bureau of the New Mexico Environment Department (NMED) (EPA, 2021a).

Areas of New Mexico continue to exceed the NAAQS for ozone, at least in part due to rising NOx and VOC emissions from the oil and gas industry (New Mexico Environment Department [NMED], 2020). NOx emissions have generally decreased throughout the United States, except in areas dominated by the oil and natural gas industry (Majid et al., 2017). In the Permian Basin, oil production increased by 17% and gas production by 18% *per year* from 2005 to 2015 (Dix et al., 2020). During the same years, NOx emissions increased by 1 to 4.5% per year (Majid et al., 2017), a rapid growth that increased alongside oil and gas production. Oil and gas development has continued to accelerate, with the total volume produced increasing by 21% per year for oil and by 9% per year for gas from 2016 to 2020 (EMNRD, 2021a). This is expected to further raise ozone levels in the region (Majid et al., 2017).

Currently, the only designated ozone nonattainment area in New Mexico is the Sunland Park area in Dona Ana County (EPA, 2021b). However, according to NMED, ozone levels in seven other New Mexico counties exceed the NAAQS (NMED, 2021). These are Eddy and Lea counties in the southeast, and Bernalillo, Rio Arriba, Sandoval, San Juan, and Valencia counties in the northwest, all located in or near major oil and natural gas producing areas (shown in Figure 7). The EPA designates regions as in nonattainment within two years of new or revised NAAQS rulemaking, but the last of these occurred in 2015 for ozone. NAAQS exceedances for these seven counties occurred after that time frame, and as a result they have not been formally designated yet..

Moreover, not all counties have monitors for ozone. In the Permian Basin, there are only two monitors in Eddy County, one in Lea County, and none in Roosevelt and Chaves counties. Although oil and gas activity occurs across the basin, including in counties that lack ozone monitoring stations, NMED recognizes only Eddy and Lea counties as exceeding NAAQS for ozone. As oil and gas activity in Chaves and Roosevelt counties can contribute to ambient ozone concentrations, EPA must redesignate all four counties in New Mexico's Permian Basin as in nonattainment for ozone (see 42 U.S.C. § 7407(d)(1)(A)(i); 7407(d)(3)). Additionally, officials should install ozone monitors in Chaves and Roosevelt counties to assess potential air quality violations.

Ozone Nonattainment Designations

Ozone nonattainment designations are made when an area does not meet the NAAQS over a period of time. Specifically, this occurs when the three-year average of the fourth-highest daily ozone concentrations measured in a year exceeds the eight hour ozone NAAQS standard set in 2015 (NMED, 2020).

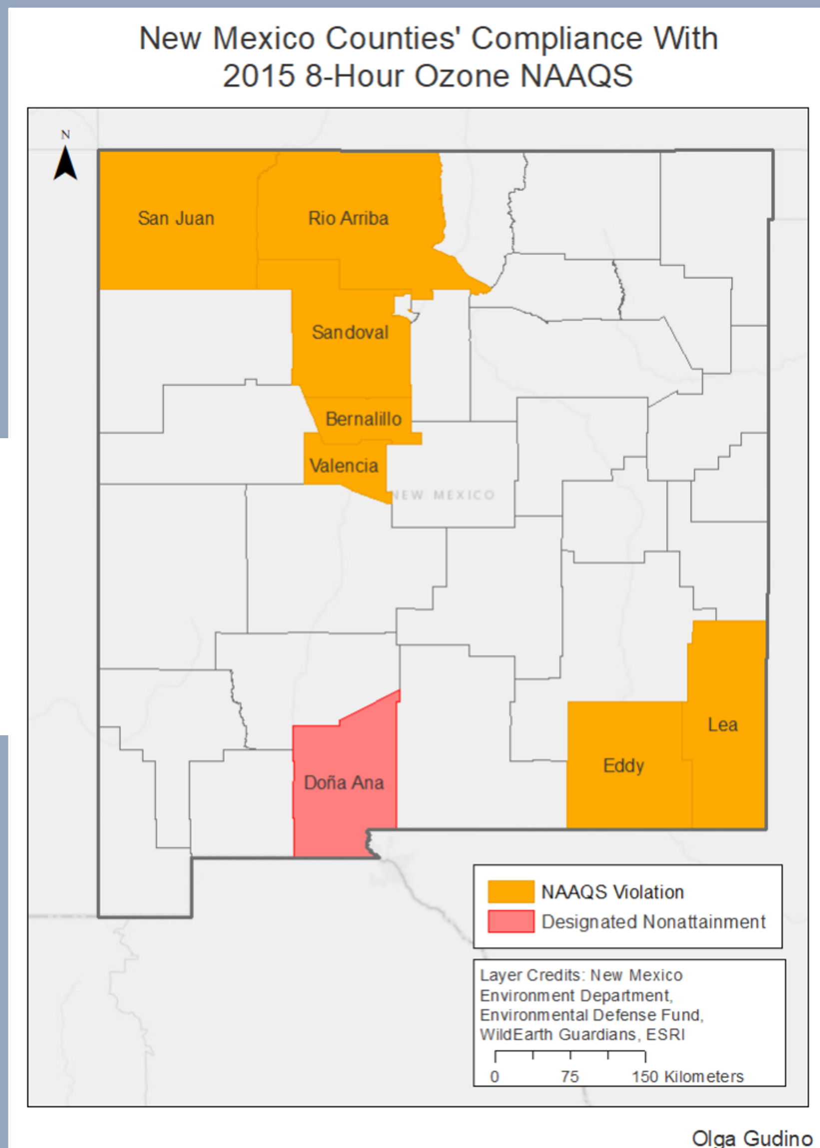


Figure 8. Only Dona Ana County has been designated as out of attainment for ozone. But Bernalillo, Rio Arriba, Sandoval, San Juan, and Valencia counties in the northwest and Lea and Eddy in the southeast are in violation of the 8-hour ozone NAAQS (NMED, 2021).

In addition to setting NAAQS, the EPA works with states to limit hazardous air pollutants (HAPs); these are toxic or harmful air pollutants outside the six criteria pollutants (EPA, 2020a). Regulation of HAPs is primarily carried out under Section 112 of the CAA, where "major sources" of air pollution are required to apply for an operating permit and annually demonstrate their compliance with that permit. The CAA defines major sources as "any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit" at or above a major source threshold (MST). MSTs are defined as "10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants" (42 U.S.C. §7412(a)(1)) or "one hundred tons per year or more of any air pollutant," including the six criteria pollutants controlled under the NAAQS program (42 U.S.C. §7602(j)). As a result, oil and gas infrastructure such as storage vessels, glycol dehydration units, and ancillary equipment are considered major sources (40 CFR § 63.760(b)(1)(i)). However, individual oil and gas wells are exempted from this aggregation requirement and are thus not considered major sources that require CAA permits (Kosnik, 2007).

New Mexico Law

New Mexico regulates oil and natural gas production under the New Mexico Oil and Gas Act (N.M. Stat. § 70-2-1), which is enforced by the Oil Conservation Division (OCD) of the New Mexico Energy, Minerals, and Natural Resources Department (N.M. Stat. § 70-2-6). The law regulates waste from oil and gas development, collects data on wells, manages permit applications, and ensures restoration of abandoned wells (N.M. Stat. § 70-2-12). Under the Oil and Gas Act, any owner or operator wishing to drill a well is required to apply for a permit from OCD.

Operators must also disclose if they are using hydraulic fracturing for a well completion or recompletion, and they must provide a list to the public of chemicals used during the fracking process (N.M. Code R. §19.15.16.19). However, fracking operators are not required to divulge chemicals considered to be trade secrets and that would put the operator at a disadvantage to its competitors.

Photo by John Fowler

Separate from well construction, the New Mexico Environment Department (NMED) is responsible for administering the CAA and enforcing CAA air quality standards in the state (NMED, n.d.). NMED's regulatory authority stems from the New Mexico Environmental Improvement Act, the New Mexico Air Quality Control Act, and its EPA-approved State Implementation Plans (SIPs).

Title V of the CAA, established under 1990 amendments to the Act, created an operating permit system for major sources. NMED is responsible for reviewing and issuing Title V permits in New Mexico. Under the program, oil and gas operators must submit a Notice of Intent (NOI) prior to beginning any construction on a facility that has the potential to emit more than 10 tons per year of a regulated pollutant (42 U.S.C. §7661(a); 42 U.S.C. §7412(a)(1)). NMED will then provide the operator with CAA permits or exemptions. Operators may only begin construction of a facility after receiving a permit or exemption.

Our team interprets facility infrastructure to include the drilling of new wells, as each is dependent on the other – wells must have a facility to process the oil and natural gas, and facilities have no function without the products from wells. Thus, a facility would be in violation of the CAA if the well or wells supplying the facility are drilled prior to the facility operator's receipt of a CAA permit or exemption. However, since the drilling of wells is regulated by a separate agency than CAA permitting for facilities, it can be difficult to determine whether an operator begins drilling a well prior to obtaining a CAA permit or exemption for its corresponding facility.

The Ozone Attainment Initiative

Photo by John Fowler

Recognizing that ground-level ozone is a pollutant threatening both public health and the environment, the Clean Air Act requires the EPA to set NAAQS, which require ozone concentrations to be at or within 95% of the maximum level. These standards are updated as necessary, and in 2015 the NAAQS for ozone was lowered from 75 parts per billion (ppb) to 70 ppb, averaged over an 8-hour period. Areas of New Mexico continue to exceed this limit (NMED, 2020). Pursuant to the NAAQS and the New Mexico Air Quality Control Act, NMED must develop a plan to reduce ozone levels, primarily through a reduction of emissions of nitrogen oxides and VOCs in counties that exceed 95% of the NAAQS (Kemball-Cook, 2016). This plan is called the Ozone Attainment Initiative (OAI).

The first draft of the OAI, released on July 20, 2020, contained numerous loopholes and broad exemptions that would significantly reduce its intended effect. For example, as stated in section 20.2.50.6 of the initiative's first draft, equipment located at stripper wells and at individual facilities that emit less than 15 tons of VOCs per year are considered exempt from requirements stated in the initiative.

Stripper wells, which are wells that produce below a specified daily rate, are not considered significant primary producers at the individual level, but in the aggregate can contribute substantially to emission of ozone precursors and other pollutants. The exemption for stripper wells would rule out approximately 16,000 oil and 20,000 gas wells that were active in 2020, omitting 95% of wells and production sites, including 94.9% of wells in the San Juan Basin and 97.3% of wells in the Permian Basin (EMNRD, 2021; Environmental Defense Fund et al., 2020). Because of their combined output, exempting these stripper wells would effectively result in 27% of VOC emissions and 64% of VOC emissions from low-emitting facilities being ignored (Environmental Defense Fund et al., 2020).

In addition to this loophole, emission standards contained in the OAI's original draft lacked requirements regarding location of allowed emissions. The first draft required any operator to capture at least 98% of VOC emissions overall. While this standard applied to various types of equipment, including compressor seals, glycol dehydrators, hydrocarbon liquid transfers, pig launching and receiving operations, and storage tanks, the standard did not set any restrictions on location of the equipment (Sierra Club Members, 2020). This means that companies that operate in both the San Juan and Permian Basins could emit the allowed 2% of uncaptured VOC emissions in a single location rather than distributed across multiple sites, resulting in pollution hotspots. If oil and gas producers choose to only emit VOCs in the San Juan Basin, for example, the potential for their operations to disproportionately impact Tribal and Latino communities would increase substantially (Sierra Club Members, 2020).

Another major concern for New Mexico's OAI is the effectiveness of the proposed reporting requirements for owners and operators. There are extensive monitoring and recordkeeping requirements in place under the OAI, such as an obligation to implement an Equipment Monitoring Information and Tracking Tag (EMITT), which displays a unit's potential to emit for VOCs and NOx (20.2.50.6.A.(6)). While this technology supports effective monitoring and recordkeeping, the OAI draft lacks stringent reporting requirements. The rule states that "owners and operators of a source having an excess emission shall submit a Root Cause and Corrective Action Analysis upon the request of the department" (20.2.50.12.D.). This reporting requirement shifts responsibility from the owners and operators at fault onto the Department, thereby possibly delaying or altogether avoiding remediation of excess emissions. One study investigating the effectiveness of corporate sustainability tactics concluded that devising additional reporting requirements does not result in an increase of disclosure rates and instead suggests that disclosure

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requirements be clearly monitored or redefined to remove the department's discretion (Peters & Romi, 2013).

Fortunately, the above loopholes have been documented by various organizations, causing NMED to reconsider its enforcement goals and improve the OAI in its second draft, released on May 6, 2021. In particular, the second draft discards exemptions for low-emitting facilities and stripper wells, a necessary step towards curbing pollution and the human health risks it poses in the state. But the final language for the OAI is in progress, and additional work is necessary to address ozone pollution in the state..

Photo by Patrick Alexander

Our Research Questions

In a limited scope analysis, the 2019-2020 Practicum on Impacts of oil and gas development on Native communities in New Mexico performed for WildEarth Guardians determined that it is possible to link some recently drilled wells in the Greater Chaco Region to their corresponding facilities that have received air quality permits under the federal Clean Air Act. This was done in order to determine if wells were potentially being drilled illegally, before receiving the necessary permit.

To expand on their work, we assessed whether wells in both the San Juan and Permian Basins can be confidently linked to a facility. Then, where well-facility pairings were feasible, we quantified how many wells appear to have been drilled before air quality permits were obtained. If wells were drilled before the necessary permits were obtained, it would constitute a violation of the CAA.

Finally, we provided recommendations for revisions for the Ozone Attainment Initiative to address continued permitting issues.

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Methodology

Acquiring Permits via Government Entities

Last year, the 2019-2020 IoES WildEarth Guardians Practicum Team analyzed 69 well-facility pairings in San Juan County. They first attempted to connect a set of wells to the facility that each well individually supplies using a combination of information obtained from permit documents and by using mapping and geospatial information to identify wells and facilities that are clustered in close proximity to one another, indicating they may be associated. Then, the team obtained relevant Clean Air Act permits pertaining to 62 of the 69 well-facility pairings they had identified. Using this information, the team cross referenced the dates of the Clean Air Act permits or NOIs issued by NMED with the dates the wells were drilled (provided by the OCD). If a well was drilled before a Clean Air Act permit was approved for its associated facility, they considered this a potential violation. The 2019-2020 team found that approximately 35% of the wells surveyed in the Greater Chaco region of New Mexico that could be paired to a facility were constructed prior to obtaining required permits under the federal Clean Air Act (CAA).

As discussed above, under the CAA, an operating permit for any facility meeting emissions criteria must be issued before any construction begins on a well or any other component of the infrastructure. In New Mexico, a Notice of Intent (NOI) is required if a facility has the potential to emit more than 10 tons per year of a regulated air contaminant (NMAC 20.2.73.200). The facility is required to wait on any construction or activity until the New Mexico Environmental Department confirms that no permit is required or the facility receives the final approved permit. However, the New Mexico Oil Conservation Division handles permits for the construction of new wells, and the two agencies do not share data or track analogous information. This makes it difficult to check whether an operator may unlawfully drill a well prior to receiving a CAA permit or exemption.

Therefore, an essential component of this project was to acquire the relevant CAA facility permits and well spudding (initial drilling of a well) data from the relevant New Mexico agencies. Well data, which contains information on well activity, production information, permit requests, violations, acreage, and history, was acquired from OCD. Separately, we requested documentation from NMED through New Mexico's Inspection of Public Records Act (IPRA). By correlating wells to their corresponding facilities, we hoped to assess whether violations of the CAA were occurring. We filed public records requests to obtain information regarding permit applications and NOIs from 2010-2020 for Lea, Eddy, Chaves, and San Juan Counties. A summary of our methodology is given below, for more in depth discussion and examples of analysis, please see the Technical Appendix.

WHEN DO OPERATORS NEED A NOTICE OF INTENT?

Operators that plan to construct or modify a stationary source which has a potential to emit more than 10 tons per year of any regulated air contaminant must file a notice of intent with the department before beginning construction. Construction cannot begin before the operator receive a written determination that a permit is not required, or if required, prior to being issued the permit.

Data Collection, Geospatial Analysis, and Processing through Programming Languages

Our team utilized the geospatial analysis platform ArcMap and the programming language Python to create visual representations of the available data.

First, we expanded upon the work of the 2019-2020 Practicum Team, which primarily focused on the San Juan Basin, by mapping wells in the Permian Basin. Then, we used Python to attempt to connect wells to specific facilities. Various Python packages were utilized, the most crucial of which were Pandas, NumPy, Matplotlib, and Scikit Learn. In addition to these standard packages, we also used geospatial packages such as Geopandas and Fiona to read and process geospatial data.

The 2019-2020 Practicum Team had focused only on two prominent companies, Enduring and Hilcorp, in the San Juan Basin. This year, our team broadened the scope of analysis to a wider slate of companies over the past decade to develop a comprehensive list of well-facility pairings with potential permitting violations. We were able to use a modified version of the Python script the 2019-20 team developed to create additional well-facility pairings based on spatial proximity in the San Juan Basin. However, the geographic distribution of wells and facilities in the Permian Basin made using the same script unreliable in this region, as discussed below. Thus, the team attempted to connect wells to facilities based on other attributes in the Permian basin.

After reviewing multiple potential paths, we believe our method of pairing facilities to wells based on spatial relationships provides the highest potential accuracy. The clustering and pairing of wells with facilities was completed with a modified version of the previous year's practicum code written by Christopher Reed. Details of our analysis and links to the code can be found in this report's Technical Appendix.

The close proximity between oil wells on pads in the San Juan Basin allowed us to employ a process known as Density-based Spatial Clustering of Applications with Noise (DBSCAN). For our project, we used 200 meter ranges with a minimum of 1 well per cluster parameters for DBSCAN. This results in all wells within a 200 meter range being clustered together. The center-points of the well-clusters were identified and then used to pair the well-clusters with the closest facility within a 200 meter range. In San Juan County, we were ultimately able to pair a total of 216 wells with 114 facilities, accounting for approximately 43 percent of oil and gas wells drilled in San Juan County between 2010 and 2020.

To determine which of these pairings had potential violations, we compared well spud dates within each well cluster-facility pairing with the NOI issue dates obtained by public records request from NMED for the corresponding paired facility. The results of our analysis are below.

Photo by Guy Schmickle

Figure 9. Aerial photo of oil and gas well distribution in the Permian Basin; the red circles are single wells, the blue circles are permitted facilities, and the purple circles are storage tanks (Google Earth).

The Permian Basin, which has recently experienced a drastic increase in drilling, proved to be a far more difficult region for assessing potential CAA violations. Oil and gas well pads in the Permian Basin are typically arranged in grid-like patterns, with only a single well or facility on each well pad, and with well pads spaced as much as 400 meters apart from one another. Using the same Python script as for the San Juan Basin to attempt to cluster wells or to associate wells with facilities yielded unreliable results. For example, many wells paired with multiple facilities because they were equidistant from them, as opposed to being co-located on the same well pad. As we were unable to create well-facility pairings based on distance or by clustering well sites, we attempted to use alternate means of connecting wells in the Permian Basin to an associated facility.

First, we looked at naming conventions, speculating that if a well and facility had a shared name and were proximately located they could be associated as a result. This appeared to work for a small number of possible pairings, but in general, we were unable to pair most wells to a facility because either their names were unique or because facilities that had similar names to individual wells or groups of wells were not spatially connected. For example, in Eddy County there are four facilities and six wells designated "Dark Canyon". One facility had similar coordinates to three of the wells, located approximately one hundred meters away. However, the other three facilities, as well as the other three wells were located several miles away within Eddy County. Overall, we concluded that this method was not sufficient to base our analysis on.

Next, we attempted to use attributes including well spudding date, facility permitting date, well and facility ownership, and type of well (oil or gas) to try and pair wells with facilities. Our attempts at pairing wells and facilities in this process included utilizing information obtained from our public records requests from NMED, most notably the dates NOI permits were issued from facilities in Eddy, Chaves, and Lea counties in the last five years, but also NMED's agency interest number and the facility identification number for each facility. After several attempts at clustering wells based on these characteristics, we concluded none of these attributes could reliably predict a relationship between wells or facilities.

As a last attempt to pair wells and facilities, we reached out directly to NMED and OCD to see whether the agencies themselves were able to connect the two. During a phone call with Kirby Olson, the Major Source Program Manager for NMED, she said that "we [NMED] do not have any information on our sheet that would connect [the facilities we issue NOIs for] directly to the wells." We did not receive a response from OCD to our inquiry. To our knowledge, the agencies directly responsible for oversight and enforcement of the CAA and New Mexico state law do not have the ability to track or enforce compliance for well construction with either one.

Our Findings

Expanding on Past Analysis in the San Juan Basin

Data from OCD was filtered to identify active wells in San Juan County that were spudded, or began drilling, after 2010 - a total of 504 new oil and gas wells. We then visualized the data to provide an exploratory analysis, which can be viewed in the Technical Appendix. Our analysis revealed that significantly more gas wells than oil wells were spudded during this period and that spudding activity decreased in the latter half of the decade. This may be due to the sharp increase in drilling in the Permian Basin.

504 active oil and gas wells spudded between 2010 and 2020 were grouped into 404 total clusters using the DBSCAN process. However, we were only able to pair 120 of these well clusters (comprising 207 wells) with facilities. Due to several instances in which, due to proximity to more than one facility or cluster, either a cluster was paired to multiple facilities, or conversely, a facility was paired to multiple clusters, the 120 well clusters were paired with 125 facilities (with some overlap). This occurred primarily for oil well pairings - in most instances where well clusters were paired with more than one facility, the facilities represented different infrastructure types, e.g., a compressor and a tank farm.

We then matched the well cluster-facility pairings with the respective facility NOI documents. 100 (188 wells) of the 120 well-cluster-facilities were successfully matched. The spud dates of wells within the well cluster-facilities pairs were compared to NOI issue dates tied to the facility. This analysis revealed that 46 of the 100 well cluster-facility pairs had potential drilling violations, in which wells were spudded before the NOI for their corresponding facilities were issued. 66 of the 188 total wells in the pairings, or 35% the total wells assessed were potentially drilled in violation of the Clean Air Act. A large portion of the implicated wells were spudded up to 180 days before the corresponding NOI permit was issued.

Figure 10 shows a graphical representation of potential CAA violations for drilling in San Juan County for 2010-2020. Each vertical column represents one of the 188 individual well-facility pairings we identified. The red dots indicate when each well was drilled and the yellow dots represent the NOI issue date from NMED. In total, 66 well-facility pairings, shown by the dashed vertical line, were identified as having potential violations.

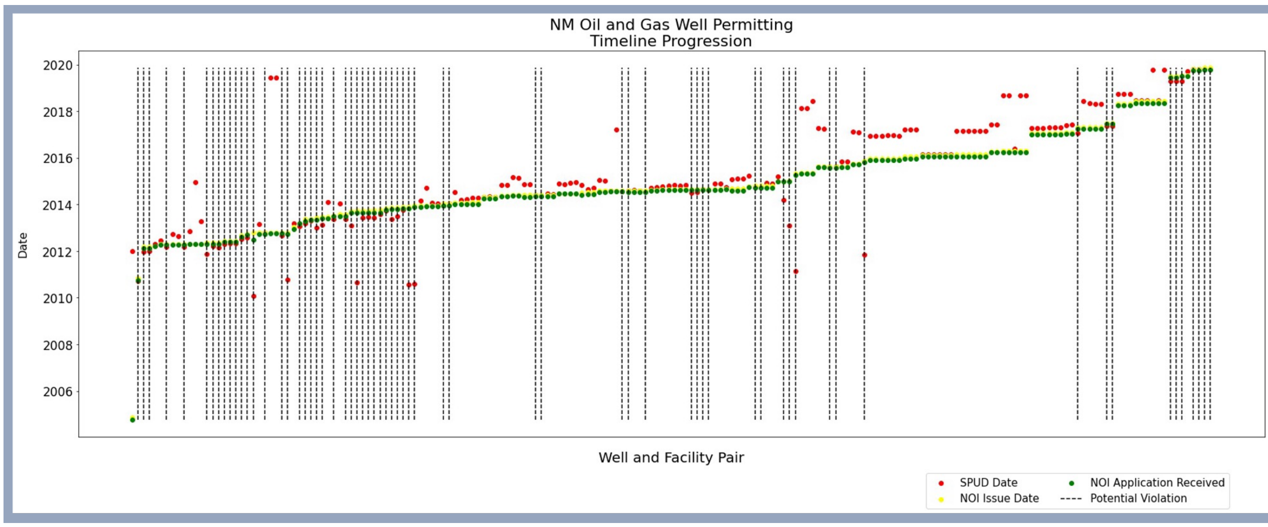

Figure 10. Chart showing the timeline for given well-facility pairings in San Juan County for 2010-2020.

The Challenge of Pairing Wells to Facilities in the Permian Basin

As discussed above, even even after using spatial analysis, naming conventions, and information provided from NMED, we were unable to connect facilities and wells in the Permian Basin. Without this association, NMED and OCD cannot ensure that owners and operators are not preemptively drilling before obtaining permits required by the CAA.

Recommendations for CAA Management and Enforcement

We recommend that NMED and OCD either track these permit applications and drilling dates conjointly or create a common variable that will make well-facility association a feasible, reviewable option. Having NMED and OCD maintain unrelated sets of data hinders proper oversight of state and federal law, with the potential result that increased air pollution will occur in the state. We also recommend that NOI permit applications be made available to the public so that public records requests are not required to obtain relevant information. With these suggestions, management and enforcement of the CAA can more easily be explored by both the public and agencies tasked with their oversight.

Analysis and Policy Recommendations for the Ozone Attainment Initiative

We encourage efforts to Improve the New Mexico OAI in order to strengthen the initiative's ability to mitigate emissions of ozone precursors. First, we highly recommended that the final version remove exemptions for stripper wells and low-emitting facilities present in the initial draft. Since 94.9% and 97.3% of all wells in the San Juan and Permian Basins could be included under this exemption, the scope of the OAI's impact would be greatly restricted if this exemption remains.

Second, when setting emission standards and capture requirements for pollutants, including VOCs and NOx, we recommend that standards account for location in order to prevent the accumulation of allotted emissions in a single region. Including this recommendation will help to prevent companies who operate in both the San Juan and Permian Basins, for example, from releasing uncaptured emissions into a single basin. Setting standards by location will also assist in preventing the formation of pollution hotspots.

Third, we encourage improvements to the reporting requirements of the OAI in order to shift responsibility of reporting emissions exceedances, maintenance practices, emissions tests, PTE calculations, and other activities from the NMED onto the facility owners and operators. Currently, many reporting requirements rely on the NMED to first request the records. Instead, we recommend that owners and operators be required to submit semi-annual reports of these activities, and for a responsible official to certify the accuracy of the data.

Ensuring the safety of public health should not rely on non-government organizations or the public at large to uncover potential threats. Exhaustive studies analyzing the relationship between fracking operations and increasing ozone precursors are readily available to guide New Mexico's OAI. The risk posed by oil and gas development to New Mexicans' public health, particularly that of vulnerable communities, is indisputable, and the state's awareness of these concerns and stronger efforts to address them should be front and center in the OAI.

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