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Drilling in California: Who's at risk?

Tanja Srebotnjak
Miriam Rotkin-Ellman
Natural Resources Defense Council

Acknowledgments

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NRDC Deputy Director of Communications: Lisa Goffredi
NRDC Policy Publications Director: Alex Kennaugh
Design and Production: www.suerossi.com

Photo on front cover: oil wells in Los Angeles

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EXECUTIVE SUMMARY

As new drilling and stimulation techniques, including hydraulic fracturing ('fracking'), are heralded as the key to unlocking a new oil boom in California, there is mounting evidence that these technologies, and the expansion of oil and gas development that they enable, threaten public health. As California contemplates the safety of these technologies and necessary protections, it is important to identify the populations at risk. New analysis of oil and gas development in California shows that, already, approximately 5.4 million people (14 percent of the state's population) live within a mile of one, or more, of more than 84,000 existing oil and gas wells. More than a third of these people (1.8 million) also live in areas most burdened by environmental pollution as identified by California EPA's tool (CalEnviroscreen 2.0). These communities, highly vulnerable to additional pollution from oil and gas development, consist primarily of Latinos/Hispanics (69 percent), African Americans (10 percent), and Asian Americans (11 percent). In total, people of color make up nearly 92 percent of the 1.8 million people living within a mile of oil and gas development and in communities already heavily burdened by pollution.

Currently, the drill sites that use stimulation technologies like hydraulic fracturing are generally located near existing oil and gas extraction, primarily in Kern (2,361 wells), Los Angeles (124 wells), and Ventura (456) counties. However, a smaller number of sites have also been recorded in nine other counties, including Monterey, Fresno, and Santa Barbara. The push to use hydraulic fracturing and other well stimulation technologies to access oil from formations underlying some of the state's most fertile agricultural lands and densely populated urban areas raises public health concerns, including harmful air pollution, contaminated ground and surface waters, and large amounts of toxic waste. Increased oil and gas production using these new technologies can bring more contaminants—many of which have been linked to respiratory and neurological problems, birth defects, and cancer[1,2]—to backyards, communities, and cities. Future unconventional oil and gas development using hydraulic fracturing and other well stimulation techniques in these areas, and its expansion into new areas, may exacerbate environmental problems and health threats for communities that have already been disproportionately impacted. A comprehensive evaluation of the safety of expanding oil drilling must include and ensure protections for the most vulnerable, and already overburdened, communities.

Of the statewide population living within one mile of oil and gas development and in communities identified as most vulnerable by CalEPA's new alEnviroScreen 2.0, nearly 92 percent are people of color (69 percent Hispanic/Latino, 10 percent African American, 11 percent Asian, and 2 percent Other).

Oil wells in Los Angeles

MAPPING OIL AND GAS ACTIVITY AND COMMUNITIES BURDENED BY ENVIRONMENTAL POLLUTION IN CALIFORNIA

The objective of our analysis is to examine where and how communities, especially those that are vulnerable to environmental pollution and degradation, are affected by existing and potential oil and gas development in California. In light of the impacts associated with the rapid scale-up of tight oil[3] and shale gas[4] development in Pennsylvania, Texas, Colorado, and North Dakota, the prospect of new and expanded oil exploration and production in California must be closely evaluated, including identifying who will be impacted by it and where.

We used the California Division of Oil, Gas and Geothermal Resources (DOGGR) "AllWells" and "Well Stimulation Treatment Notices Index" databases, the South Coast Air Quality Management District (SCAQMD) "Oil and Gas Wells Activity Notification" database, and the chemicals disclosure registry database FracFocus.org (all as of July, 2014) to map and describe oil and gas wells.[5,6]

The oil and gas wells that we selected from the "AllWells" database for our analysis are classified by DOGGR as either "New" or "Active". "New" wells are those that have been permitted to be drilled, while "Active" wells include producing wells and wells not plugged according to DOGGR standards. These wells may hence pose an ongoing threat as potential production sites or conduits for pollution.[7] We used the "New" and "Active" codes because they provide a measure of the number of wells that may—now or in the future—contribute to the total environmental burden on the communities. We then expanded this database to include the SB4 notification, SCAQMD, and FracFocus.org information while eliminating duplicate well entries. (For more details on well selection see Appendix I).

In a second step, we mapped the vulnerability of communities to environmental pollution and overlaid the location of oil and gas wells. We used the CalEnviroScreen 2.0—a tool developed by CalEPA to evaluate multiple pollution sources (including air, water, and soil pollution) in a community while accounting for its vulnerability to pollution's adverse health effects. The tool is now being used by several state agencies in their decision-making processes and to identify areas and communities that are in particular need of resources to address these pollution sources and cope with the negative health effects.[8] CalEnviroScreen 2.0 provides a means to identify communities that could be most vulnerable to pollution from new and existing oil and gas development. It aggregates a pollution burden index with Census characteristics that have been linked to pollution sensitivity and ranks census tracts from lowest to highest. We focus in particular on the subset of communities—the top 20% of census tracts—that CalEnviroScreen 2.0 identifies as the most highly burdened, and most vulnerable, communities in the state with respect to cumulative environmental pollution.[9]

Using spatial buffering techniques, we then calculated the number and demographics of people who live near oil and gas wells (within a quarter mile and within one mile).[10] (More detail on the calculation methods is included in Appendix I.)

EXTRACTION TECHNOLOGIES POISED TO EXPAND OIL DRILLING IN CALIFORNIA

Advanced well drilling and stimulation technologies such as horizontal drilling, hydraulic fracturing, and acidizing have brought a huge boom over the past decade in unconventional oil and gas development in at least 17 states.[11] The term 'unconventional' refers to reservoirs that have low permeability and porosity and require technologies such as hydraulic fracturing to produce oil or gas. Hydraulic fracturing ('fracking') involves pumping large volumes of water mixed with chemicals underground at high pressures to fracture the rock.[12] Acidizing is a process that increases the flow of oil and gas by injecting acids into the well to dissolve rocks and/or sediments and mud solids that are clogging the rock pores.[13] Hydraulic fracturing, as well as cyclic steam and water flooding, is also used for enhanced oil recovery (EOR) to improve formation permeability and oil flow.[14]

The Monterey Formation (see Map 1) contains various oil-bearing components known as members,[15] including the Puente or Modelo formations and the Nodular Shale in the Los Angeles Basin and the McClure, Reef Ridge, and Antelope shales in the San Joaquin Basin.[16] The Temblor Formation (including the Santos Shale), which underlies the central and southern San Joaquin Valley, has also been identified as prospective for oil. The Monterey Formation underlies much of the Central Valley's rich agricultural soils and important groundwater aquifers. In Los Angeles and Santa Barbara counties, it overlaps with one of the most populated regions in the country.

Despite uncertainty about how much oil is recoverable in the Monterey Formation tight oil play,[17] the industry continues to aggressively use and develop unconventional stimulation and enhanced recovery methods such as hydraulic fracturing to unlock oil deposits in California.[18,19] This could result in hundreds if not thousands of new wells—in addition to the more than 84,000 existing oil and gas wells (see Map 1)— in heavily drilled areas such as Kern County and new areas, even those near towns and cities.

Our database counts 84,434 active and new oil and gas wells. Of that, 7,177 are 'new' wells that have recently received a permit to be drilled, and, at least 3,003 wells that have been stimulated using hydraulic fracturing, acidizing, and other stimulation methods (including 596 SB4 notices). Since DOGGR only began adding this information recently, however, this estimate may be too low. Differences in reporting requirements also led to discrepancies between the South Coast Air Quality Management District (SCAQMD) well notices[20] and DOGGR's databases. These discrepancies, and the resulting underreporting in California, highlight the need for more effective regulation of an industry that hydraulically fractured approximately 82,000 wells in 17 other states between 2005 and 2013[21] while taking advantage of exemptions from portions of the nation's major environmental and public health protection laws.[22]

POLLUTION AND HEALTH THREATS ASSOCIATED WITH OIL AND GAS DEVELOPMENT

Experts are concerned that expanded oil drilling in California by developing the Monterey tight oil play could pose significant threats to health and the environment from hydraulic fracturing and other stimulation methods.[23,24,25] Although the extent to which these methods will be deployed in California is debated,[26,27] the literature linking oil and gas development, including hydraulic fracturing, to significant releases of air, water, and soil pollutants as well as physical, safety, and health hazards raises the potential for significant impacts.[28,29,30] Recent review studies of shale gas development identified pollutant emissions at all stages beginning with well pad construction and continuing through drilling, well completion, production, and ultimately well abandonment.[31,32] The majority of these pollutants, detailed below, are also present in unconventional oil development, which also uses hydraulic fracturing and acidizing.

AIR POLLUTION

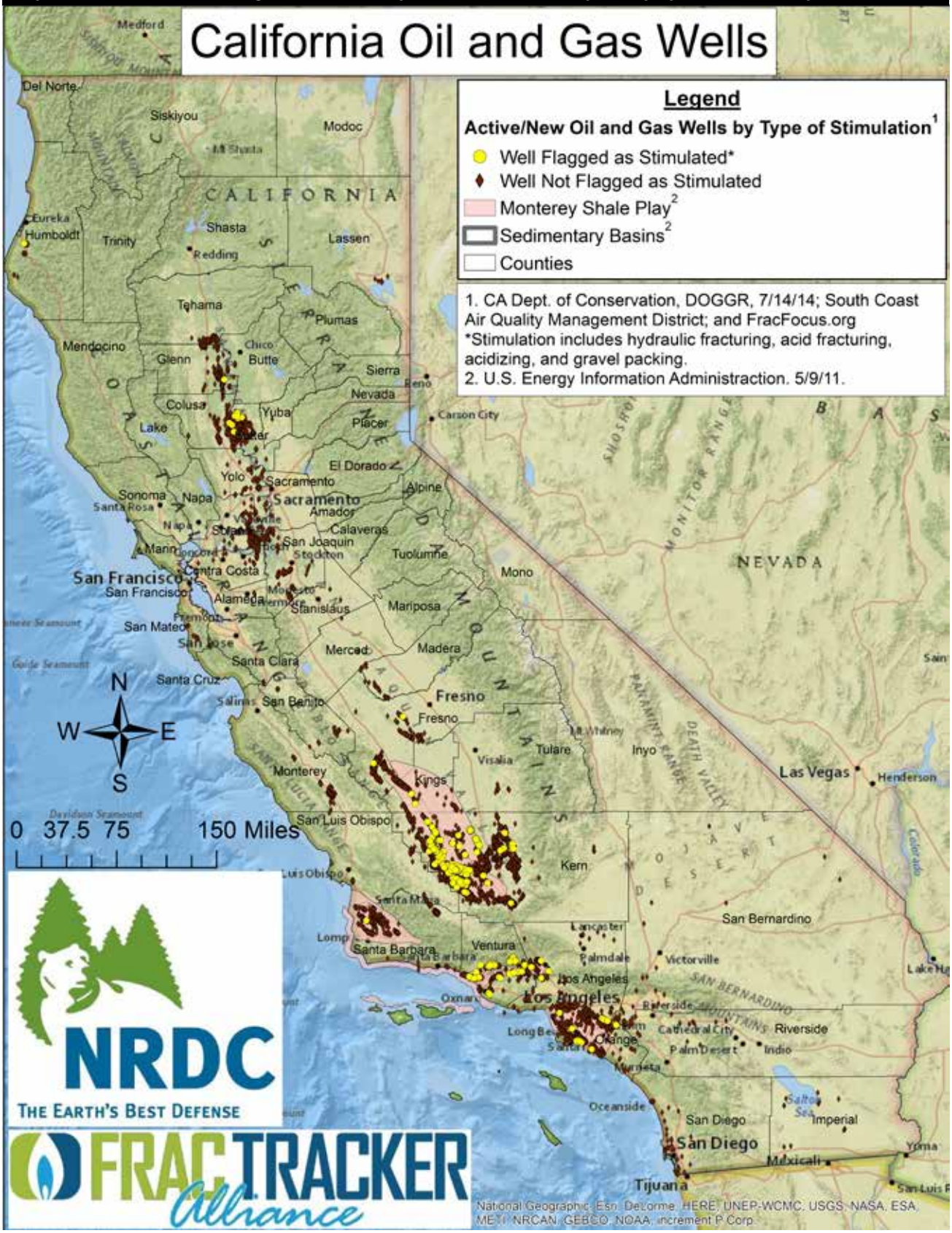
Multiple studies have found that air pollution from oil and gas development can reach levels associated with adverse health impacts for residents and communities in regions with intense oil and gas development. Air pollution from unconventional oil and gas development can be classified into emissions during preproduction, production, transmission and storage, use, and after well abandonment.[33] Preproduction emissions (i.e., well pad preparation, drilling, well stimulation, and completion) include methane, benzene, toluene, ethylbenzene, and xylene (BTEX),[34] volatile organic compounds (VOCs), nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$), hydrogen sulfide, and silica dust.[35,36,37,38] VOCs and NO_x contribute to the formation of regional ozone, which causes smog and harms the respiratory system.[39,40,41] During production, methane and non-methane VOCs, including numerous toxic air contaminants (TACs), may continue to be released from the wellhead and other equipment such as condensate tanks, compressor stations, and open wastewater impoundment pits. Oil and gas transmission and storage release VOCs and methane.[42,43] Improper plugging of a well at the end of its life cycle can cause continued leakage of oil, methane, and other VOCs even after the well has ceased production.[44]

A broad range of health effects are associated with exposure to these air pollutants, including mild to severe respiratory and neurological problems, cardiovascular damage, endocrine disruption, birth defects, cancer, and premature mortality.[45,46]

CONTAMINATION OF DRINKING WATER AND SOILS

The large-scale exploration and production of conventional and tight oil deposits using hydraulic fracturing and related stimulation techniques risks water and soil contamination from spills and leaks; well blowouts; and faulty well casings, cement, and equipment. A recent analysis estimated that between 2012 and 2013, the number of reported spills in 15 major oil and gas producing states rose by 17 percent to more than 7,000.[47] Although many of these spills were small, their combined volume totaled more than 26 million gallons of oil, hydraulic fracturing fluid, wastewater, and other chemicals and compounds used or produced during oil and gas production. Hydraulic fracturing fluid and wastewater are often a toxic soup of chemicals. For example, a study of 353 fracking fluid constituents found that more than 75 percent of them have been shown to affect the

Map 1: Active and new oil and gas wells as of July 2014 and the Monterey shale play and sedimentary basins



skin, eyes, other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40–50 percent can affect the central nervous system and the brain, the immune and cardiovascular systems, and the kidneys. Thirty-seven percent are known endocrine disruptors and 25 percent are linked to cancer and mutations.[48] Underground, the hydraulic fracturing fluid mixes with formation brines. This so-called "produced water" can be much saltier than seawater and can contain heavy metals and Naturally Occurring Radioactive Materials (NORM).[49,50,51] It is brought to the surface along with oil and gas over a well's lifespan. During "flowback" (several days following the fracturing process), between 10 and 80 percent of the hydraulic fracturing fluid returns to the surface.[52] The handling and disposal of this wastewater has been linked to air pollution when volatile contaminates evaporate and to water contamination incidents involving local groundwater and nearby waterways.

Methane, hydrocarbons, hydraulic fracturing fluid components, heavy metals, and formation fluids have been found in water wells near oil and gas sites.

Another potential source of water contamination is loss of mechanical integrity from improper well construction, maintenance, or plugging.[53] Failure of well casings and cement bonds could allow oil, gas, hydraulic fracturing fluids, and naturally occurring toxic and radioactive materials to migrate into shallower groundwater aquifers. While well integrity failure may not necessarily lead to groundwater contamination, monitoring and effective regulations are needed to detect and remediate well integrity problems and to properly plug wells. For example, a 2009 study examined records of more than 315,000 oil and gas production and injection wells drilled through 2004 in Alberta, Canada and found that 4.6 percent had gas migration problems due to improper construction. It remains unclear what percentage of these wells may have impacted groundwater.[54]An examination of more than 75,000 compliance reports for 41,381 conventional and unconventional oil and gas wells drilled in Pennsylvania between 2000 and 2012 found that the incidence of cement and/or casing issues was six-fold higher for unconventional wells compared with conventional wells and that incidence varied by geographical location.[55]

Several other studies have found methane, hydrocarbons (including BTEX), hydraulic fracturing fluids, formation brine, heavy metals, and NORM in water samples from drinking water wells and surface water bodies near oil and gas sites.[56,57,58,59,60] It is, however, difficult to determine the exact origin and pathways that led to the contamination. NORM also poses risks to workers at the well site, neighboring communities, and the environment. It can accumulate in pipes and other well equipment, build up in sediments downstream of wastewater treatment facilities, and contaminate the air and soil when wastewater is sprayed on roads.[61,62] Illegally dumped radioactive solid waste from oil and gas production has also caused contamination problems.[63]

NOISE AND LIGHT POLLUTION

Hydraulic fracturing and other well stimulation methods can lead to prolonged periods of noise and light pollution for nearby communities. Well pad preparation, drilling, and well stimulation generate significant noise levels for neighboring residences, schools, and work places. The noise—from trucks, generators, drilling operations, and pumps—can occur intermittently for days at a time over several years as wells are hydraulically fractured and reworked many times.[64] Produced gas that is not captured and sold may be flared, i.e., burned off, 24 hours a day, producing not only additional air pollution but a constant roar and bright light.[65] The health effects associated with noise and light pollution include sleep disturbance, fatigue, reduced school and work performance, hypertension, and cardiovascular problems.[66]

PUBLIC SAFETY

In areas with inadequate road infrastructure, traffic accidents are one of the largest sources of injuries and fatalities related to tight oil and shale gas development, because of the substantial amount of heavy truck traffic involved.[67,68] Other impacts include increased crime and social disruption, accidents at well sites and pipelines, fires, and explosions.[69]

SEISMIC RISKS

Researchers have known for a long time that underground injection can lubricate faults and change fault pressures potentially resulting in seismic events. The injection of oil and gas wastewater into deep underground wells (so-called UIC Class II wells) has repeatedly been linked to such events, known as induced seismicity.[70] Researchers at the U.S. Geological Survey found that the rate of earthquakes of magnitude 3.0 and higher in the central and eastern United States has increased from an average of 21 per year from 1967 through 2000 to more than 300 in the years 2010 through 2012. In 2011 alone, there were 188.[71] An analysis of the disposal of toxic wastewater in deep injection wells in California showed that 54 percent of 1,553 active and new injection wells are within 10 miles of a recently (within the past 200 years) active seismic fault line. Another 23 percent are within five miles and 6 percent are within one mile.[72] Most earthquakes caused by oil and gas activities have been relatively small. Some, like the 2011 magnitude 5.7 earthquake in Oklahoma that was triggered by wastewater injection, have been large enough to cause property damage and injuries.[73] Even small induced earthquakes, however, may compromise well integrity or other infrastructure, leading to water and soil contamination.

OIL AND GAS WELLS ARE CONCENTRATED IN COMMUNITIES STRUGGLING WITH AND VULNERABLE TO POLLUTION

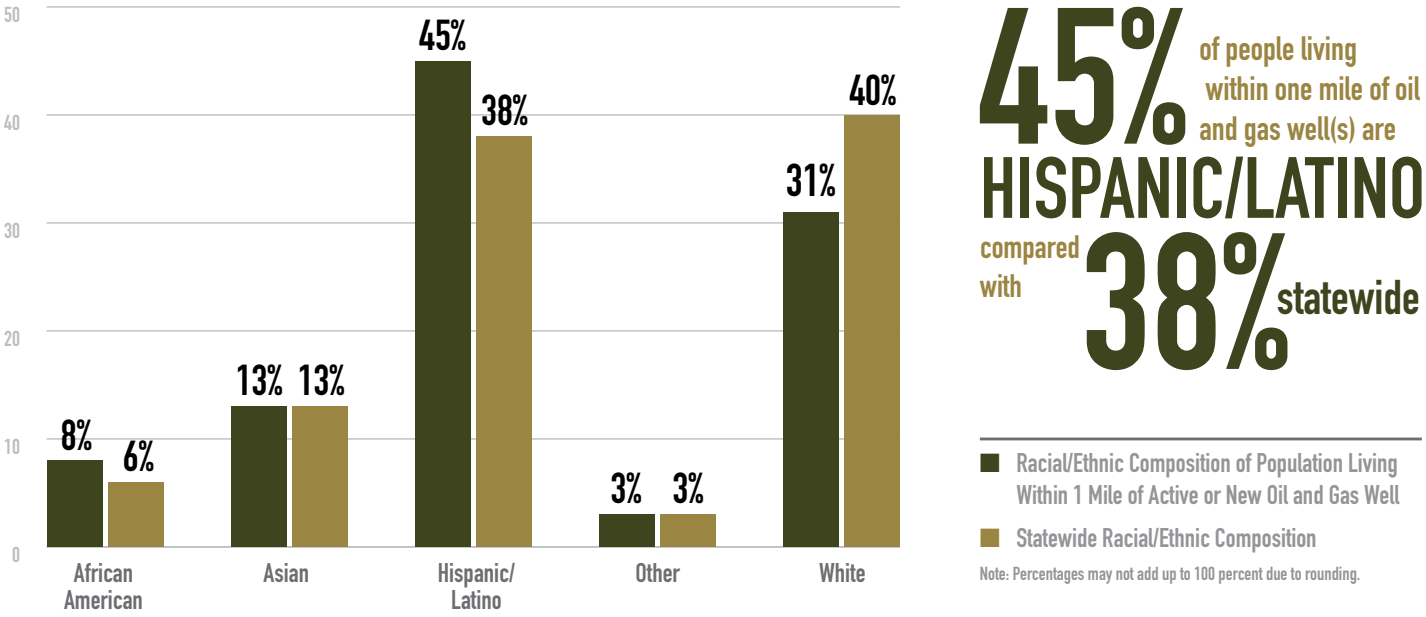
The number of oil and gas wells per census tract varies widely in California. The largest number of wells, more than 28,000, is found in a rural census tract west of Bakersfield in Kern County. Kern and Los Angeles counties top the charts with total well counts of 63,430 and 6,065, respectively. Map 2 shows the number and distribution of wells in relation to the 20 percent of census tracts identified by CalEnviroScreen 2.0 as most vulnerable. Since census tracts are roughly linked to population sizes, rural census tracts tend to be larger in area and therefore tend to have a greater number of wells. In Los Angeles, high population density means that the census tracts are much smaller and well counts of 1–100 are more typical and often found near other urban pollution sources.[74] Our maps show that residents in the southern part of the San Joaquin Valley and the greater Los Angeles area suffer from high pollution concentrations as well as a high concentration of oil and gas wells.

In California, approximately 5.4 million people (14 percent of the state's population) live within a mile of one or more oil and gas wells. This translates to roughly 1 in 5 African Americans, 1 in 6 Hispanics/Latinos, 1 in 7 Asians, and 1 in 9 Whites. More than a third of these people, 1.8 million (mainly in Los Angeles and Kern Counties), also live in areas identified by CalEnviroScreen 2.0 as most burdened by environmental pollution. A breakdown by race and ethnicity, as shown in Figure 1, reveals disparities in potential exposure for communities of color compared to the state's total population.[75]

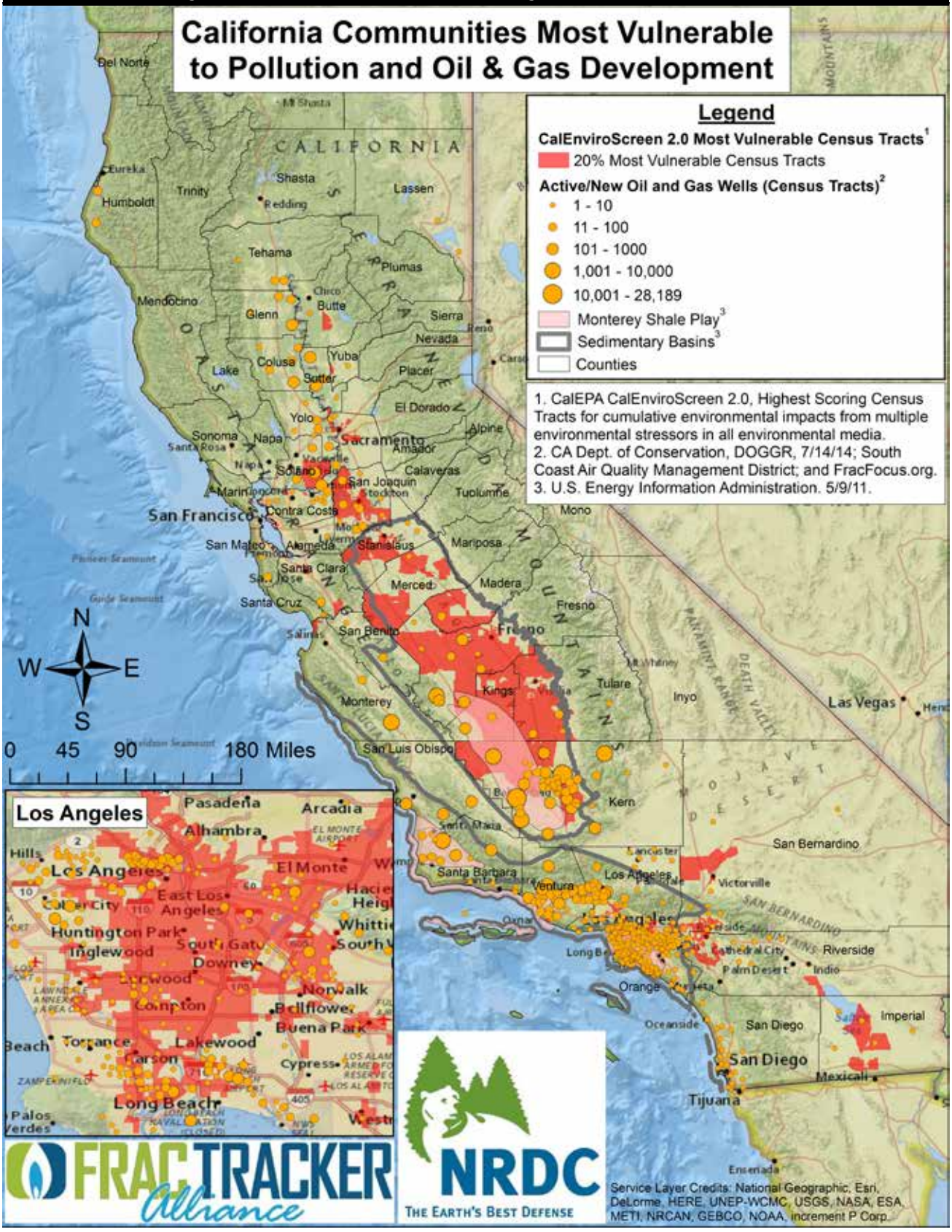
Of the statewide population living within one mile of oil and gas development and in communities identified as most vulnerable by CalEPA's new CalEnviroScreen 2.0, nearly 92 percent are people of color (69 percent Hispanic/Latino, 10 percent African American, 11 percent Asian, and 2 percent Other). Within the top 20 percent of census tracts ranked as most vulnerable—with a combined population of nearly 7.5 million—the number of oil and gas wells ranges from 0 to 6,575 per census tract, with a total of 11,329 wells. (See Appendix II for more detail.) Without the necessary monitoring data, scientific understanding, and health regulations, expanded oil development in these parts of the state could further exacerbate the toll on the most vulnerable communities.

Additionally, the geologic formations targeted for potential new exploration using hydraulic fracturing and other techniques include areas that are already heavily burdened by pollution, particularly in the Central Valley. So far, most of the new drilling and well stimulation techniques have been concentrated in areas of existing oil and gas drilling in Kern County. Los Angeles and Ventura counties each also have more than 100 stimulated wells. Fresno and Monterey counties, too, are seeing hundreds of new well permits and a handful of wells flagged as stimulated (Table 1 in Appendix II). Although it remains to be seen whether, and how, this exploration will be conducted given the geology of these basins in California, which is challenging for large-scale hydraulic fracturing, even small increases in pollution in already heavily burdened areas could result in increased health threats.

Figure 1: Demographics of Population Living Near Wells and Statewide in California



Map 2: Active and new oil and gas well counts as of July 2014 by census tract and the 20 percent most vulnerable census tracts according to the CalEnviroScreen 2.0 released in August 2014



Although the 3,003 wells identified as having been stimulated using hydraulic fracturing and other techniques (including 596 well stimulation notices under SB4) are likely an undercount, more than 80 percent of them are located in just three census tracts. Two of those tracts are in Kern County and one in Ventura County.[76] The two Kern County tracts (west and northwest of Bakersfield) also have the most new well permits and account for 591 of the 596 SB4 well stimulation notifications included in our database (430 and 161 notices, respectively). Of the 7,177 newly permitted wells—6,141, or 86 percent—are located in Kern County. More than half (3,209) are in the census tract with the most wells followed by 1,194 and 843 new wells in the next two tracts. The three census tracts surround Bakersfield to the west, northwest and northeast. This area also ranks in the top third of census tracts for environmental pollution.

According to CalEnviroScreen 2.0, the communities already experiencing new drilling, hydraulic fracturing, and acidizing are also exposed to high levels of ozone, particulate matter, diesel particulate pollution, water and soil contamination, and hazardous waste sites. If current drilling trends continue—and new well drilling, hydraulic fracturing and other stimulation techniques are concentrated in areas with existing oil and gas activity—more than 1.8 million Californians, already heavily burdened by pollution, may be saddled with even more health threats.

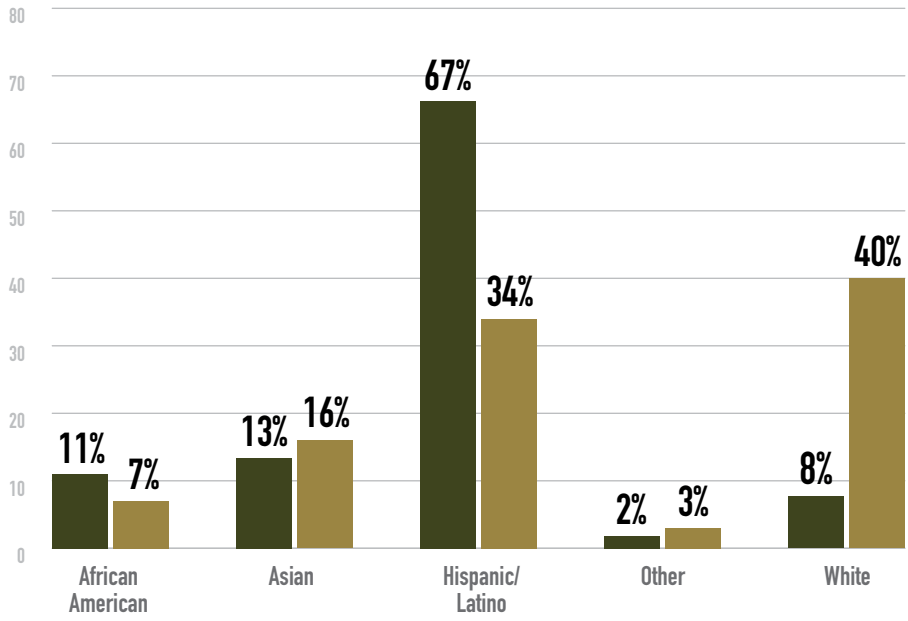
HOTSPOTS IN SOUTHERN CALIFORNIA: GREATER LOS ANGELES AND THE SOUTHERN SAN JOAQUIN VALLEY

GREATER LOS ANGELES

Los Angeles is home to the Inglewood Oil Field, the largest urban oil field in the United States.[77] This field is in the Baldwin Hills' community, which includes 300,000 residents.[78] Well pads often contain 30 or more wells within a few feet of buildings, roads, and parks. Map 3 illustrates that in Los Angeles, oil and gas wells are frequently in immediate proximity to, or even part of, neighborhoods and communities that are burdened by multiple environmental stressors with limited ability to address and cope with the associated health risks.

In Los Angeles County, 580,000 people live within a quarter mile of 5,715 active and 350 newly permitted oil and gas wells. At a one mile distance the number grows to 3.5 million (i.e., one third of the County's population), nearly half are Hispanic/Latino. Ninety-seven of Los Angeles County's 855 census tracts with the highest environmental pollution burden have at least one well for a total number of 1,723 wells (28 percent of the total number of wells in Los Angeles County). Furthermore, people of color are more likely to live near oil and gas wells in Los Angeles County: 44 percent of African Americans, 37 percent of Hispanics/Latinos and 38 percent of Asians compared with 31 percent of Whites.

Figure 2: Racial/Ethnic Composition According to the CalEnviroScreen 2.0 and 1/4 Mile Distance to Oil and Gas Wells in Los Angeles County



67%

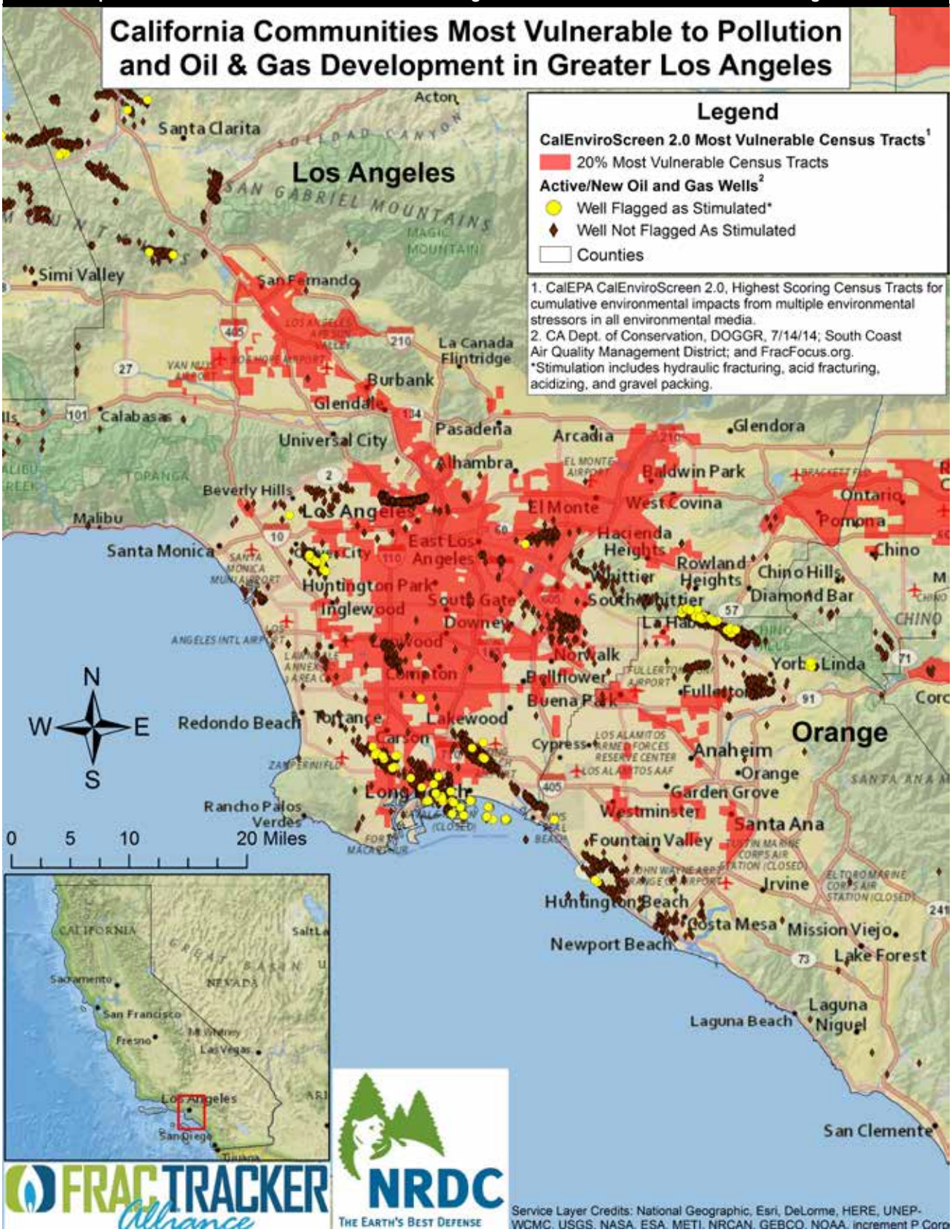
of people living within a quarter mile of oil and gas well(s) and in areas facing the worst environmental health threats are

HISPANIC/LATINO.

- Most Vulnerable Communities With Oil and Gas Wells Within 1/4 Mile
- Less Vulnerable Communities Without Oil and Gas Wells Within 1/4 Mile

Note: Percentages may not add up to 100 percent due to rounding.

Map 3: Greater Los Angeles area showing the density of active and new oil and gas wells as of July 2014 and the 20 percent most vulnerable census tracts according to the CalEnviroScreen 2.0 released in August 2014



Of the more than 262,000 Los Angeles County residents that live within a quarter mile of oil and gas wells *and* in areas facing the worst health threats from pollution in the state; 67 percent are Hispanics/Latinos, 11 percent African Americans, 13 percent Asians, and 2 percent Other. In contrast, the communities less impacted by environmental pollution and not living in close proximity to oil and gas wells have a significantly higher White population (Figure 2).

Although many of Los Angeles' oil fields have been tapped for several decades, new stimulation and recovery techniques could bring currently idle wells back into production.[79] Much of the greater Los Angeles region is underlain by the Monterey Formation, which could soon be explored using unconventional drilling and stimulation techniques.

SAN JOAQUIN VALLEY AND KERN COUNTY

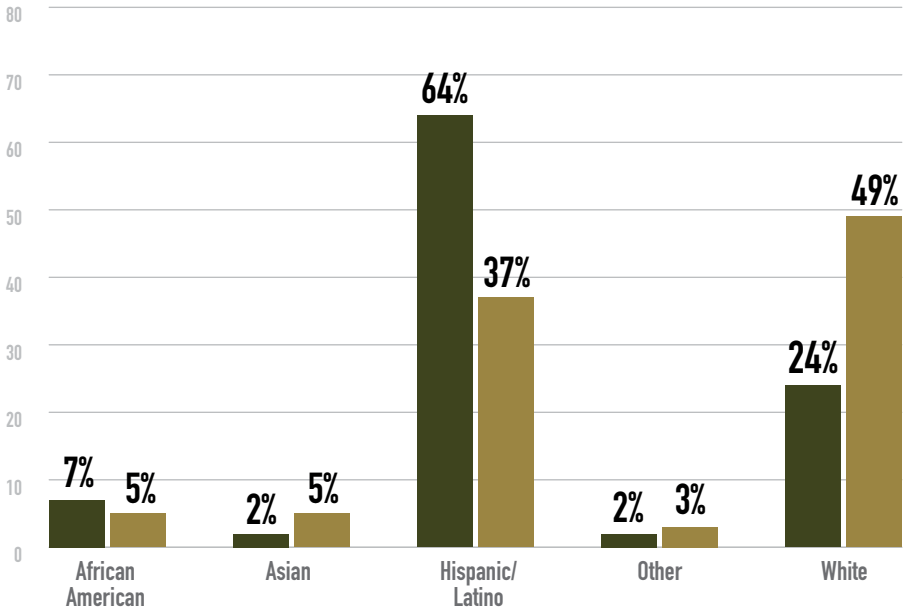
The San Joaquin Valley stretches from San Joaquin County in the north to Kern County in the south. Although mostly rural, this region contains several larger metropolitan areas, including Fresno, Bakersfield, Stockton, and Modesto.[80] The region is a major producer of agricultural crops, livestock, and other products, but also suffers from a high rate of food insecurity and poverty.[81] The San Joaquin Valley's air quality consistently ranks as among the worst in the nation with high levels of ozone and fine particulate matter ($PM_{2.5}$). More than 36 percent of the census tracts in the San Joaquin Valley rank in the top 20 percent for combined pollution threats, including air pollution and toxic releases.

While CalEnviroScreen 2.0 flags many census tracts throughout the San Joaquin Valley as highly impacted and vulnerable, we focus on Kern County because of its high concentration of oil and gas development and because new development using hydraulic fracturing and acidizing of the Monterey Formation is already underway there. Kern County produces approximately 75 percent of California's oil and about 58 percent of its natural gas.[82] Map 4 shows the dense distribution of the 63,430 active and new oil and gas wells in the County—6,141 of which are newly permitted and at least 2,361 have been stimulated—with up to 28,188 wells per census tract.

Kern County has 63,430 active and new oil and gas wells and at least 2,361 of them have been stimulated using hydraulic fracturing or other methods.

CalEnviroScreen 2.0 ranks 55 Kern County census tracts, with a population of 330,000, as among the most vulnerable to pollution and this includes many tracts with a high well density. Slightly more than 290,000 people (35 percent of the population) live within one mile of one of the 63,430 oil and gas wells. In Kern County, Hispanic/Latino and African American communities carry a disproportionate environmental pollution burden, which may be exacerbated by the effects of oil and gas production. Of the approximately 122,000 people living close to oil and gas wells *and* suffering

Figure 3: Demographics of Kern County According to the CalEnviroScreen 2.0 and 1 Mile Distance to Oil and Gas Wells in Kern County



64%

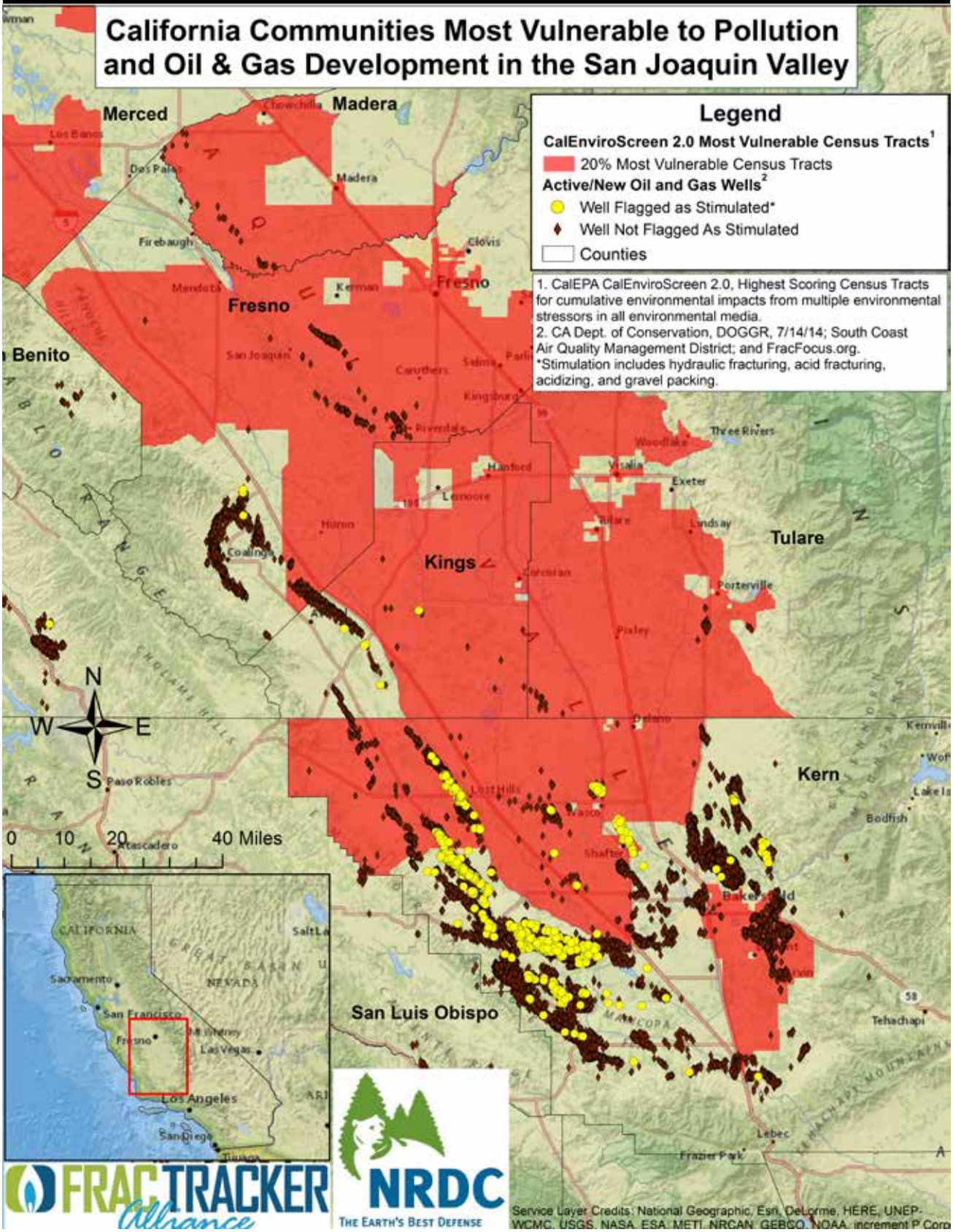
of people living within one mile of oil and gas well(s) and in areas facing the worst environmental health threats are

HISPANIC/LATINO.

- Most Vulnerable Communities With Oil and Gas Wells Within 1 Mile
- Less Vulnerable Communities Without Oil and Gas Wells Within 1 Mile

Note: Percentages may not add up to 100 percent due to rounding.

Map 4: Southern San Joaquin Valley showing the density of active and new oil and gas wells as of July 2014 and the 20 percent census tracts most vulnerable census tracts according to the CalEnviroScreen 2.0 released in August 2014



the most health threats from pollution as measured by CalEnviroScreen 2.0, nearly 92,000 (76 percent) are people of color.[83] In contrast, the communities less impacted by environmental pollution and not near oil and gas wells are majority white (49 percent) (see Figure 3).

Kern County is also the epicenter of well stimulation notices filed under the SB4 interim regulations. As of July 2014, 596 notices for well stimulation using hydraulic fracturing, acidizing, and other techniques have been filed, 591 of them for wells in Kern County. The majority of these wells were hydraulically fractured, while a smaller proportion used acid matrix stimulation. The western part of the county overlies the Monterey tight oil play and is considered prospective for development. There is also current production from the Monterey Formation.[84] Kern County's rural communities, which are already heavily impacted by pollution and predominantly Latino/Hispanic and low-income, are at the frontlines of new drilling and technologies with the accompanying health risks from heavy truck traffic, air pollutant emissions, accidents, and wastewater disposal.

CONCLUSIONS

Expanding oil production in California, in areas already heavily drilled or in new areas, can threaten the health of communities. For many already living with oil and gas wells and at ground zero for new drilling activity, these threats are piled on top of a heavy burden of environmental contamination. Evaluations of the safety of new drilling techniques must account for the threats to these communities and California policymakers must ensure that new oil exploration and development does not come at their expense.

RECOMMENDATIONS

To prevent further environmental damage and public health threats, major improvements are required before hydraulic fracturing, acidizing, and other stimulation techniques are allowed in California:

A comprehensive evaluation of pollution and health threats from oil and gas development, including well stimulation using hydraulic fracturing and other methods, must include the following:

- a full inventory and assessment of the types, sources, and quantities of contaminants associated with oil and gas development and production, including hydraulic fracturing and acidizing;
- an assessment of their health threats; and
- an evaluation and quantification of additional pollution, health threats, and environmental degradation from increased oil and gas extraction in existing oil fields and expansion into new areas within the Monterey tight oil play.

The current tracking, reporting, and notification system for oil and gas well development, activity, and stimulation methods is inaccurate and fragmented and is not transparent. DOGGR must work to overhaul its databases and improve data integration and reporting. Comprehensive measures are needed to ensure that oil and gas development does not contribute to environmental degradation, pollution, or threatens the health of residents in neighboring communities. Until this is complete, communities already overburdened with environmental pollution will remain in harm's way.

Endnotes

1 John L. Adgate, Bernard D. Goldstein, Lisa M. McKenzie, "Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development," *Environmental Science & Technology*, February 2014, doi:10.1021/es404621d.

2 Lisa M. McKenzie et al., "Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado," *Environmental Health Perspectives*, 2014, doi:http://dx.doi.org/10.1289/ehp.1306722.

3 Tight oil, also called shale oil, is light crude oil trapped in formations of low permeability, often shale or tight sandstone.

4 Shale gas is natural gas that is trapped in shale formations of low permeability.

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APPENDIX I: METHODS

Our analysis uses well location data from California's Division of Oil, Gas, and Geothermal Resources (DOGGR), the South Coast Air Quality Management District (SCAQMD), and FracFocus.org to locate existing and potentially new oil and gas development.[1] We overlay this information with the total environmental burden and vulnerability score from the California EPA's (CalEPA) cumulative environment impact tool (CalEnviroScreen 2.0).[2]

OIL AND GAS WELL DATA

We located active (AOG) wells and new (NOG) wells through the DOGGR's AllWells database (version released July 14, 2014) using the *GISSymbol* field. Active wells, according to DOGGR's classification, include producing wells and unplugged wells that may not be producing (e.g., idle and buried wells) but that can still be brought back into production or become a conduit for pollution.[3] New wells have recently been permitted to be drilled.[4] We used the AOG and NOG codes because they provide a more complete measure of the total number of wells that may be sites of active development or serve as a conduit for pollution and contribute to the total environmental burden. We note that the "AllWells" database also includes the *WellStatus* field. There are discrepancies between the *GISSymbol* field and the *WellStatus* field and neither is fully accurate at this point. The discrepancies should be investigated and corrected by DOGGR. Communication with DOGGR staff, and other experts, suggested that although the *GISSymbol* field is not perfect, DOGGR staff regularly use it for spatial analysis of well data. We, therefore, concluded that the use of this field is justified to account for wells that are currently producing or may be brought back into production in the future.

We then added information from DOGGR's new Well Stimulation Notices database, which was developed in response to Senate Bill 4 (SB4), California's law for oil and gas well stimulation enacted in 2013 (SB4 notices as of July 2014).[5] The SB4 interim regulations[6]—developed by DOGGR and effective since January 1, 2014—require well operators to file notices at least 30 days prior to commencing well stimulation using controversial technologies such as hydraulic fracturing and acidizing. We also added information from the South Coast Air Quality Management District's Oil and Gas Wells Activity Notification database, which was developed under Rule 1148.2, as well as the Chemicals Disclosure Registry website FracFocus.org. We then removed duplicates, multiple entries for well reworks, offshore wells, and wells without correct latitude and longitude coordinates. Our final total came to 84,434 wells (77,257 active and 7,177 newly permitted wells).

To determine the number of wells that have been stimulated, we used the DOGGR AllWells database, the SB4 Well Stimulation Treatment Notification Index, the SCAQMD Oil and Gas Well Activity Notification database, and FracFocus.org. We counted 3,003 wells that have used or plan to use hydraulic fracturing, acid fracturing, acidizing, and/or gravel packing. These 3,003 wells include 596 wells, for which SB4 stimulation notices are available.

In 2012 DOGGR added the field *HydraulicallyFractured* to its "AllWells" database as a basic yes/no indicator and is still adding this information to the database. Therefore, our count of stimulated wells—while it is the best currently available—is still likely an undercount. According to the DOGGR, the new field will be used to identify future wells using hydraulic fracturing techniques and former wells that have used hydraulic fracturing techniques.[7]

ENVIRONMENTAL POLLUTION AND VULNERABILITY DATA

The CalEnviroScreen 2.0 data layer (released in August 2014) was downloaded from the California Office of Environmental Health Hazard Assessment's (OEHHA) CalEnviroScreen website.[8] We use the census tracts falling into the top 20 percent of most vulnerable communities according to the CalEnviroScreen 2.0 aggregate score. The CalEnviroScreen tool was developed to evaluate multiple pollution sources (including air, water, and soil) in a community while accounting for a community's vulnerability to pollution's adverse health effects.[9]

CALCULATING THE POPULATION VULNERABLE TO ENVIRONMENTAL POLLUTION AND AFFECTED BY OIL AND GAS DEVELOPMENT

The number and percentage of people living within 0.25 and 1 mile of active and new oil and gas wells was estimated using 2012 population data from the U.S. Census Bureau[10] and well location information from our well database. The 0.25 and 1 mile distances were chosen to represent oil- and gas-related health threats at scales relevant to urban and rural settings, respectively, and to reflect both local and regional pollution.[11] To do so, circles of 0.25 and 1 mile, as appropriate to the area, were drawn around each well to create a buffered well layer. The boundaries of these circles were merged and the resulting shape was intersected with the census tract population layer. We then calculated the portions of each census tract that overlapped with the buffered well layer. Assuming that the census tract population (total population and population by race and ethnicity) is uniformly distributed across the census tract, we then determined the fraction (total population and by race and ethnicity) that lived within the buffered well layer. All maps were produced in ArcGIS version 10.1.

Appendix I Endnotes

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APPENDIX II: TABLES

The tables in this Appendix provide details on the number and location of oil and gas wells in California. The data was extracted from public databases maintained by California's Division of Oil, Gas, and Geothermal Resources (DOGGR), the South Coast Air Quality Management District (SCAQMD), and FracFocus.org. Data from the AllWells database is current as of July 14, 2014 and the information on SB4 Well Stimulation Notices Index, the SCAQMD Oil and Gas Activity Notification database, and FracFocus.org are current as of July 2014.

The following well types are included in our analysis:

- Active Oil and Gas Wells (AOG): According to DOGGR's classification, these wells include producing wells and wells that have not been plugged and may not be producing, such as idle and buried wells, but can still represent a potential for reactivation or conduit for pollution.
- New Oil and Gas Wells (NOG): These wells have recently been permitted to be drilled.
- Stimulated wells: These wells have been stimulated using hydraulic fracturing, acid fracturing, acidizing, and/or gravel packing as compiled from the DOGGR AllWells database, and SB4 Well Stimulation Treatment Notices Index, the SCAQMD Oil and Gas Activity Notification database, and FracFocus.org.
- SB4 Wells: These wells are listed as approved in DOGGR's SB4 interim well stimulation notices database. These wells are a subset of the stimulated wells.

Table 1: Counties with at least one active or new oil and gas well

County	Total Number of Active and New Oil and Gas Wells	Active Wells	New Wells	Stimulated Wells	Stimulated Wells with SB4 Notifications
Kern	63,430	57,289	6,141	2,361	591
Los Angeles	6,065	5,715	350	124	-
Fresno	3,671	3,470	201	3	2
Ventura	3,078	2,988	90	456	3
Santa Barbara	2,141	2,058	83	3	-
Orange	1,585	1,530	55	30	-
Monterey	1,263	1,153	110	1	-
Sutter	423	417	6	14	-
San Luis Obispo	402	323	79	-	-
Colusa	372	350	22	3	-
Kings	366	358	8	6	-
Glenn	325	323	2	1	-
Solano	248	247	1	-	-
Sacramento	214	206	8	-	-
Tehama	151	149	2	-	-
San Joaquin	147	143	4	-	-
Tulare	102	99	3	-	-
Yolo	75	73	2	-	-
San Bernardino	67	67	-	-	-
Humboldt	57	57	-	-	-
San Benito	46	44	2	-	-
Contra Costa	43	42	1	-	-
San Diego	31	31	-	1	-

Table 1: Counties with at least one active or new oil and gas well (cont'd.)

County	Total Number of Active and New Oil and Gas Wells	Active Wells	New Wells	Stimulated Wells	Stimulated Wells with SB4 Notifications
Madera	29	25	4	-	-
San Mateo	25	25	-	-	-
Riverside	18	18	-	-	-
Santa Clara	16	13	3	-	-
Imperial	13	13	-	-	-
Butte	10	10	-	-	-
Alameda	7	7	-	-	-
Lassen	7	7	-	-	-
Stanislaus	3	3	-	-	-
Merced	2	2	-	-	-
Santa Cruz	1	1	-	-	-
Yuba	1	1	-	-	-
TOTAL	**84,434**	**77,257**	**7,177**	**3,003**	**596**

Data sources: DOGGR "AllWells" database (as of 7/14/2014). DOGGR SB4 Well Stimulation Notices database (as of July 2014). The total number of active and new oil and gas wells is the sum of active wells and new wells. Stimulated wells include wells with SB4 notifications.

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6019003900	Fresno	96-100%	5804	72%	541	9%	389	7%	117	117	0	0	0
6019007801	Fresno	81-85%	2722	98%	524	19%	513	19%	109	109	0	0	0
6019007700	Fresno	91-95%	5599	74%	3001	54%	2218	40%	79	77	2	0	0
6019008200	Fresno	81-85%	6978	93%	582	8%	541	8%	35	34	1	0	0
6019007600	Fresno	86-90%	4806	76%	431	9%	329	7%	9	8	1	0	0
6019008402	Fresno	81-85%	1152	69%	24	2%	16	1%	1	1	0	0	0
6019008302	Fresno	91-95%	6562	97%	41	1%	40	1%	1	1	0	0	0
6025012400	Imperial	81-85%	1266	27%	3	0%	1	0%	3	3	0	0	0
6025010102	Imperial	81-85%	5007	85%	225	4%	192	4%	3	3	0	0	0
6029004500	Kern	86-90%	3937	95%	1086	28%	1027	26%	6575	5381	1194	587	161
6029006202	Kern	91-95%	6401	94%	1686	26%	1583	25%	804	751	53	0	0
6029001000	Kern	86-90%	9186	72%	8448	92%	6091	66%	369	356	13	0	0
6029000507	Kern	81-85%	3598	31%	3598	100%	1112	31%	224	222	2	0	0
6029006201	Kern	96-100%	2877	73%	937	33%	685	24%	147	146	1	0	0
6029003700	Kern	86-90%	3953	67%	1340	34%	891	23%	146	121	25	2	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6029004604	Kern	91-95%	15845	92%	1315	8%	1212	8%	145	97	48	0	0
6029004200	Kern	86-90%	1320	70%	268	20%	187	14%	96	94	2	1	0
6029002400	Kern	96-100%	7478	82%	4119	55%	3361	45%	60	59	1	0	0
6029004000	Kern	81-85%	7704	87%	4215	55%	3646	47%	44	35	9	18	0
6029006301	Kern	86-90%	4004	92%	3750	94%	3454	86%	40	39	1	0	0
6029001801	Kern	81-85%	5579	56%	5579	100%	3130	56%	17	17	0	0	0
6029003112	Kern	86-90%	5116	68%	5007	98%	3379	66%	6	6	0	0	0
6029002600	Kern	96-100%	3539	85%	3539	100%	3015	85%	6	6	0	0	0
6029006303	Kern	86-90%	6784	96%	6784	100%	6513	96%	3	3	0	0	0
6029000200	Kern	86-90%	7644	27%	4367	57%	1175	15%	3	3	0	0	0
6029006304	Kern	81-85%	3895	94%	3834	98%	3589	92%	2	2	0	0	0
6029004301	Kern	86-90%	7416	89%	1208	16%	1070	14%	2	2	0	2	0
6029000400	Kern	96-100%	4319	28%	2300	53%	635	15%	2	2	0	0	0
6029003114	Kern	81-85%	7654	63%	6387	83%	3992	52%	1	1	0	0	0
6029003113	Kern	96-100%	4784	78%	4759	99%	3693	77%	1	1	0	0	0
6031001601	Kings	91-95%	4516	86%	204	5%	175	4%	18	18	0	1	0
6037208000	Los Angeles	96-100%	6893	93%	6893	100%	6376	93%	167	167	0	0	0
6037980014	Los Angeles	96-100%	239	23%	217	91%	51	21%	145	138	7	1	0
6037197700	Los Angeles	86-90%	5103	90%	5103	100%	4613	90%	110	110	0	0	0
6037502700	Los Angeles	96-100%	6956	92%	6876	99%	6339	91%	108	83	25	0	0
6037530003	Los Angeles	91-95%	2983	78%	2983	100%	2318	78%	106	102	4	0	0
6037211122	Los Angeles	86-90%	3075	90%	3075	100%	2764	90%	87	87	0	0	0
6037294701	Los Angeles	91-95%	3019	96%	3019	100%	2892	96%	86	65	21	1	0
6037208302	Los Angeles	96-100%	4360	96%	4360	100%	4177	96%	82	82	0	0	0
6037502902	Los Angeles	91-95%	4043	92%	4043	100%	3711	92%	79	72	7	0	0
6037573401	Los Angeles	81-85%	1439	73%	1439	100%	1045	73%	65	63	2	1	0
6037208401	Los Angeles	96-100%	3770	97%	3770	100%	3638	96%	61	61	0	0	0
6037540902	Los Angeles	91-95%	4506	99%	4506	100%	4461	99%	46	46	0	0	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6037502802	Los Angeles	96-100%	1380	87%	1380	100%	1194	86%	44	44	0	0	0
6037572201	Los Angeles	91-95%	6197	82%	6197	100%	5106	82%	43	43	0	0	0
6037208802	Los Angeles	81-85%	2906	86%	2906	100%	2505	86%	35	35	0	0	0
6037294120	Los Angeles	86-90%	2370	99%	2370	100%	2337	99%	33	33	0	0	0
6037208301	Los Angeles	86-90%	2201	98%	2201	100%	2161	98%	26	26	0	0	0
6037543604	Los Angeles	81-85%	5620	91%	5620	100%	5109	91%	25	23	2	2	0
6037530005	Los Angeles	91-95%	4346	89%	4346	100%	3872	89%	25	25	0	0	0
6037221401	Los Angeles	91-95%	3359	91%	3359	100%	3063	91%	21	20	1	0	0
6037541001	Los Angeles	96-100%	1164	97%	1164	100%	1133	97%	21	21	0	0	0
6037208502	Los Angeles	91-95%	3571	95%	3571	100%	3385	95%	20	20	0	0	0
6037532303	Los Angeles	96-100%	4464	97%	4320	97%	4203	94%	19	19	0	0	0
6037532302	Los Angeles	96-100%	4707	98%	4096	87%	3993	85%	18	18	0	0	0
6037224010	Los Angeles	91-95%	2433	92%	2433	100%	2246	92%	17	17	0	0	0
6037207103	Los Angeles	96-100%	2077	98%	2077	100%	2033	98%	16	16	0	0	0
6037211320	Los Angeles	86-90%	3184	92%	3184	100%	2917	92%	14	14	0	0	0
6037224420	Los Angeles	91-95%	2369	95%	2369	100%	2243	95%	14	14	0	0	0
6037701100	Los Angeles	86-90%	746	60%	746	100%	444	60%	13	13	0	0	0
6037294620	Los Angeles	91-95%	4219	99%	4219	100%	4156	99%	13	13	0	0	0
6037206010	Los Angeles	96-100%	3127	96%	3127	100%	3002	96%	13	13	0	0	0
6037197600	Los Angeles	91-95%	2376	80%	2376	100%	1891	80%	11	11	0	0	0
6037291130	Los Angeles	96-100%	3582	95%	3582	100%	3410	95%	11	11	0	0	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6037208610	Los Angeles	86-90%	4195	96%	4195	100%	4036	96%	10	10	0	0	0
6037218800	Los Angeles	81-85%	2658	97%	2658	100%	2586	97%	8	8	0	0	0
6037980015	Los Angeles	81-85%	554	80%	503	91%	404	73%	7	7	0	0	0
6037550100	Los Angeles	91-95%	7518	89%	7518	100%	6653	88%	5	5	0	0	0
6037543305	Los Angeles	96-100%	2666	73%	2402	90%	1756	66%	5	5	0	0	0
6037540901	Los Angeles	96-100%	4994	98%	4994	100%	4904	98%	5	5	0	0	0
6037208720	Los Angeles	81-85%	4179	95%	4179	100%	3970	95%	4	4	0	0	0
6037503000	Los Angeles	86-90%	6057	95%	6057	100%	5724	95%	4	4	0	0	0
6037502801	Los Angeles	86-90%	6186	82%	6186	100%	5097	82%	4	4	0	0	0
6037208801	Los Angeles	91-95%	2995	93%	2995	100%	2791	93%	4	4	0	0	0
6037602802	Los Angeles	81-85%	4304	99%	4304	100%	4239	99%	3	3	0	0	0
6037553504	Los Angeles	81-85%	5368	96%	5368	100%	5159	96%	3	3	0	0	0
6037433802	Los Angeles	86-90%	2780	96%	2780	100%	2655	96%	3	3	0	0	0
6037294610	Los Angeles	91-95%	4065	96%	4065	100%	3898	96%	3	3	0	0	0
6037603900	Los Angeles	91-95%	7527	83%	7527	100%	6217	83%	3	3	0	0	0
6037291120	Los Angeles	96-100%	2210	98%	2210	100%	2168	98%	3	3	0	0	0
6037201402	Los Angeles	96-100%	4311	96%	4311	100%	4151	96%	3	3	0	0	0
6037550201	Los Angeles	81-85%	2941	90%	2941	100%	2659	90%	2	2	0	0	0
6037541100	Los Angeles	91-95%	3321	99%	3321	100%	3294	99%	2	2	0	0	0
6037602801	Los Angeles	91-95%	3819	99%	3819	100%	3777	99%	2	2	0	0	0
6037203500	Los Angeles	96-100%	3064	98%	3064	100%	2990	98%	2	2	0	0	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6037532304	Los Angeles	96-100%	3987	94%	3597	90%	3385	85%	2	2	0	0	0
6037185202	Los Angeles	81-85%	3712	76%	3712	100%	2825	76%	1	1	0	0	0
6037502004	Los Angeles	81-85%	4359	92%	4359	100%	4028	92%	1	1	0	0	0
6037603400	Los Angeles	81-85%	4367	87%	4367	100%	3817	87%	1	1	0	0	0
6037554600	Los Angeles	81-85%	4374	83%	4374	100%	3613	83%	1	1	0	0	0
6037573004	Los Angeles	81-85%	5153	92%	5153	100%	4725	92%	1	1	0	0	0
6037551300	Los Angeles	81-85%	5422	82%	5422	100%	4446	82%	1	1	0	0	0
6037541200	Los Angeles	81-85%	5662	99%	5662	100%	5622	99%	1	1	0	0	0
6037550700	Los Angeles	81-85%	6921	79%	6921	100%	5481	79%	1	1	0	0	0
6037550800	Los Angeles	81-85%	7170	76%	7170	100%	5471	76%	1	1	0	0	0
6037543602	Los Angeles	81-85%	7762	79%	7762	100%	6148	79%	1	1	0	0	0
6037124103	Los Angeles	86-90%	2030	82%	2030	100%	1659	82%	1	1	0	0	0
6037503104	Los Angeles	86-90%	2719	92%	2719	100%	2504	92%	1	1	0	0	0
6037530203	Los Angeles	86-90%	3238	93%	3238	100%	3005	93%	1	1	0	0	0
6037543201	Los Angeles	86-90%	3607	99%	3607	100%	3571	99%	1	1	0	0	0
6037530004	Los Angeles	86-90%	3695	85%	3695	100%	3152	85%	1	1	0	0	0
6037294830	Los Angeles	86-90%	3707	97%	3707	100%	3592	97%	1	1	0	0	0
6037543903	Los Angeles	86-90%	3804	92%	3795	100%	3492	92%	1	1	0	0	0
6037482800	Los Angeles	86-90%	4074	92%	3224	79%	2953	72%	1	1	0	0	0
6037602509	Los Angeles	86-90%	4118	96%	4057	99%	3891	94%	1	1	0	0	0
6037504101	Los Angeles	86-90%	5126	80%	5126	100%	4111	80%	1	1	0	0	0
6037541700	Los Angeles	86-90%	6366	99%	6366	100%	6277	99%	1	1	0	0	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6037604100	Los Angeles	86-90%	7058	84%	7058	100%	5893	84%	1	1	0	0	0
6037550300	Los Angeles	86-90%	7727	84%	7696	100%	6465	84%	1	1	0	0	0
6037403200	Los Angeles	91-95%	391	31%	391	100%	121	31%	1	1	0	0	0
6037207400	Los Angeles	91-95%	1363	79%	1363	100%	1082	79%	1	1	0	0	0
6037220100	Los Angeles	91-95%	2334	96%	2334	100%	2229	95%	1	1	0	0	0
6037241002	Los Angeles	91-95%	3606	99%	3606	100%	3584	99%	1	1	0	0	0
6037242000	Los Angeles	91-95%	3938	99%	3938	100%	3910	99%	1	1	0	0	0
6037500403	Los Angeles	91-95%	4023	95%	4023	100%	3818	95%	1	1	0	0	0
6037543400	Los Angeles	91-95%	4090	94%	2648	65%	2491	61%	1	1	0	0	0
6037534301	Los Angeles	91-95%	4636	97%	4636	100%	4511	97%	1	1	0	0	0
6037402403	Los Angeles	91-95%	5381	79%	4933	92%	3892	72%	1	1	0	0	0
6037203600	Los Angeles	91-95%	5394	99%	5394	100%	5329	99%	1	1	0	0	0
6037500600	Los Angeles	91-95%	5688	97%	5688	100%	5506	97%	1	1	0	0	0
6037502200	Los Angeles	91-95%	6585	90%	6585	100%	5894	89%	1	1	0	0	0
6037203300	Los Angeles	96-100%	2607	91%	2607	100%	2375	91%	1	1	0	0	0
6037534405	Los Angeles	96-100%	4292	98%	4292	100%	4215	98%	1	1	0	0	0
6037543000	Los Angeles	96-100%	4345	100%	4345	100%	4323	100%	1	1	0	0	0
6037553702	Los Angeles	96-100%	4902	98%	4902	100%	4814	98%	1	1	0	0	0
6037573201	Los Angeles	96-100%	4930	95%	4930	100%	4703	95%	1	1	0	0	0
6037482402	Los Angeles	96-100%	6971	95%	6280	90%	5991	86%	1	1	0	0	0
6037402402	Los Angeles	96-100%	7076	85%	2633	37%	2246	32%	1	1	0	0	0
6039000400	Madera	81-85%	1288	68%	204	16%	139	11%	29	25	4	0	0

Table 2: Census tracts that fall into the top 20% of Census tracts most vulnerable to health impacts from multiple environmental stressors as measured by CalEnviroScreen 2.0 and which have one or more oil & gas wells within their boundaries (cont'd.)

Census tract	County (alphabetically)	CalEnviroScreen 2.0 Total Score (highest percentile = worst)	Total Population	Percent Non-White	Population within 1 mile of oil and gas well	Population within 1 mile of oil and gas well (% of total)	Non-White Population within 1 mile of oil and gas well	Non-White Population within 1 mile of oil and gas well (% of total pop.)	Total Wells	Active oil and gas wells	New oil and gas wells	Stimulated Wells	Wells with SB4 notifications
6047000201	Merced	91-95%	3626	64%	246	7%	158	4%	1	1	0	0	0
6059086407	Orange	81-85%	6488	70%	5398	83%	3762	58%	5	5	0	0	0
6059011721	Orange	81-85%	5023	81%	5023	100%	4064	81%	1	1	0	0	0
6059011722	Orange	86-90%	2363	50%	2363	100%	1179	50%	1	1	0	0	0
6059099601	Orange	86-90%	7016	82%	6116	87%	5003	71%	1	1	0	0	0
6059011720	Orange	91-95%	7329	96%	6620	90%	6322	86%	1	1	0	0	0
6059110500	Orange	91-95%	8631	87%	6914	80%	5980	69%	1	1	0	0	0
6065041500	Riverside	96-100%	2053	93%	1230	60%	1141	56%	4	4	0	0	0
6065041909	Riverside	81-85%	4990	58%	1433	29%	828	17%	1	1	0	0	0
6065040808	Riverside	81-85%	7008	72%	6064	87%	4384	63%	1	1	0	0	0
6071012400	San Bernardino	96-100%	3617	91%	1391	38%	1267	35%	1	1	0	0	0
6071004004	San Bernardino	96-100%	5076	79%	1571	31%	1247	25%	1	1	0	0	0
6071001600	San Bernardino	96-100%	6133	94%	1664	27%	1567	26%	1	1	0	0	0
6073013205	San Diego	86-90%	2381	92%	2381	100%	2188	92%	1	1	0	0	0
6077003900	San Joaquin	96-100%	1749	74%	225	13%	167	10%	56	56	0	0	0
6077003803	San Joaquin	96-100%	5281	74%	2036	39%	1500	28%	23	23	0	0	0
6077004001	San Joaquin	91-95%	2508	61%	610	24%	370	15%	16	14	2	0	0
6077004902	San Joaquin	81-85%	6106	36%	351	6%	125	2%	2	2	0	0	0
6095253500	Solano	81-85%	8423	30%	2621	31%	786	9%	202	201	1	0	0
6107003400	Tulare	96-100%	7016	66%	1160	17%	764	11%	84	81	3	0	0
6107004300	Tulare	96-100%	7682	94%	501	7%	469	6%	13	13	0	0	0
6107004500	Tulare	81-85%	6628	76%	255	4%	194	3%	4	4	0	0	0
6111004704	Ventura	81-85%	1469	86%	972	66%	839	57%	50	49	1	3	0
6111004902	Ventura	96-100%	5091	99%	3887	76%	3829	75%	37	30	7	1	0
6113010102	Yolo	86-90%	7702	56%	1062	14%	592	8%	1	1	0	0	0

Data sources: DOGGR "AllWells" database (as of 7/14/2014). DOGGR SB4 Well Stimulation Notices database (as of July 2014). The total number of active and new oil and gas wells is the sum of active wells and new wells. Stimulated wells include wells with SB4 notifications.