Title: Quantifying the intersecting threats of wildfire and oil and gas development in the western United States

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Abstract

The recent increases in wildfire activity in the western United States has coincided with the proliferation of oil and gas development and substantial population growth in the wildland-urban interface. Drilling and operating oil and gas wells is already associated with emissions of harmful pollutants and higher risks of adverse health outcomes for nearby residents. Perturbation from climate-driven disasters such as wildfire could exacerbate these risks and introduce new hazards. Here, we examined historical threats of wildfires for oil and gas wells, the extent to which wildfires are projected to threaten wells as climate change progresses, and exposure of human populations to these wells. Between 1984 and 2019, we found that 102,882 oil and gas wells were located in wildfire burn areas and cumulatively 348,853 people were exposed (resided ≤ 1 km from these wells). During this period, we observed a five-fold increase in the number of wells in wildfire burn areas and a doubling of the population exposed. Approximately 2.9 million people currently reside within 1 km of the 118,409 wells in high wildfire risk areas, with disproportionately high exposure for communities of color. These trends are projected to worsen, with 87,261 additional wells projected to be in high wildfire risk areas by late century. Policymakers have an opportunity to proactively address expected wildfire impacts on oil and gas development and nearby communities by prioritizing wildfire-threatened wells for retirement, monitoring wells for leaks of flammable gases, and restricting drilling in areas projected to have high future wildfire risk.

Significance Statement

Wildfires are increasingly impacting regions of the United States where most oil and gas production takes place. People living near oil and gas wells are already exposed to harmful concentrations of pollutants, and wildfires may worsen these exposures and lead to additional hazards. In this study, we looked at the scope of wildfire impacts on oil and gas wells and nearby populations. Between 1984 and 2019, we observed a five-fold increase in the number of wells in wildfire burn areas and a doubling of the population living near these wells, with disproportionate impacts for communities of color. We projected that climate change will exacerbate these threats. Proactive interventions now may reduce future threats as climate change continues.

Introduction

The extent and intensity of wildfires have worsened in recent years across the United States (U.S.) and are expected to continue worsening as climate change intensifies (1–3). Substantial areas of the western U.S. have particularly high wildfire risk due to conditions including extreme temperature and drought, which contribute to the aridity of trees and other vegetation that can fuel wildfires (1, 3, 4). Since 2014, the U.S. has been the top global producer of crude oil and natural gas (5), with most production concentrated in western states (6, 7). Drilling is ongoing, and the Inflation Reduction Act of 2022 ties renewable energy rights-of-way on federal land to new oil and gas lease auctions (8). The impact of emerging climate-related hazards, including wildfire, on existing and future infrastructure is of relevance to diverse stakeholders, including nearby residents and land management authorities in tribal, local, state, and federal government.

The recent proliferation of U.S. oil and gas development has coincided with rising wildfire risks, as well as significant population growth in the wildland-urban interface (2, 9). Between 2010 and 2019, approximately 215,000 new wells were sited in the western US., accounting for 12.9% of all wells drilled at any time. However, it is unclear to what extent wildfires threaten oil and gas development, whether and to what degree human populations are at risk of exposure to these wells, and whether climate change will exacerbate these risks. There is already widespread exposure to oil and gas wells in the U.S., with 17.6 million people (5.4% of the population) residing within 1.6 km (1 mile) of active wells (14). There is even broader exposure to inactive wells (10), a subset of which emit methane and other flammable gases (11–13). A comprehensive assessment of wildfire risks for oil and gas development in a changing climate is a necessary step in designing interventions to proactively mitigate associated public health hazards.

Wildfires in the wildland-urban interface have destroyed and damaged residences and public works (14), polluted the air (15), and increased emergency room visits (16). Wildfires can also trigger secondary technological disasters (natechs), such as when extreme heat from wildfires results in contamination of drinking water supplies with carcinogenic compounds (e.g., benzene) (17, 18). Natech events may heighten risks to human health and the environment beyond those associated with natural disasters alone (18–20). Even in the absence of wildfire or other natech threats, drilling and operating wells has resulted in emissions of air pollutants (21–24) and contamination of ground and surface water (23, 25). There is mounting evidence that living near oil and gas wells is associated with increased risk of adverse cardiovascular, respiratory, perinatal, and mental health outcomes (26–37). Fires at oil and gas wells, unrelated to wildfire, have presented additional hazards such as high levels of radiant heat, explosions, and emissions of air toxics (38, 39).

Here, we examine the past and future hazards of wildfire in areas with oil and gas wells in the western U.S. First, we retrospectively determined to what extent wildfires have already occurred in areas with oil and gas wells and assessed population exposures. We then used data on projected wildfire risks to determine to what extent existing oil and gas wells will be threatened as climate change worsens. Our analysis shows that wildfires have already burned through areas with tens of thousands of oil and gas wells, including wells near residences, with disproportionate impacts for persistently marginalized groups. This trend has worsened in recent years and will likely continue through the end of the century as climate change progresses.

Our study had three overarching objectives. First, we examined trends in the number of oil and gas wells located in wildfire burn areas in the western U.S. from 1984–2019. Second, we estimated how many people were exposed to wells located in historical wildfire burn areas and how many people currently reside near wells with high wildfire risk. We also determined whether there are racial/ethnic disparities in exposure to wildfire-threatened wells. Third, we examined trends in the number of wells in areas projected to have high wildfire risk through the end of the century.

We assembled geospatial data on oil and gas wells, historical wildfires, projected wildfire risk, and population density for the 19 states west of the Mississippi River that had at least one oil or gas well. We obtained well data from Enverus, a private data aggregation service, for all active or inactive oil and gas wells. We obtained data on the extent of historical wildfires from two sources: Monitoring Trends in Burn Severity (MTBS) and the National Interagency Fire Center (NIFC). To estimate overall and race/ethnicity-specific populations exposed to wells in wildfire burn areas, we used high-resolution gridded population data from SocScape (40, 41). To determine which areas had high historical or future wildfire risk, we used a dataset with the Keetch-Byram Drought Index (KBDI) calculated for the historical period 1996–2004, as well as projected KBDI in mid-century (2046–2054) and late century (2086–2094) (4). We used two KBDI thresholds to consider historical and future wildfire risk: KBDI $\geq$ 600 indicating high wildfire risk (4); and KBDI $\geq$ 450 indicating moderately high risk, a more conservative threshold used by some government agencies (42).

We first identified oil and gas wells located within historical wildfire burn areas in the western U.S. for each state and year (Figure 1). Next, we determined how many people were exposed, which we defined as residing within 1 km of these wells. Prior studies have consistently found that residing within 1 km of oil and gas wells is associated with worse air quality and higher health risks (22, 43–47). To assess temporal trends both for the number of wells in wildfire burn areas and the population exposed to these wells, we fit ordinary least squares (OLS) regression models with and without adjustment for state. Finally, we assessed how many people reside within 1 km of wells in areas with high historical and projected future wildfire risk. Because past studies indicate racially marginalized people have disproportionately high exposure to oil and gas wells (10, 48), we investigated whether there were racial/ethnic disparities in exposures to wildfire-threatened wells. To do so, we estimated group risk ratios (RR), where $RR > 1$ indicates disproportionately high exposure and $RR < 1$ indicates disproportionately low exposure.

Results

Cumulatively, between 1984 and 2019 wildfires burned areas containing 102,882 oil and gas wells (Figure 2). Most of these wells were in Oklahoma ($n = 39{,}352$), Texas ($n = 32{,}426$), and California ($n = 17{,}143$). Across the study region, the annual mean ± standard deviation (SD) of wells in wildfire burn areas was 2,858 ± 4,012 (median: 779), with a peak of 18,047 in 2011 (Table S1). The number of wells in burn areas increased five-fold over our study period ($p < 0.001$) (Figure 2), from an annual average of 1,065 ± 161 in 1984–1993 to 5,098 ± 1,054 in 2010–2019. We observed significant increasing trends in Oklahoma and Texas, though there were fluctuations throughout the study period (Figure S1). There was not a significant time trend in California, where there were several years with a relatively high number of wells in wildfire burn areas throughout the study period. We identified 3,341 individual wildfires that had at least one well in the burn area. Some wildfires were particularly impactful, including 15 wildfires with over 1,000 wells in the burn area. For example, the 2006 East Amarillo Complex Fire in Texas burned an area containing 3,845 oil and gas wells (Figure S2).

In 1996–2004, 118,409 oil and gas wells were in high (KDBI ≥ 600) wildfire risk areas (Figure 2), of which 103,878 (87.7%) were in California and 9,753 (8.2%) in Texas (Table 1). By late century (2086–94), we project that 205,670 wells will be in high wildfire risk areas, an increase of 73.7% from 1996–2004, of which over half (n = 109,801, 53.3%) are in California and 76,320 (37.2%) are in Texas. Wildfire threats for wells were consistently high in counties in southern California counties such as Los Angeles, whereas there were substantial increases in the number of wildfire-threatened wells in other regions (Table S3). For example, currently there are no wells in Uintah County, Utah, in areas with KBDI ≥ 600, but we estimate that by late century 12,790 will be in areas with KBDI ≥ 600. In Dimmit County, Texas, we estimate a seven-fold increase in wildfire-threatened wells, from 631 wells in 1996–2004 to 4,784 in 2086–2094. We estimated that 25,828 of the 166,106 (15.5%) wells on federal land were in areas with high wildfire risk by late century (2086–2094), a 29.8% increase from historical (1996–2004) risks (Table S4).

When we considered areas with moderately high wildfire risk (KBDI ≥ 450), we identified 551,676 wells historically threatened (1996–2004), increasing by 116.3% to 1,193,386 wells by late century (Table 1). Most of these wells are in Texas, Oklahoma, California, and Louisiana. Again, the threats were consistently high in counties in southern California, and there were also substantial increases in the number of wildfire-threatened wells in other regions. For example, we observed a 252% increase in wildfire-threatened wells in Eddy County, New Mexico (7,808 wells in 1996–2004 to 27,509 in 2086–2094) and a 1,351% increase in Lea County, New Mexico (1,879 wells in 1996–2004 to 27,269 in 2086–2094) (Table S5). By late century, 90,737 (54.6%) of wells on federal land are projected to be in areas with KBDI ≥ 450, an 82.8% increase from 1996–2004 (Table S6).

Between 1984 and 2019, cumulatively 348,853 people resided within 1 km of oil and gas wells located in wildfire burn areas (Table S7). Most exposed people lived in California (n = 252,644, 72.4%), Oklahoma (n = 60,542, 17.4%), and Texas (n = 22,734, 6.5%) (Table S7). Across all 19 states from 1984–2019, the annual average count of people living near wells in burn areas was 9,690 ± 10,507 (median: 8,521), peaking at 51,452 in 2008 (Figure 2). The annual average count of people exposed to wells in wildfire burn areas increased from 6,927 ± 1,483 in 1984–1993 to 13,380 ± 3,440 in 2010–2019. Oklahoma, Kansas, California, and Texas saw the steepest increases in the number of people exposed to wells in burn areas (Figure S3).

We estimated that 10,618,601 people live within 1 km of wells with moderately high wildfire risk areas (KBDI ≥ 450 in 1996–2004), with disproportionately high exposure among Asian, Black, and Hispanic people (Figure S4, Table S9). In Arkansas, Colorado, Louisiana, New Mexico, Oklahoma, and Utah, American Indian/Alaska Native people had disproportionately high exposure. In Utah, the representation of Native American/Alaska Native people residing within 1 km of wildfire-threatened wells was approximately 22 times the representation of this group across the state, the widest disparity we observed. Of the 31,400 wells in Utah, 22,599 (72.0%) are in the Uintah and Ouray Reservation of the Ute Tribe and 1,091 (3.5%) are in the Navajo Nation. When we used a more stringent threshold for historically high wildfire risk (KBDI ≥ 600), we estimated that 2,915,457 people live ≤ 1 km of wildfire-threatened wells, with 2,597,330 in California and 303,569 in Texas (Table S8). In both states, Hispanic people disproportionately lived near wells in high wildfire risk areas, with RRs of 1.23 for Hispanic people in California and 2.27 in Texas (Table S10). All other racial/ethnic groups had disproportionately low exposure in these two states (Figure S4). Aggregated across all states, Hispanic and non-Hispanic Asian people were also more likely to live near wells in high wildfire risk areas (Table S10).

Discussion

From 1984 to 2019, we observed a five-fold increase in the number of oil and gas wells in wildfire burn areas, with varying temporal trends by state. As climate change worsens, we project that by the end of the century the number of wells in high wildfire risk areas will increase to over 200,000, a 53.9% increase from the present day. Furthermore, we project that approximately 1 million additional wells will be in areas with moderately high risk of wildfire by late century, over twice the number of wells historically threatened by wildfire. Approximately 350,000 people have already been exposed to wells in historical wildfire burn areas. As wildfire risk expands to new locations in the coming decades, wildfires in urban or peri-urban oil fields could pose a hazard for many more residents. Indeed, we estimated that approximately 2.9 million people in the study region live within 1 km of wells in areas with high historical wildfire risk, and approximately 10.6 million people live near wells with moderately high wildfire risk. The greatest concentrations of populations living near wildfire-threatened wells, both in historical and projected future assessments, were in California and Texas. The public health implications of population exposures to wildfire-damaged wells remain unclear, and further work is needed to elucidate potential acute and chronic human health effects.

There are already well-known hazards associated with fires (unrelated to wildfire) in areas with both active and inactive wells, particularly in densely populated areas. Blowout and ignition near gas wells has resulted in radiant heat strong enough to cause second-degree burns within several hundred feet of wells (38). These hazards may be exacerbated by the broad scale of wildfires, some of which have encompassed thousands of wells at a time. Wildfire damage to oil and gas wells may also increase emissions of pollutants from the wells, with implications for sensitive cultural sites, the health of humans and non-human animals, and ecosystem functioning.

We found that Asian, Black, Hispanic, and Native American people had disproportionately high exposure to wells at risk of wildfire. Prior research has already identified environmental justice concerns related to oil and gas wells and, separately, wildfires. Studies of California, Texas, and Colorado have found that racially and socioeconomically marginalized people are more likely to live near oil and gas development compared to their white and more privileged counterparts (10, 48–51). One prior study has investigated climate-related risks and population exposures to hazardous facilities including oil and gas wells, finding that racially and socioeconomically marginalized people had disproportionately high exposure to hazardous sites threatened by sea level rise in California (52). There is some evidence that Native American, Black, and Hispanic/Latinx people are more likely to live in communities that are the most vulnerable to wildfire (53, 54). A 2021 study found that Indigenous people in North America are more likely to live in wildfire-prone areas due to forced migration and land dispossession (55). Racially and socioeconomically marginalized communities may experience disproportionate wildfire impacts due to structural factors that reduce their capacity to undertake wildfire mitigation measures, such as hazardous fuels reductions (56).

To our knowledge, this is the first study to investigate historical and projected future wildfire threats to oil and gas infrastructure across the U.S. Notably, a 2018 report from FracTracker Alliance found that approximately 10,000 wells in 160 California oil fields were impacted by wildfire between 1998 and 2018, which highlighted the need for further research as undertaken here (57). In the current study, we leveraged 36 years of historical observations and climate projections spanning a century, the widest available timespan for which reliable wildfire data were available nationwide.

There are several limitations to our study. For historical and projected future fires, the dataset we used did not contain variables that affect wildfire intensity, such as ecological characteristics or atmospheric conditions including humidity and wind speed. Consideration of fire intensity in future work could be informative for understanding and predicting natech risks. Our projections of future wildfire risks were based on current population and demographic data and we did not model future demographic shifts. However, if the trends of recent decades continue (2, 9), we can expect the number of people living within the wildland-urban interface to grow. Finally, we only assessed wildfire threats for wells that were drilled prior to 2020. New wells are drilled each year, and thus our estimates of the number of wells threatened by wildfire and the populations likely affected are conservative.

Future research, including air quality modeling, could better characterize the exposure and health implications of wildfires that burn oil and gas wells, understand how wildfires in oil and gas fields affect non-human animals and disrupt ecosystem functioning, and assess to what extent wildfire-related shocks disrupt oil and gas production. As government agencies concurrently undertake efforts to retire existing wells and permit new wells, decision-makers and regulatory scientists should consider population risks associated with wildfires. This is particularly important in those states where we observed the greatest historical and projected future risks of wildfire overlap with wells and human populations. Interventions could include limiting or eliminating drilling in high wildfire risk areas, creating setbacks between wells and sensitive receptors (e.g., residences, schools, medical facilities), and utilizing technological controls including proper well plugging and monitoring for leaks of flammable gases (58). Evacuation has already been necessary in cases where industrial fires have occurred at oil and gas wells (38), and the broad scale of wildfires could complicate disaster response efforts.

We found that from 1984–2019 the number of wells in wildfire burn areas increased five-fold, with wildfire threats projected to worsen by the end of the century. The intersection of wildfires in areas with oil and gas wells represents a pernicious feedback loop. The production and consumption of fossil fuels is the primary driver of climate change (59), with associated rising global temperatures increasing the frequency and intensity of wildfires (1–3). Greenhouse gas emissions from major carbon producers may be responsible for 37% of the area burned by wildfires in the western U.S. and southern Canada (60). Wildfire damage to oil and gas infrastructure contributes, in turn, to fugitive greenhouse gas emissions, further exacerbating climate change. Given ongoing oil and gas leasing and population growth in the wildland-urban interface (9), public health hazards associated with wildfire-damaged wells are becoming increasingly likely as climate change worsens. Future climate and energy policy—at local, state, and federal levels—should account for co-occurrent risks to human health.

Materials and Methods

Study region

The study region comprised 19 oil and gas-producing states west of the Mississippi River, spanning from Washington and California in the west to Missouri and Louisiana in the east, and including Alaska. We excluded Hawaii, Idaho, Iowa, Minnesota, and Washington, as none of these states had oil and gas wells. The 19 states in the study region were the most productive for crude oil in the country and included all states that produced at least 10 million barrels in 2021 (61).

Data

We assembled geospatial data on oil and gas wells, historical wildfires, and projected wildfire risk for the 19 western states with at least one oil or gas well. We obtained data on the extent of wildfires from two sources: Monitoring Trends in Burn Severity (MTBS) and the National Interagency Fire Center (NIFC). The MTBS dataset comprises wildfire data from multiple state and federal agencies: the Alaska Interagency Fire Center, California Department of Forestry and Fire Protection (CalFire), Bureau of Indian Affairs, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service. The NIFC dataset included wildfires that were up to 1,000 acres in size. The final dataset comprised all reported wildfires in the western U.S. between 1984 and 2019 that were reported to these agencies and made publicly available. For wildfires that were represented in both datasets, we removed the duplicates so that each wildfire only appeared once in our analytic dataset.

The wildfires dataset used in the current study included 65,971 individual wildfires encompassing 725,814 km^2 of burn area between 1984 and 2019 (Figure 1a). Among individual wildfires, there is substantial variation in burn area, with a mean $\pm$ standard deviation of 10.8 $\pm$ 64.0 km^2 (median: 0.45; range: 0.001, 3,240.4). For this reason, in primary analyses we focused on the aggregate burn areas for each state and year, rather than assessments for individual wildfires. In a secondary analysis, we assessed how many wells were burned in each individual wildfire, with the aim of identifying wildfire events with the greatest impact.

We obtained data on the locations of properties of oil and gas wells from Enverus DrillingInfo, a private data aggregation service, for all oil and/or gas wells drilled on or before December 31, 2019. To examine the timing of well siting, we used the following operational date variables: spud date, completion date, first production date, and last production date. Given missingness in some of these date observations for some wells, we used the earliest available date to determine whether a well had been sited prior to the wildfire. For the primary analyses, we assumed that these wells without any reported operational dates were sited before 1984 due to poor record-keeping practices at the onset of oil and gas development. Most wells (89.1%) had operation dates. The dataset used in our analyses included 1,671,699 oil and gas wells sited in the study region (Figure 1a).

Assessment of wells in historical wildfires

We determined how many wells were in wildfire burn areas for all historical wildfires in our dataset. We spatially aggregated all wildfire burned areas in each state and year, because some wildfires cross state boundaries and, in primary analyses, we were not focused on results for individual wildfires.

Next, we determined how many oil and gas wells spatially intersected these aggregated state-year wildfire burn areas, including wells where the earliest operation date occurred before the wildfire year or was missing (and assumed to predate the study period). In a secondary assessment, we determined how many wells were located in each individual wildfire. To determine whether there were time trends with respect to increasing numbers of wells in wildfire burn areas, we fit ordinary least squares (OLS) regression models, both unadjusted and adjusted for state. We fit separate models by state to examine differences in time trends.

Assessment of wells in areas with high wildfire risk

To determine which areas had high historical or future wildfire risk, we used a dataset with the Keetch-Byram Drought Index (KBDI) calculated for 1996–2004 (historical), as well as projected KBDI in 2046–2054 (mid-century) and 2086–2094 (late century) (4). The KBDI is a fire index that calculated from daily maximum temperature, daily precipitation, and annual accumulated precipitation, accounting for vegetation moisture content and the potential for wildfire to spread after ignition (4, 62). The index ranges from 0 (indicating complete soil saturation and no wildfire risk) to 800 (indicating extreme wildfire risk) (62). For the projected future wildfire risk, Brown and colleagues calculated KBDI under representative concentration pathway (RCP) 8.5, a climate scenario which assumes relatively little mitigation of greenhouse gas emissions (4, 63). The historical KBDI values were available at a spatial resolution of 4 x 4 km, and projected mid-century (2046–2054) and late-century projections (2086–2094) KBDI values were available at a resolution of 12 x 12 km spatial resolution. In our assessments of wildfire risk in areas with oil and gas wells, we used two thresholds to consider historical and future wildfire risk: KBDI $\geq$ 600 indicating high wildfire risk, and KBDI $\geq$ 450 indicating moderately high risk. At KBDI values of 600 or greater, wildfires are difficult or, at 750 or greater, impossible to control (4). Some government agencies in the U.S. use KBDI $\geq$ 450 as a more conservative threshold to consider wildfire risks (42). To estimate projected risks, we assigned the maximum KBDI in any season (spring, summer, fall) for each well and time period (historical, mid-century, late century). For each KBDI threshold and time period, we determined which areas had moderately high (KBDI $\geq$ 450) or high wildfire risk (KBDI $\geq$ 600) in any season. Then we determined how many wells intersected with the high wildfire risk areas in each of the three time periods.

Assessing population exposures

We obtained gridded population data from SocScape-30 (40, 41). The dataset comprises estimates of the number of residents in each 30 x 30 m pixel across the U.S. and is derived from decennial census estimates using dasymetric methods. For the current study, we used gridded 1990 population data for the period 1984–1994, 2000 population data for 1995–2004, 2010 population data for 2005–2014, and 2020 population data for 2015–2019. To determine risk ratios for racial/ethnic groups exposed to high wildfire risk wells, we used the "Racial grids" product, which provides the same gridded population estimates for 2020 disaggregated into the following racial/ethnic groups: Hispanic and non-Hispanic Asian, Black, Native American/Alaska Native, Pacific Islander, other, and White.

For each state and year, we determined which wells sited prior to the wildfire year were located in wildfire burn areas. Next, using the gridded population data, we determined how many people resided within 1 km of these wells in each state and year. Prior studies have consistently found that residing within 1 km of oil and gas wells is associated with higher health risks (22, 43–47), and this is less than the distance of 2.4 km from densely vegetated areas typically used to identify residents of the wildland-urban interface (9).

To investigate whether there were racial/ethnic disparities in exposures to high wildfire risk wells, we did a similar procedure as described above, but for wells in areas where KBDI was estimated to historically be ≥ 450 or ≥ 600. Using SocScape-30 data for 2020, we determined how many people resided within 1 km of these wells, for all residents and for residents disaggregated by race/ethnicity. Next, to determine whether there were racial/ethnic disparities in exposures to these wells, we calculated a group risk ratio for each racial/ethnic group as described previously (10). We used the following formula:

$$RR = \frac{\frac{\sum Group_{exposed}}{\sum Group_{total}}}{\frac{\sum Population_{exposed}}{\sum Population_{total}}},$$

which is the ratio of the proportion of a sub-population of interest who were exposed to the proportion of the total population who were exposed. An RR greater than 1 indicates that the sub-population had disproportionately high exposure and an RR of less than 1 indicates disproportionately low exposure. We did this in aggregate for the entire study region and separately for each state with ≥ 10,000 exposed individuals.

Given the wide disparity we observed for Native American or Alaska Native people living in Utah for exposure to wells threatened by wildfire, we conducted a secondary analysis to determine how many wells were located on land managed by state or federally recognized tribes. To do this, we utilized the American Indian/Alaska Native/Native Hawaiian Area National Shapefile available from the U.S. Census Bureau (64).

Assessment of wells threatened by wildfire on federal land

To determine which wells were on federal land, we used a geospatial dataset from the National Atlas of the United States datasets include units with a minimum area of 640 acres that are owned or administered by the Bureau of Land Management, Bureau of Reclamation, Department of Defense, Department of Justice, Fish and Wildlife Service, National Park Service (65).

Data, Materials, and Software Availability. All publicly available data are available through Dryad (temporary link: https://datadryad.org/stash/share/AiCy6UXwqaHutn0egT8ldRkqMNjo2EeWvazIUR7xuOY) and reproducible code are available through Zenodo (https://doi.org/10.5281/zenodo.8222874). Several datasets we utilized are not publicly available but may be available upon request for research purposes, including data from Enverus DrillingInfo and the gridded historical and projected future KBDI estimates from Brown et al. (2021).

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Figure Legends

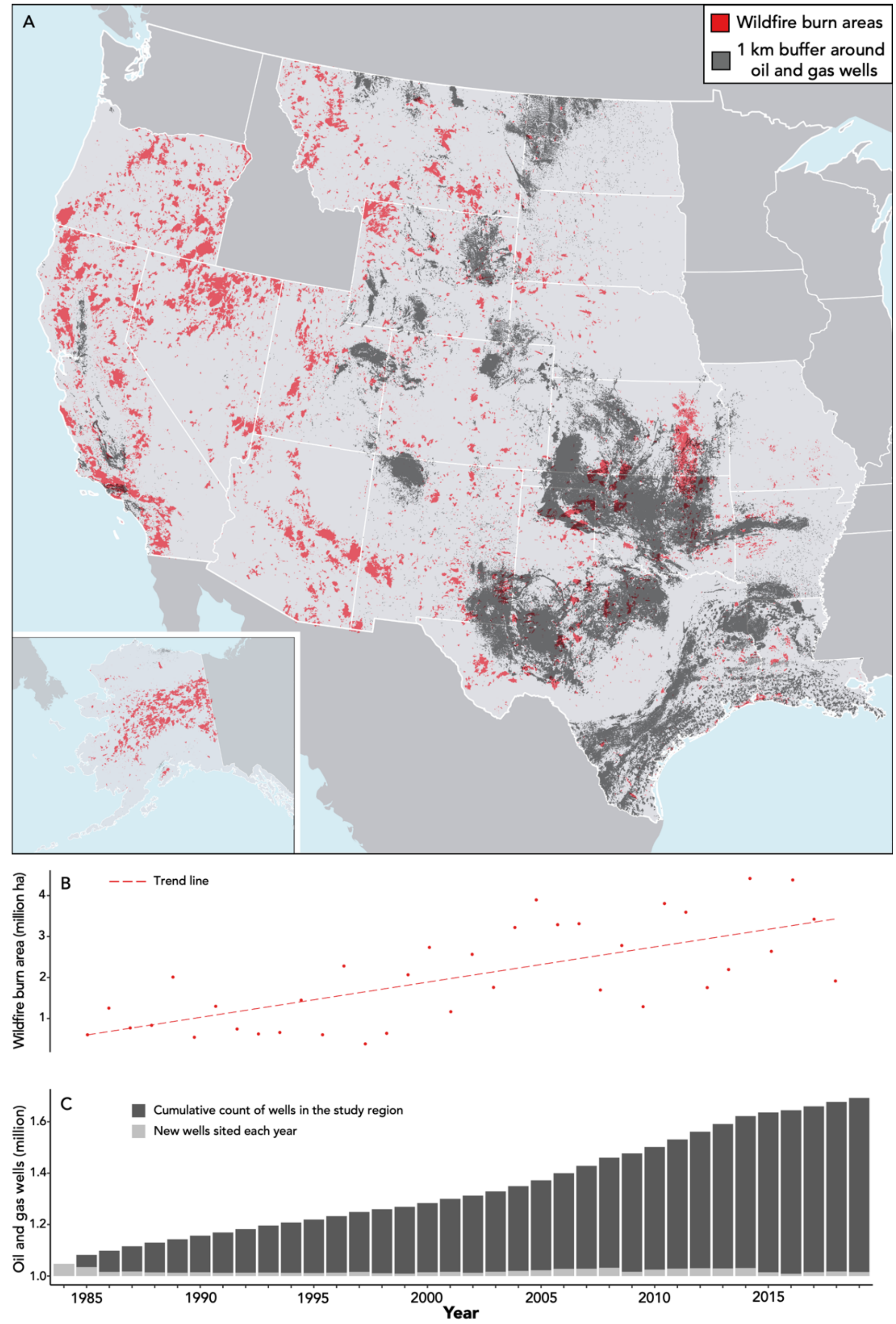

Figure 1. (a) Map of study area showing extent of wildfires that burned during the study period and 1 km buffers around all oil and gas wells drilled during or prior to the study period, 1984–2019. (b) Total area burned by wildfires in the study region by year with trend line. (c) Cumulative number of oil and gas wells in the study region by year (including both active and inactive wells) and, in lighter gray, the number of new wells sited each year.

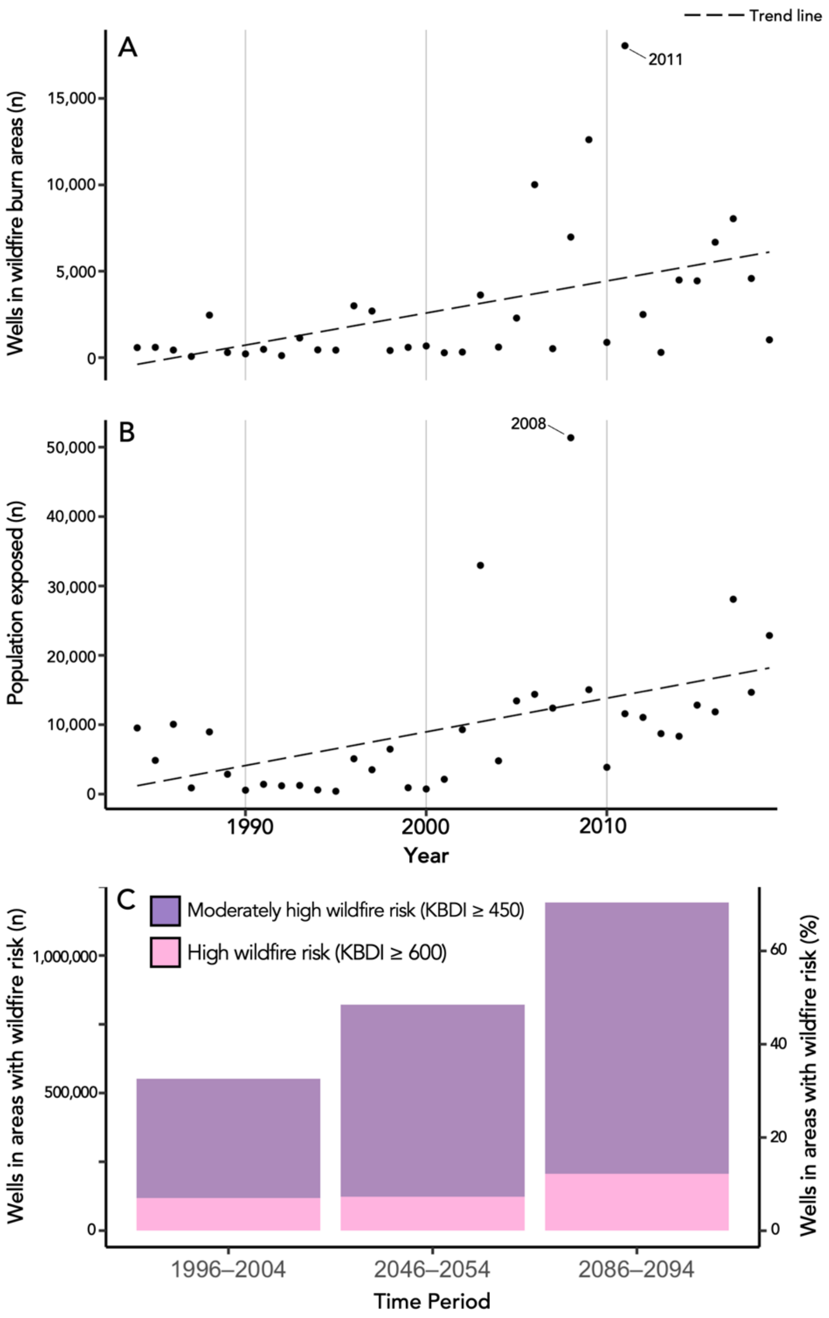

Figure 2. Results from the (a, b) retrospective and (c) projected analyses investigating risks associated with wildfire in areas with oil and gas wells. (a) The count of oil and gas wells in wildfire burn areas by year with trend line. Each point represents the total number of wells located in wildfire burn areas across the study region each year. (b) Estimated population exposed to wells in wildfire burn areas, with trend line. Each point represents the total population living within 1 km of oil and gas wells located in wildfire burn areas across the study region each year. (c) Estimates for the number of wells (and, on righthand y-axis, percent of all oil and gas wells) in areas projected to have moderately high wildfire risk (KBDI ≥ 450) or high (KBDI ≥ 600) wildfire risk historically (1996–2004), in mid-century (2046–2054), and in late century (2086–2094).

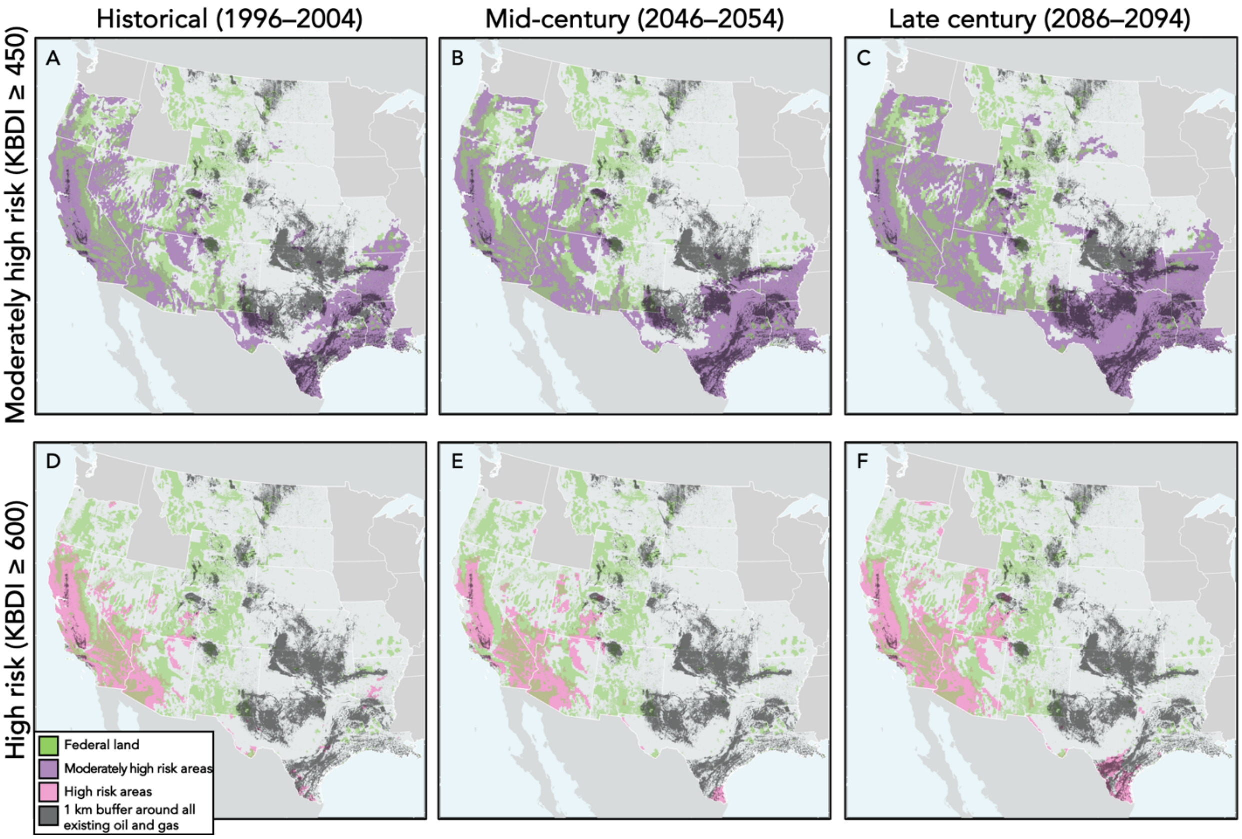

Figure 3. In the western U.S., these are the locations of oil and gas wells that were sited before 2020, areas subject to wildfire risk, and the extent of federally managed land. We assessed how many wells are in areas with moderately high wildfire risk, which we defined maximum estimated seasonal KBDI ≥ 450 (A–C), as well as areas with high risk, defined as maximum estimated seasonal KBDI ≥ 600 (D–F). We considered wildfire risk in three time periods: historical (1996–2004, left column), mid-century (2046–2054, middle) and late century (2086–2094, right). States included in the study region are shown in light gray.

Table 1. Count (column %) of wells in areas projected to have moderately high (KDBI ≥ 450) or high (KBDI ≥ 600) wildfire risk historically (1994–2004), in mid-century (2046–2054), and in late century (2086–2094).

	KBDI ≥ 450			KBDI ≥ 600		
State	1996–2004	2046–2054	2086–2094	1996–2004	2046–2054	2086–2094
Arizona	43 (0.0)	53 (0.0)	54 (0.0)	1 (0.0)	1 (0.0)	2 (0.0)
Arkansas	35,652 (6.5)	35,233 (4.3)	44,227 (3.7)	682 (0.6)	0 (0.0)	0 (0.0)
California	128,936 (23.4)	130,628 (15.9)	131,007 (11.0)	103,878 (87.7)	104,338 (85.4)	109,801 (53.4)
Colorado	2,252 (0.4)	1,098 (0.1)	7,763 (0.7)	5 (0.0)	31 (0.0)	51 (0.0)
Kansas	687 (0.1)	98 (0.0)	4,849 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)
Louisiana	72,077 (13.1)	95,718 (11.7)	118,395 (9.9)	2,149 (1.8)	0 (0.0)	0 (0.0)
Missouri	15 (0.0)	4 (0.0)	46 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Montana	0 (0.0)	0 (0.0)	445 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
North Dakota	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Nebraska	2 (0.0)	0 (0.0)	181 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
New Mexico	15,383 (2.8)	52,515 (6.4)	80,898 (6.8)	8 (0.0)	867 (0.7)	876 (0.4)
Nevada	101 (0.0)	116 (0.0)	117 (0.0)	99 (0.1)	58 (0.0)	66 (0.0)
Oklahoma	6,133 (1.1)	36,316 (4.4)	143,491 (12.0)	0 (0.0)	0 (0.0)	0 (0.0)
Oregon	68 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
South Dakota	65 (0.0)	0 (0.0)	165 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Texas	269,936 (48.9)	443,346 (54.0)	631,453 (52.9)	9,753 (8.2)	4,500 (3.7)	76,320 (37.1)
Utah	20,190 (3.7)	23,599 (2.9)	26,569 (2.2)	1,888 (1.6)	12,391 (10.1)	18,554 (9.0)
Wyoming	136 (0.0)	1,830 (0.2)	3,726 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)
All	551,676	820,554	1,193,386	118,409	122,186	205,670