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Costs and Benefits of Decommissioning Orphaned Oil and Gas Wells: Evidence from Six States

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Abstract

In 2021, the US federal government provided billions of dollars to decommission orphaned oil and gas well sites. This program was touted by federal policymakers from both major political parties as a “win-win” for the environmental and economic benefits it would provide. In this analysis, we examine the costs and benefits of that program using data from roughly 2,150 well sites across six states. We estimate the effects of this spending on employment, methane abatement, and property values. On average, decommissioning costs were roughly $67,000 per well site, but with wide variation. Nine sites exceeded $1 million, while five sites reported the lowest costs of just $1,000. Total costs were roughly $145 million, and we estimate benefits on the order of $30 to $40 million, mostly from higher property values. For the small number of wells where methane was measured, decommissioning costs exceeded the social benefits of methane abatement in 75 to 80 percent of cases. Our results should be interpreted with caution because of extensive data limitations and the sensitivity of results to key methodological assumptions. Prioritizing decommissioning for wells with the highest environmental impacts, such as high rates of methane emissions, would easily pass cost–benefit tests in most cases.

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1. Introduction

During times of deep recession, government can improve economic outcomes by paying workers to dig holes, then fill them in again.[1] This argument was one rationale behind a major policy effort enacted in 2021 by the US federal government. But what if the holes had already been dug?

Across the United States, millions of oil and gas wells have been drilled since the industry's inception in 1859. Although the precise number may never be known due to limited record-keeping, credible sources estimate that more than 4 million production wells have been drilled to date, rising to nearly 5 million if additional well types (e.g., injection, storage) are included (Cleveland 2023).

As wells age, their productivity generally declines due to falling subsurface pressure, making them less profitable for operators. Once an oil and gas well reaches the end of its useful life, operators are legally obligated to decommission, or "plug," the wells to prevent pollution and protect ongoing oilfield operations. However, hundreds of thousands of wells that were drilled in the industry's early years were never subject to such requirements, and most existing state regulations do not fully incentivize operators to decommission wells at the end of their useful lives (Mitchell and Casman 2011; Davis 2015; Ho et al. 2018; Government Accountability Office 2019; Armitage et al. 2026).

As a result, hundreds of thousands of wells in the United States sit "orphaned" with no legal owner (Jahan et al. 2025). What's more, millions of additional wells could become orphaned in the future as their productivity declines and if companies discharge their liabilities through bankruptcy proceedings. Like children who lose their parents, orphaned wells become wards of the state, who take on the responsibility and cost of managing and decommissioning wells and their associated infrastructure (e.g., storage tanks, processing equipment).

In 2021, the US Congress passed, and the president signed, the Infrastructure Investment and Jobs Act (IIJA), a major piece of legislation that included, among many other provisions, $4.7 billion (in nominal dollars) for decommissioning orphaned wells. This program, whereby federal funds flowed to state and Tribal governments to contract with local businesses who would plug wells, was described as a "win-win" because it would both reduce pollution risks and create jobs in oil- and gas-producing communities (US Department of the Interior 2024a). In January 2021, President Joe Biden remarked:

> *"We're also going to create more than a quarter million jobs to do things like plug the millions of abandoned oil and gas wells that pose an ongoing threat to the health and safety of our communities."*
>
> (The White House 2021)

1 This idea, derived from the writings of economist John Maynard Keynes, is actually a shorthand of Keynes' writing, which discusses the possibility of filling old bottles with banknotes and burying them in coal mines, to be excavated later by private companies (Keynes 1936).

In statements about the IIJA's orphaned well program, policymakers from both major US political parties emphasized the expected environmental, health, and economic benefits:

> *"These investments are good for our climate, for the health of our communities, and for American workers. With this additional funding, states will put more people to work to clean up these toxic sites, reduce methane emissions and safeguard our environment."*
>
> – Former US Secretary of the Interior Deb Haaland (US Department of the Interior 2023)

> *"This brilliant idea … is a win-win-win for workers, the environment, and North Dakotans. We can use that land to mine what's underneath it for the good of the economy, our national security and our country, and for the good of society."*
>
> – US Senator Kevin Cramer (North Dakota) (Cramer 2023)

In this analysis, we seek to evaluate some of the key environmental and economic outcomes of the program. Although data are limited across a variety of dimensions, they are sufficient to provide at least an early assessment of the costs and benefits of the IIJA's orphaned well program.

1.1. Risks and Opportunities Related to Orphaned Wells

Idle, abandoned, or orphaned oil and gas infrastructure can pose a variety of environmental and health risks. Abandoned wells, as defined by US Environmental Protection Agency (EPA), are those with "no recent production," regardless of whether they have been plugged (EPA 2024). This analysis focuses on orphaned wells, which are the subset of abandoned wells that have no legal owner.

Regardless of their production status, oil and gas wells have the potential to leak methane, a greenhouse gas with a global warming potential 82.5 times greater than carbon dioxide over a 20-year period, and roughly 30 times greater over 100 years (Masson-Delmotte et al. 2021). EPA estimates that in 2022, abandoned wells released 8.5 million metric tons of carbon dioxide equivalent, representing roughly 3 percent of all emissions from US natural gas and petroleum systems (EPA 2024).[2]

However, EPA's estimates come with a wide range of uncertainty, from 83 percent below to 204 percent above the central estimate (Environmental Protection Agency 2024). This uncertainty stems from unknowns about the total number of abandoned

2 This EPA inventory uses a 100-year global warming potential value for methane of 28, derived from the IPCC's Fifth Assessment Report. The most recent 100-year global warming potential for fossil methane, as of the IPCC's Sixth Assessment Report, is 29.8.

wells, limited empirical measurements of methane at well sites, and high variability in emissions rates (Kang et al. 2023; Townsend Small et al. 2016; Gianoutsos et al. 2026). In addition to methane, orphaned and abandoned wells can emit hydrogen sulfide, carbon monoxide, and volatile organic compounds that can have serious health consequences if encountered in sufficient concentrations (El Hachem et al. 2025; El Hachem and Kang 2022; DiGiulio et al. 2023). Leaks of hydrocarbons, produced water, and other substances at the surface also pose environmental and health hazards (Townsend-Small and Hoschouer 2021).

Orphaned and abandoned wells also pose threats to water quality. Kang et al. (2023) estimated 35 percent of documented orphaned wells in the United States are within one kilometer of at least one domestic groundwater well, while Woda et al. (2025) found 55 percent of documented orphaned wells in the United States are located within the primary aquifers used for most human water consumption. Orphaned and abandoned wells can contaminate groundwater sources with methane, oil residues, brines, hydrogen sulfide, and other chemicals, which can then migrate to the surface and, in the case of gases, continue to be emitted via soils surrounding the wells (El Hachem et al. 2025; Woda et al. 2025; Shaheen et al. 2025; Fleming et al. 2021). Wells located near coal mines can also carry acid mine drainage into groundwater aquifers, contaminating them with iron, calcium, magnesium, and sulfates (Hedin et al. 2005). While existing research clearly suggests multiple avenues for wells to impact water supplies, sparse data means these threats are not well understood or quantified (Kang et al. 2023).

In some cases, orphaned wells overlap with suburban and urban settlements (Joyce and Wyoming Public Radio 2016; Miyazaki 2009). In Pennsylvania, for instance, 22 percent of documented abandoned wells are located within 100 meters of a building, and nationally, an estimated 4.6 million people live within one kilometer of at least one documented orphaned well (Kang et al. 2023; DiGiulio et al. 2023). Considering the large number of undocumented orphaned wells, the true number is surely higher.

Proximity to population centers and infrastructure magnifies orphaned and abandoned wells' risks, as gases leaking from these wells can be trapped in indoor environments with little ventilation, increasing the risk of explosions while worsening indoor air quality (El Hachem et al. 2025). Abandoned wells have been linked to explosions in Ontario, Canada, and Pennsylvania, with flammable gases making their way into buildings via water wells (El Hachem et al. 2025; Ensing and Grassa 2021; Pennsylvania Department of Environmental Protection 2009).

1.2. Costs and Benefits of Decommissioning Orphaned Wells

A limited body of research has sought to assess the potential costs and benefits of decommissioning oil and gas infrastructure, with a focus on orphaned or abandoned wells. Decommissioning costs are quite straightforward, consisting of payments to contractors to plug the well, remove equipment, and restore the well site to predrilling conditions. Against these costs, benefits include:

- Reduced human health impacts including from air pollution, water contamination, explosive risks, or trip and fall hazards,
- Reduced environmental damage from soil or water contamination,
- Reduced risk of interference with ongoing oilfield operations in proximity to orphaned wells,
- Climate benefits via reduced methane emissions and increased carbon dioxide sequestration from restored soils,
- Increased agricultural productivity on remediated lands; and,
- Increased local property values from reduced risk of pollution, health impacts, and blight.

1.2.1. Decommissioning Costs

Boomhower et al. (2018) use a limited number of data points in California to estimate costs of roughly $83,000 per well, with wide variation across sites (all dollar figures shown in this analysis are in 2024 dollars unless otherwise noted). In Pennsylvania, Weber et al. (2018) estimate that decommissioning horizontally drilled shale gas wells would likely cost roughly $110,000 per well site. Raimi et al. (2021) estimate costs of roughly $91,000 on average, again with wide variation, based on data from thousands of onshore wells decommissioned across five states. More recently, Agerton et al. (2025) found that wells plugged in Louisiana with IIJA funds cost roughly $50,000 on average. These estimates vary in part due to differences in well characteristics (e.g., depth, age) and differences in expectations for site reclamation (e.g., size of well pad, whether pipeline rights-of-way need to be reclaimed).

Decommissioning offshore wells can be far more costly. For offshore wells in the US Gulf, Agerton et al. (2023) estimate that decommissioning would cost $675,000 for shallow water wells and $25 million on average for deepwater wells. Globally, Kaiser (2023) estimates that decommissioning costs range from roughly $95,000 per well for one large company (Gazprom, which primarily operates onshore wells) to more than $11 million per well for another (Equinor, which primarily operates deepwater offshore wells). Considering the vast scale of the domestic and global oil and gas system, cumulative decommissioning costs easily run into the hundreds of billions of dollars.

1.2.2. Benefits of Decommissioning

Hayden Chomphosy et al. (2021) quantify the benefits of well site reclamation for carbon sequestration and increased agricultural productivity on remediated lands. Their estimates vary across space because regions vary in terms of their potential to sequester carbon and produce agricultural goods. Benefits are generally lowest in desert or arid regions (roughly $15,000 per site) and highest in high-productivity agricultural lands in California (more than $300,000 per site). However, these figures rely on problematic assumptions, which we describe in Section 2.

Decommissioning well sites can also make locations more attractive for development. Harleman et al. (2022) estimate that construction activity around plugged and abandoned wells in one Pennsylvania county was significantly higher than construction around unplugged wells over several decades. They estimate that increased investment near plugged wells raised property values by 12 percent (compared with properties surrounding unplugged wells) due to decades of decisions not to build in close proximity to unplugged wells.

Ex ante estimates on the cost-effectiveness of decommissioning orphaned wells suggested that plugging wells could reduce methane emissions at a cost roughly in line with recent estimates for the social cost of methane (Raimi et al. 2020). However, Agerton et al. (2025) found that this has not been the case for IIJA-funded decommissioning in northern Louisiana. They find average costs of roughly $50,000 per well and methane emissions rates of 27 grams per hour, more than 2.5 times higher than the relevant emissions factor from EPA. However, they determine that plugging costs outweigh the societal benefits of methane abatement for most wells given that most wells in their study were low- or non-emitting.

Another analysis from Harleman (2018) compares estimates of future decommissioning costs and benefits for shale gas wells in Pennsylvania, including quantified benefits of methane abatement, land restoration, and reduction in risks to drinking water supplies and public health. In addition to the costs of site decommissioning, the analysis estimates that methane abatement and reduction in environmental and health risks would provide roughly $12,000 in social benefits per well.

Finally, decommissioning orphaned wells reduces the risk that these wells will interfere with ongoing oilfield operations. Although we are unaware of any analysis seeking to quantify the scale of this benefit, these effects may be substantial and would primarily accrue to oil and gas operators and landowners who stand to profit from royalty payments.

1.3. Details on the Federal Program

The IIJA marked the first major federal effort to address orphaned oil and gas wells nationally. Crafted during the COVID-19 pandemic, the provision sought to accomplish multiple goals. The two primary goals, as articulated by President Biden, focused on jobs and environmental benefits. By spending billions of dollars, lawmakers sought to put oil and gas workers, many of whom had been laid off as a result of the low oil prices induced by the pandemic, back to work while also reducing environmental and public health damages.

Of the $4.7 billion in (nominal) federal funds made available to decommission orphaned wells, the bulk ($4.1 billion nominally) was apportioned to states, who would then manage those funds and hire contractors to perform the work.[3] Many states and Tribal Nations already operated orphaned well plugging programs, which they expanded using these federal dollars.

Through fiscal year 2025, the US Department of Interior's Orphaned Well Program Office (OWPO) had awarded $1.5 billion (nominally) to states, along with roughly $322 million (nominally) for decommissioning on federal and Tribal lands. The states with the largest allocations to date have been Texas, Oklahoma, California, and Pennsylvania. In the years following the IIJA's passage, well decommissioning has increased across the nation. In 2023 (the most recent year for which data are available), states plugged more than 8,700 wells, up from 2,800 the previous year, with the bulk of the funding coming from federal dollars (IOGCC 2024).

The OWPO estimates that IIJA-funded plugging efforts to date have resulted in the plugging of more than 10,000 wells, preventing 5,900 metric tons of methane annually, remediating 5,259 acres of land, and creating 5,217 jobs in fiscal year 2025 (US Department of the Interior 2025). For context, OWPO's estimate for methane emissions averages 20.9 grams per hour (g/h) per well. This figure is consistent with averages found across the empirical literature, which are typically on the order of tens of grams/hour and reach—at the high end—into the hundreds of grams per hour (Townsend Small et al. 2016; El Hachem and Kang 2022; Agerton et al. 2025; Kang et al. 2014; Riddick et al. 2019, 2024).

Along with reducing pollution, restoring land, and providing jobs, one of the original objectives of IIJA funding was to gather more information about the characteristics of orphaned wells across the nation. With a better understanding of the range of ways that orphaned wells affect the environment and local communities, analysts would be able to identify which wells should be prioritized for decommissioning in the future, thereby improving cost-effectiveness (Kang et al. 2021; US Department of the Interior 2024b). However, policy changes from OWPO in 2025 substantially reduced the requirements for data collection such as measuring methane emissions before and after decommissioning (Orphaned Wells Program Office 2025).

In the following section, we describe the data and methods we use to evaluate the impacts of the program.

3 Conversations with Congressional staff indicated that the $4.7 billion figure was based on the number of documented orphaned wells identified in contemporaneous reports from the Interstate Oil and Gas Compact Commission multiplied by the per-well decommissioning costs in Raimi et al. (Raimi et al. 2021).

2. Materials and Methods

2.1. Decommissioning Data

We gathered data on well decommissioning from two main sources: public websites maintained by state governments and emailed data requests sent to state regulators. We sought data from over a dozen states and were able to gather data from eight: Colorado, Michigan, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and West Virginia, six of which (Michigan, North Dakota, Oklahoma, Pennsylvania, Texas, and West Virginia) had data sufficient to allow for the analysis that follows. Future analysis can build on our work by gathering additional data to assess benefits and costs at a larger scale.

After cleaning the data, we analyzed 2,158 well sites, with decommissioning costs of $145.4 million (see the Appendix for a map of site locations). The regions represented in our data range from booming (e.g., the Permian Basin in West Texas, the Bakken region of North Dakota, and Marcellus in Pennsylvania) to declining or depleted (e.g., Michigan, Pennsylvania's historic oil region, the Texas panhandle). Four percent of the wells in our dataset were drilled horizontally or directionally, well below the 27 percent figure for active US wells.[4] Our wells also appear to be more shallow than the national average (roughly 6,000 feet in 2008, the most recent available year) (EIA 2025).

We include a small number of wells that were decommissioned using funding from state programs to improve the statistical power of our analysis and because one state (West Virginia) adds a substantial amount of information on methane emissions. Because including wells plugged with state funds could introduce bias into our sample (for example, technical requirements could differ depending on whether state or federal funds were used), we carry out sensitivity analyses that indicate, with the exception of methane emissions, that including these wells has no significant effect on our results (we discuss the implications of differences in methane emissions in our results section, with additional information in the Appendix). Work at 90 percent of well sites included both well plugging and site reclamation, while 10 percent of sites had only plugging or reclamation work done.

We supplemented this administrative data with information on well characteristics from the commercial oil and gas data firm Enverus. Among other services, Enverus aggregates and standardizes state-level data on oil and gas wells through its Drillinginfo application, which we use here. These data provided information such as well depth, well type (e.g., oil or gas), drill type (e.g., vertical, directional), and well location.

4 Based on analysis of data from Enverus.

As Table 1 shows, well characteristics vary considerably across states. Wells in North Dakota and Texas were generally deeper and younger[5] than other states, particularly Pennsylvania and West Virginia. Ninety-six percent of wells were drilled vertically or their drill type is unknown, which indicates that these wells were most likely older vertical wells drilled before modern regulatory and record-keeping practices.

Table 1. Summary Statistics of Decommissioned Well Sites

State	Number of wells	Average TVD (feet)	Share vertical or unknown	Share of gas wells	Average well age (years)	Average decommissioning cost	Maximum cost
Michigan	379	1,390	90%	69%	27	$62,473	$1,229,686
Oklahoma	233	1,420	100%	14%	74	$21,796	$106,061
Pennsylvania	222	523	100%	17%	108	$110,348	$261,679
Texas	898	3,661	97%	23%	48	$57,298	$4,201,760
North Dakota	106	5,076	73%	0%	31	$89,967	$569,825
West Virginia	320	945	100%	0%	90	$97,391	$300,634
Total	**2,158**	**2,364**	**96%**	**25%**	**59**	**$67,381**	**$4,201,760**

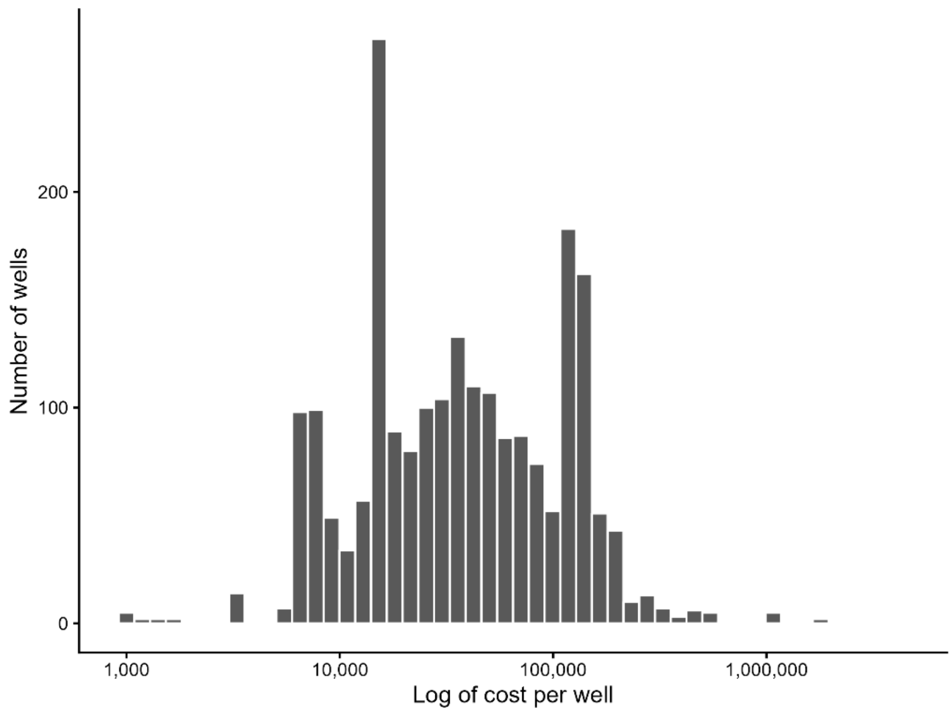
Note: TVD = Total vertical depth.

Across all states, average (mean) decommissioning costs were roughly $67,000. When we only include the 1,948 sites where both plugging and reclamation occurred, costs are modestly higher, averaging roughly $72,000. These values are roughly 20 percent lower than historical decommissioning costs as documented in Raimi et al. (2021), who found average costs of roughly $91,000 per well.

5 Some wells, particularly those in Pennsylvania, have no recorded date for spudding, completion, or initial production. This likely means that they were drilled before the implementation of modern regulations and record-keeping. For these wells, we assume an initial production date of 1900 (production began at scale in Pennsylvania in 1859). Some wells lack data on the date when they were plugged, likely because of a simple data entry error. For these wells, we assume a plug year of 2024.

Similar to Raimi et al. (2021), plugging costs exhibit a long right tail, with eight wells exceeding $1 million and one costing $4.2 million. The median decommissioning cost in our dataset is roughly $35,000. Figure 1 illustrates this long tail with a histogram showing the log of decommissioning costs for all 2,158 sites in our dataset. Most wells fall roughly between $10,000 and $100,000, with a small number outside of that range. High-cost wells are likely the result of surface or subsurface contamination requiring weeks or months of cleanup time (Ramos and Pskowski 2024; Pskowski 2025).

Figure 1. Distribution of Decommissioning Costs



The state government data we gathered on environmental impacts of decommissioned wells were incomplete and often not clearly documented. Reporting was inconsistent across states (i.e., states did not report a consistent set of variables) and within states (i.e., reporting was inconsistent from site to site). This is consistent with our conversations and correspondence with state regulators and the OWPO, who indicated that state reporting on the initial tranche of federal grants was inconsistent and of mixed quality. Although these data should be interpreted with caution, we believe they offer early insight into the efficacy of IIJA funding on environmental and other outcomes of interest to policymakers, researchers, and the public.

One reason for these data limitations is that the first tranche of IIJA orphaned well funds were allocated through $25 million “initial grants” that encouraged, but did not require, states to systematically measure and report methane emissions, groundwater contamination, and other local impacts (Orphaned Wells Program Office 2022). Most of the wells plugged in our dataset were funded through these grants. Subsequent phases of funding, known as "formula grants" and "performance grants," initially had more stringent data and reporting requirements, although these requirements were dramatically reduced in 2025 (Orphaned Wells Program Office 2025).

Table 2 shows the most comparable environmental outcomes reported in the data. Methane scanning efforts were made at roughly 40 percent of well sites, with methane detected at roughly 12 percent of those sites. Many of these detection efforts used technologies that only indicate the presence or absence of methane (e.g., optical gas imaging), rather than quantifying emissions rates. Methane quantification occurred at only 6 percent of sites. In our analysis of methane abatement costs and benefits, we only include the costs (and abatement benefits) for wells where emissions rates were quantified.

Table 2. Summary Statistics of Environmental and Social Metrics

State	Number of wells	Methane scan conducted	Methane detected*	Methane quantified	Average emissions rate (g/hr)^	Human impact	Water impact	Community impact
Michigan	379	100%	5%	5%	361.8			0.3%
Oklahoma	233	0%						
Pennsylvania	222	100%	18%			11%	5%	
Texas	898	20%	1%	0.1%	3.0			17%
North Dakota	106	0%						
West Virginia	320	28%	48%	28%	31.4			
Total	**2,158**	**40%**	**12%**	**6%**	**91.2**	**11%**	**1%**	**12%**

Notes: *Includes only sites where methane scanning occurred. ^Includes only sites where methane quantification occurred. Blank cells indicate data are not available.

North Dakota and Oklahoma did not report any information on methane emissions or methane detection efforts in their data. Inspectors in Pennsylvania did report methane measurements for some wells, but state regulators indicated that these numbers are rough estimates and should not be interpreted as precise emissions rates. Because of the uncertainty of this data, we exclude Pennsylvania observations from our methane analysis. As a result, we use data from West Virginia, Michigan, and Texas in our methane analysis. See the Appendix for additional discussion of methane data limitations.

The average (mean) emissions rate for the 110 sites where methane quantification occurred was 91.2 g/h, while the median rate was 2 g/h. Consistent with other analyses (Townsend-Small and Hoschouer 2021; Riddick et al. 2019, 2024), a small number of sites contributed an outsized share of emissions, with 10 wells emitting more than 100 g/h, four emitting more than 500 g/h, and two emitting more than 3,000 g/h. These two wells accounted for roughly two-thirds of the total methane emissions in our sample.

Other metrics, such as community impact, groundwater impact, and water impact were reported inconsistently or not at all. It is also not clear how inspectors determined what constitutes a "community impact" or how they determined that a well had impacted groundwater sources. According to these imperfect data, human impacts (which one state regulator described as indicating whether a well was very close to a home or affecting a drinking water supply) occurred at 11 percent of Pennsylvania sites; ground- or surface-water impacts were found occasionally in Pennsylvania but not at all in Texas; and community impacts were reported at 17 percent of sites in Texas but just 0.3 percent of sites in Michigan.

2.2. Hypotheses

Based on previous literature, our statistical analysis tests the following hypotheses with regard to well plugging costs:

H1. Decommissioning costs will be positively correlated with:

> **H1a**: Well depth. Previous work has shown that deeper wells are, on average, more costly to plug than more shallow wells (Raimi et al. 2021). Additional time and materials are involved in plugging deeper wells.
>
> **H1b**: Well age. Previous work has shown that older wells are, on average, more costly to plug than younger wells (Raimi et al. 2021). Deterioration of steel and cement occurs over time at all well sites.
>
> **H1c**: Whether a well site was remediated, as opposed to plugged only. Previous work has shown that sites with remediation had higher costs than sites where only a well was plugged (Raimi et al. 2021). Remediating the surrounding surface and, in some cases, subsurface, can be time intensive and costly.
>
> **H1d**: Well type. Previous work has shown that gas wells are more expensive to decommission than oil wells or wells that produce both oil and gas (Raimi et al. 2021). Gas wells may pose a greater explosive hazard, therefore requiring additional safety measures and time.

H2. Decommissioning costs will be negatively correlated with the number of wells per contract. Previous work has shown per-well decommissioning costs decline with the number of wells in a given contract, suggesting contractors are taking advantages of economies of scale (Raimi et al. 2021).

H3. Decommissioning costs will vary by state. Previous work has found that costs vary considerably by state, as states have different requirements for decommissioning and different market environments (Ho et al. 2018; Raimi et al. 2021).

H4. Decommissioning costs will vary over time. Market conditions, such as labor and capital availability, vary over time, which will likely affect contractors' costs for decommissioning wells.

For the economic and environmental benefits of decommissioning, we do not prepare hypotheses because our methods for estimating those benefits (Section 2.4) make them positive by their very nature, and we do not have ex ante information about their magnitude or whether they are likely to exceed decommissioning costs.

2.3. Statistical Analysis

To test our hypotheses, we run an ordinary least squares regression with decommissioning cost as the dependent variable. Our independent variables are listed and briefly described in Table 3.

Table 3. Variables Used for Statistical Analysis

Variable	Description	Data source
Total vertical depth	Total vertical depth of well (feet)	Enverus
Well age	Number of years between when the well was plugged and when it first began production. When an initial date is not available, we assume 1900.	Enverus (for first year), states (for plug year)
Wells per contract	Number of wells per contract	States
Site reclamation	Binary indicator for whether the contractor plugged the well and remediated the site	States
Methane scan conducted	Binary indicator for whether state inspectors sought to detect methane emissions at the site	States
Natural gas well	Binary indicator for whether a well primarily produced natural gas	Enverus
Horizontal well	Binary indicator for whether the plugged well was horizontally drilled	Enverus
State	Control variable for the well site's state	States
Plug year	Control variable for the year in which the site was decommissioned	States

Because the cost data are not normally distributed, we run sensitivity analysis that drops outliers and report results for all three specifications in our results section.

2.4. Estimating Methane Abatement Benefits

To quantify the benefits of methane abatement, we use reported methane emissions rates (in grams per hour) and extrapolate them to annual rates, using the simplifying assumption that emissions rates remain constant over the course of the year. Due to a lack of precise plugging dates in some state data, we assumed methane abatement began on the first day of the treatment year (i.e., a well plugged in 2024 was assumed to be plugged on January 1, 2024). This may result in a small initial overestimate of abatement benefits for wells which were plugged near the end of each year, but the cumulative effect of this approach is minimal. (The exception to this approach is the highest-emitting well in our sample, which was plugged on December 13, 2023. We prorated the abatement duration for this well to avoid exaggerating its benefits in 2023. See Appendix for more details).

One important question is whether methane emissions from decommissioned wells would have increased or decreased over time had the well been left unplugged. In general, we would expect subsurface pressure to decline over time, which would lead to emissions rates declining over time. However, subsurface or surface equipment degrades over time, which could lead to the opposite effect. Over the long term, the decline in subsurface pressure will dominate (Handler et al. 2025), driving emissions rates toward zero. But the time period over which this occurs is unclear, and we are unaware of any empirical data quantifying long-term methane emissions decline rates from orphaned wells.

For our central estimate of decline rates, we turn to Handler et al. (2025), who calculate that production declines by 6.4 percent for the average oil and gas well after 10 years of production.[6] We apply this decline rate to all emitting wells in our sample; for instance, if a well emitting 10 MT/year of methane was plugged in 2023, we assume that well would have released 9.36 MT/year in 2024 if left unplugged, 8.76 MT/year in 2025, and so on. Because of the uncertainty described in the previous paragraph, we also present results that assume a much lower (1 percent) decline rate over time.

After extrapolating wells' declining emissions to future years, we use the EPA's 2023 estimates for the social cost of methane (SCM), assuming a 2 percent discount rate, to estimate the present value of societal benefits created by methane abatement in each year (EPA 2023). Because of the uncertainty about emissions decline rates over time, and because these wells may have been plugged in the future using non-IIJA funds,

6 Of the 64 emitting wells in our dataset, only 1 was in production for less than 10 years before plugging. This well (5 years old) would have a higher annual decline rate through year 9 before settling at a constant decline rate of 6.4 percent from year 10 onward. Nonetheless, we apply the same 6.4 percent terminal decline rate to this well's emissions across all years for simplicity, given that it was not a high-emitting well and doing so had a *de minimus* impact on results.

we estimate abatement benefits under three counterfactual scenarios, which assume that the well would have stopped emitting methane (due to geological factors or state-funded plugging) 10, 25, and 50 years in the future.

2.5. Estimating Economic Benefits

A variety of analyses have demonstrated that pollution mitigation efforts not only benefit the environment, but also can reduce public health risks and raise local property values (Currie et al. 2011; Zabel and Guignet 2012; Gamper-Rabindran and Timmins 2013; Haninger et al. 2017; Marcus 2021). We are unable to explicitly quantify the public health benefits associated with decommissioning orphaned oil and gas wells, but we were able to estimate the benefits that could accrue to local property values.

We initially sought to estimate ecosystem service benefits, considering results from Haden Chomphosy et al. (2021), which calculates the carbon sequestration and agricultural productivity benefits from reclaiming the surface of well sites in different regions of the United States. (US EPA 2015). However, their analysis relies on several problematic assumptions that render it inappropriate for this analysis (see Appendix).

Instead, we estimate the economic benefits of land restoration using local land value data for agricultural and residential properties. We gathered data from ATTOM Data, a proprietary real estate data provider, for every agricultural and residential property in every county in which a site in our dataset was decommissioned, totaling roughly 590,000 agricultural and more than seven million residential properties. We used R to carry out geospatial analysis to identify the geographic relationships between the wells in our dataset and these properties.

Our geospatial data are limited to point locations (identifying the centroid of each parcel), rather than shape files, which means we are unable to precisely observe which wells are decommissioned on which parcels of land. Because we expect agricultural land parcels to be fairly large, we identify all agricultural properties where the centroid of the parcel is within a fairly large distance (1,000 meters) of a decommissioned well. This raises the concern that we could be overcounting the number of affected properties if, for example, a single well is within 1,000 meters of the centroid of multiple agricultural parcels. To address this concern, we take the average per-acre property value for each agricultural property within 1,000 meters of the well.[7] We use the same approach for residential properties, but limit the range to 100 meters, as previous work has shown meaningful property value effects within this diameter (Harleman et al. 2022).

7 We include only land values in this analysis and exclude the value of improvements in the large majority of cases. In some cases, however, data limitations mean that we do not observe land and improvement values separately. In those cases, we use total value per acre and again take the average per-acre property value.

We assume that decommissioning each site restores a maximum of 2 acres of land, roughly equivalent to estimates for conventional well sites in Yeh et al. (Yeh et al. 2010). In cases where a given property occupies less than 2 acres, we assume that decommissioning restores the full property site. We further assume that decommissioning increases the value of the restored land by the average per-acre property value of land on surrounding parcels (we exclude the value of improvements).

For example, if a well is decommissioned on agricultural land, and the average value of nearby parcels is $1,000 per acre (which we observe from data aggregated by ATTOM Data), we assume that property values increase by $2,000 (2 acres * $1,000 per acre). These simplifying assumptions are necessary because we do not observe property values before and after site decommissioning, making it impossible to observe real-time changes in property values.

We make sure not to double count wells that could be within 100 meters of a residential property *and* 1,000 meters of an agricultural property. When a given well is proximate to both, we include only the effects on residential properties and drop the agricultural property estimate.

In total, our dataset includes 1,745 wells within 1,000 meters of agricultural properties and 296 wells within 100 meters of residential properties. 254 wells met both criteria, so our final analysis incorporates property value effects for 1,491 wells on agricultural lands and 296 wells on residential lands.

We do not attempt to separately estimate the potential health and groundwater benefits from decommissioning because previous work has shown that these risks are (at least partially) capitalized into property values (Muehlenbachs et al. 2015; Haninger et al. 2017). Nor do we attempt to estimate the potential property value effects of restoring well sites on commercial, industrial, or other lands. We omit this analysis because of the small number of wells in our dataset that are on these lands, and because we are unaware of any analysis suggesting a clear link between decommissioning activities and increased property values outside of residential or agricultural lands.

To estimate the potential employment impacts of the program, we take two approaches: one that estimates 0.24 job-years per well based on information gathered from state regulators in 2020 (Raimi et al. 2020); and one that estimates 5.9 job-years per million dollars in spending (Pollin and Chakraborty 2020). These approaches do not measure actual employment effects of the program, but instead provide plausible ranges that future research can compare with empirical data. Actual employment data (e.g., FTEs or work hours) were not reported in our data. We do not include employment results in our cost–benefit analysis, which we discuss further in Section 3.3.

3. Results and Analysis

We analyze our hypotheses on decommissioning costs under three specifications: our full dataset, one dataset that removes the costliest 1 percent of wells (outliers removed), and a third that removes both the costliest 1 percent and all wells where sites were restored but no wells were plugged (outliers and surface-only sites removed).

In most cases, our hypotheses are validated under our two main specifications, reported in Table 4 (columns two and three). Many of these results are statistically significant and economically meaningful. The results shown in column one appear to be driven by the small number of high-cost outliers. Although these outliers are important for understanding the overall costs of decommissioning a fleet of wells, they do not provide helpful information on the typical relationships between decommissioning costs and well attributes such as depth or age (see the Appendix for figures illustrating some of these trends).

Table 4. OLS Regression Results

Dependent variable: change in decommissioning cost in 2024 dollars			
Variable	**Full dataset (not preferred)**	**Outliers removed**	**Outliers and surface-only sites removed**
Intercept	9,446	–2,144	–34,667 ***
	(22,006)	(7,499)	(7,722)
TVD (feet)	8.76 ***	4.30 ***	5.00 ***
	(1.50)	(0.51)	(0.48)
Well age (years)	226	110 **	285 ***
	(119)	(40)	(45)
Wells per contract (number of wells)	–892 ***	–759 ***	–655 ***
	(100)	(34)	(35)
Site reclamation (binary)	30,978	31,713 ***	40,423 ***
	(15,886)	(5,411)	(5,487)
Methane scan (binary)	43,260 ***	7,604	36,068 ***
	(12,047)	(4,120)	(4,213)

Natural gas well (vs. others)	818.87	−12,669 ***	−14,780 ***
	(8,452)	(2,882)	(2,724)
Horizontal well (vs. vertical)	4,958	−3,138	−958
	(21,417)	(7,326)	(6,503)
Plugged in 2021 (vs. 2024)	56,666	82,792	—
	(127,721)	(43,350)	—
Plugged in 2022 (vs. 2024)	−49,039 ***	−18,170 ***	−5,399
	(14,822)	(5,048)	(5,149)
Plugged in 2023 (vs. 2024)	−35,282 ***	−4,267	4,084
	(10,351)	(3,538)	(3,905)
Plugged in 2025 (vs. 2024)	−97,251 ***	−53,180 ***	−47,485 ***
	(10,352)	(3,560)	(3,926)
Michigan (vs. Texas)	164,706 ***	139,121 ***	132,640 ***
	(15,347)	(5,266)	(5,507)
North Dakota (vs. Texas)	26,589	40,520 ***	52,817 ***
	(16,338)	(5,561)	(5,147)
Oklahoma (vs. Texas)	3,060	19,268 **	30,637 ***
	(18,582)	(6,328)	(6,418)
Pennsylvania (vs. Texas)	35,095 *	77,854 ***	46,817 ***
	(14,439)	(4,933)	(6,025)
West Virginia (vs. Texas)	87,878 ***	86,527 ***	90,839 ***
	(10,490)	(3,566)	(3,868)
Diagnostics			
R^2	0.14	0.48	0.52
Adjusted R^2	0.14	0.48	0.51
Observations (well sites)	2,158	2,140	1,656

Notes: Statistical significance is indicated as * for p < 0.90, ** for p < 0.95, and *** for p < 0.99. Standard errors shown in parentheses. TVD = Total vertical depth.

For our preferred specifications (columns 2 and 3), each foot of TVD is associated with $4 to $5 in additional costs when controlling for other factors. Each additional year of age is associated with $285 in additional costs (we focus on specification three here, as it omits sites that were reclaimed but where no well was plugged). Each additional well per contract is associated with roughly $700 in lower costs per well in our preferred models, and wells where full decommissioning occurred are roughly $32,000 more expensive than sites where only a well was plugged (again we focus here on specification three).

Methane scanning is associated with higher costs in all three models, but results are not statistically significant in our second specification. Unexpectedly, we find that natural gas wells are less costly to plug than other types of wells, costing $13,000 to $14,000 less when controlling for other factors. We find no significant results related to horizontally drilled wells, although our statistical power for this variable is quite low, as only 2 percent of the wells in our sample were horizontally drilled.

Decommissioning costs also vary considerably over time, with 2023 and 2024 (our control year) appearing to be relatively high-cost years compared with 2022 and 2025. Although we expected costs to vary over time, we have no compelling explanation for why costs were tens of thousands of dollars lower in 2022 and 2025 compared to 2023 or 2024.

Across states, we see wide cost variation. Outside of Texas (our control state), costs are much higher. This is particularly true in Michigan, Pennsylvania, and West Virginia, where we see higher costs on the order of $75,000 to $130,000 per well. We suspect that one reason why Texas exhibits lower costs is because, as the nation's leading oil and gas producer, it has a ready supply of labor and capital available across the state. Texas also has a large preexisting orphaned well plugging program, which likely leads to a more robust supply of bidders competing to plug wells on state contracts, which would put downward pressure on prices. Another potential explanation is that Texas may have less stringent requirements around site remediation or other expectations related to decommissioning wells.

3.1. Methane Abatement Benefits

When we assume a 6.4 percent annual emissions decline rate, the cumulative societal benefits from methane abatement are $1.4 million, $2.7 million, and $3.4 million under counterfactual scenarios where the wells would have continued emitting methane for 10, 25, and 50 years, respectively. However, these results are highly sensitive to the assumed decline rate. If we instead assume a 1 percent annual decline rate, the social benefits increase to $1.7 million, $4.9 million, and $9.3 million under the 10-, 25-, and 50-year counterfactuals, respectively (Table 5).

Table 5. Societal Benefits of Methane Abatement with 10-, 25-, and 50-Year Counterfactuals

Counterfactual emissions duration	Assuming 6.4% decline rate		Assuming 1% decline rate	
	Cumulative methane abated (metric tons)	Cumulative societal benefits ($2024)	Cumulative methane abated (metric tons)	Cumulative societal benefits ($2024)
10 years	571	$1,382,024	708	$1,721,602
25 years	1,057	$2,720,239	1,834	$4,850,068
50 years	1,288	$3,395,932	3,372	$9,306,514

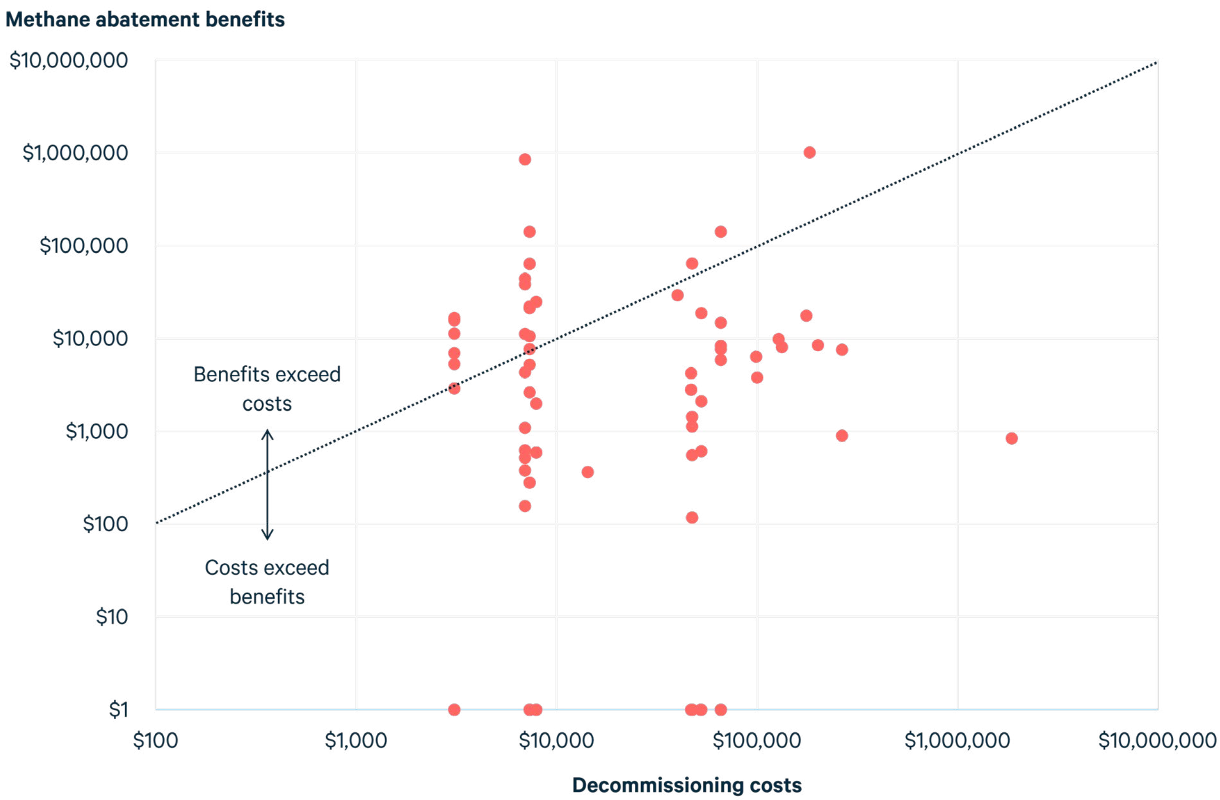
Considering the cost to plug the 110 wells where methane quantification occurred ($5.89 million), decommissioning costs outweigh cumulative methane benefits under most scenarios considered here. Future work that better characterizes emissions rates from orphaned wells over long time periods would allow us to better understand which assumptions about emissions decline rates and counterfactual scenarios are most appropriate.

Decommissioning and methane abatement benefits vary considerably from well to well. For the top five emitting wells in our sample, methane abatement benefits exceed decommissioning costs, in some cases by wide margins. Benefits exceeded costs within a single year for two of these wells, and within 3, 8, and 15 years for the remaining three.

However, these wells are the exception rather than the rule. The median emitting well in our sample (of the 110 wells where emissions were quantified) reported an emissions rate of 2.11 grams per hour (0.02 tons per year), with decommissioning costs of roughly $8,000. Under our baseline assumption of a 6.4 percent emissions decline rate, the social benefits of methane abatement from this well are just $762 assuming the well would not have been plugged for 50 years (with a 1 percent decline rate, the social benefit would be roughly $2,000 over 50 years).

Assuming a 6.4 percent decline rate, methane abatement benefits exceeded costs for just 15, 20, and 21 percent of the 110 methane-quantified wells in our sample assuming 10-, 25-, and 50-year counterfactuals, respectively. Using a 1 percent decline rate, these figures rise to 18, 24, and 25 percent, respectively. Figure 2 illustrates the range of costs and methane abatement benefits for each well, assuming a 25-year counterfactual period.

Figure 2. Methane Abatement Benefits and Decommissioning Costs (Log scale)



Note: Methane abatement benefits in this figure assume that emissions decline by 6.4 percent annually and that the well would have emitted methane for 25 years if it had not been decommissioned.

3.2. Local Economic Benefits

As described in Section 2, decommissioning abandoned wells can increase agricultural and residential property values because land occupied by the well could be put to more productive uses. To estimate the potential scale of these benefits, we carry out geospatial analysis to understand the value of residential properties and agricultural properties in proximity to the decommissioned sites in our dataset (see Appendix for national maps and illustrative examples). We find that 296 of the wells in our dataset were within 100 meters of a residential property, with average land values of roughly $29,000 per acre (excluding improvements). Following the approach described in Section 2.4, we estimate that restoring these sites would increase residential property values by roughly $14 million.

For agricultural properties, property values within 1,000 meters of the decommissioned wells in our dataset averaged roughly $5,000 per acre of land (excluding improvements). If restoring well sites allows 2 acres of these lands to reenter productive use, which increases land values by the average per-acre value (in this case, roughly $5,000), this would add roughly $15 million in property values. Notably, these estimates do not include ecosystem service benefits (e.g., carbon sequestration, runoff prevention) that are not capitalized into property values. Table 6 summarizes the results of our property value analysis.

Table 6. Estimated Effects of Land Restoration on Residential and Agricultural Properties

Property type	Number of wells	Average land value ($2024 per acre)	Property value benefits ($2024)
Residential	296	$28,987	$13,856,373
Agricultural	1,491	$5,114	$15,249,836

Note: For residential properties, total property value benefits do not equal the number of wells multiplied by twice the average per-acre land value because some parcels are smaller than two acres. In those cases, we assume that only the size of the parcel is restored.

3.3. Employment

One of the main motivations for decommissioning orphaned wells was to provide jobs during a downturn in oil and gas employment. Ideally, we would analyze empirical data from state or federal regulators on the number of work hours involved in each well site. However, our conversations with state and federal regulators indicate that this information has not been systematically collected. Lacking empirical data, we turn to the two approaches to derive job-years described in Section 2. Using these approaches, we estimate 511 job-years based on Raimi et al. (2020) and 856 job-years based on Pollin and Chakraborty (2020). These modest figures reflect the limited number of wells in our dataset.

As noted in Section 2, the OWPO reports that it spent roughly $480 million in fiscal year 2025, creating 5,217 jobs in that year. This level of job creation would suggest 10.9 job-years per million dollars of spending (compared with 5.9 job-years per million in Pollin and Chakraborty), or 0.49 job-years per decommissioned site (compared with 0.24 job-years per well in Raimi et al.). This indicates that OWPO's assumptions about job creation are roughly twice as high as those from other sources.

We do not attempt to monetize the benefits of job creation because this would require a detailed understanding of local labor markets (including their evolution over time) in each region where wells are plugged, which is beyond the scope of our analysis. Work from Bartik (2015), which provides an overview for how one might monetize the social costs (or benefits) of job loss (or gains) associated with government programs, suggests that any such benefits would be quite small in the case of this program.

4. Conclusion and Policy Implications

Overall, we find that the IIJA's orphaned well program appears to have provided meaningful environmental and economic benefits, but these benefits likely fall short of the program's costs. However, this finding is subject to a range of uncertainties and important assumptions that could affect results. What's more, additional environmental and economic benefits likely exist that are not fully captured in our analysis (e.g., reduced risk to health or ongoing oilfield operations, ecosystems service benefits).

The costs of the program appear to outweigh the climate benefits from methane abatement, at least under most sets of assumptions we apply. However, some wells easily pass a cost–benefit test due to high emissions rates, which vary by several orders of magnitude across sites. This dynamic points to the importance of quantifying wells' methane emissions, then prioritizing plugging high-emitting wells. But such an approach requires high-quality and low-cost methane quantification technologies, which are not widely available. The IIJA included tens of millions of dollars in investments in such technologies, and further investment—if it leads to high-quality and low-cost quantification methods—would be quite valuable (US Department of Energy 2025).

Our results also highlight the importance of better understanding methane emissions from orphaned wells over time. Future research that quantifies emissions over years and—ideally—decades, would be useful to calculate the benefits of orphaned well programs. Such measurements would be valuable for plugged and unplugged wells. If the integrity of plugged wells deteriorates over 10, 50, or 100 years, methane emissions could resume at some sites. Ensuring that decommissioned wells remain at or near zero emissions will require continued monitoring and—perhaps—additional rounds of plugging, ideally with innovative materials that are less prone to deterioration.

The benefits for local residential and agricultural property values appear to be substantial, totaling an estimated $29 million in this analysis. These benefits reflect the value of residential land that becomes more usable after reclamation, along with the potential for restored agricultural lands to reenter production. We do not explicitly account for the health or environmental benefits of reduced risk from air or water pollution, although these effects will be capitalized, at least partially, into property values.

If policymakers sought to improve the benefit–cost ratio of decommissioning programs, they could prioritize plugging wells near higher-value properties. However, this approach would raise obvious environmental justice concerns, as health and pollution risk mitigation would likely benefit wealthier households. One option to address this concern could be to focus on orphaned wells in low-income communities in cities such as Los Angeles, where a large number of abandoned and low-producing wells sit on valuable land that is home to many low-income households.

Regardless of the location of well plugging, policymakers also need to consider the appropriate scale of investment to address this issue. One concern as programs scale up is that the marginal benefits of decommissioning could decline over time.

Specifically, state orphaned well programs typically prioritize well plugging based on factors including the risks to human health and groundwater (Texas Railroad Commission). If additional funding leads state programs to plug wells that are lower priority, the marginal environmental and health benefits of plugging each well would decline as well (methane emissions rates are typically excluded from state prioritization criteria because emissions rates are usually unknown).

When considering the effect on jobs, it is important to note the timing of program implementation. The economic rationale for government-funded plugging programs is most justified during times of high unemployment. When the IIJA was crafted in 2021, upstream oil and gas employment[8] had fallen by more than 100,000 since 2019 (US Bureau of Labor Statistics 2026a, 2026b). But as the program was implemented in the following years, oil and natural gas prices rose along with employment. This suggests that the employment benefits of the program were diluted considerably.

Another concern relates to the overlap between state and federally funded decommissioning programs. Although the total number of wells decommissioned in recent years has increased substantially, the number of wells plugged using state dollars has declined from roughly 4,000 in 2020 to less than 2,000 in 2023 (IOGCC 2024). If federal funds are crowding out state-funded plugging, the environmental and economic benefits of the federal program are less than they would otherwise appear. Another interpretation is that federal dollars are allowing states to plug wells sooner than they otherwise would. If this is the case, then the benefits would also be lower than they appear in our analysis. This uncertainty is one motivation for presenting our methane benefit results in (10, 25, and 50-year) counterfactual scenarios (Table 5).

Each of these uncertainties presents opportunities for further research. In addition, the limitations in our dataset can be improved by future data releases, although the 2025 revision of federal reporting requirements may make future analysis more difficult.

Looking forward, the challenge of orphaned and other abandoned oil and gas wells will be considerable. Although oil and gas companies are naturally the appropriate entities to pay for the costs of decommissioning their wells, multiple factors may make it difficult for states and the federal government to fully enforce the legal requirements that companies cover the costs they leave behind. Nonetheless, our results suggest that government-funded decommissioning programs provide meaningful economic and environmental benefits, and that targeting these programs to the wells that impose the greatest environmental damages can result in program benefits exceeding costs.

8 Here we refer to North American Industrial Classification Codes 211, "Oil and gas extraction," and 213, "Support activities for mining," which is mostly support services for oil and gas production activities.

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A.1. Appendix

A1.1. Plugging Costs: Additional Summary Statistics

Because 14 percent of the wells in our sample were decommissioned using state (rather than federal) funds, we carry out a sensitivity analysis to determine whether their inclusion alters our main results. Tables A1 and A2 report the summary statistics for all wells in our sample compared with only IIJA-funded wells.

Table A1. Summary Statistics for IIJA-Funded Wells

State	Number of wells	Average TVD (feet)	Share vertical or unknown	Share of gas wells	Average well age (years)	Average decommissioning cost	Maximum cost
Michigan	379	1,390	90%	69%	27	$62,473	$1,229,686
Oklahoma	89	1,646	100%	13%	67	$27,756	$104,508
Pennsylvania	222	523	100%	17%	108	$110,348	$261,679
Texas	898	3,661	97%	23%	48	$57,298	$4,201,760
North Dakota	106	5,076	73%	0%	31	$89,967	$569,825
West Virginia	203	1,228	100%	0%	80	$125,564	$143,478
Total	**1,897**	**2,565**	**95%**	**28%**	**54**	**$72,285**	**$4,201,760**

Note: TVD = Total vertical depth.

Table A2. Environmental and Social Metrics for IIJA-Funded Wells

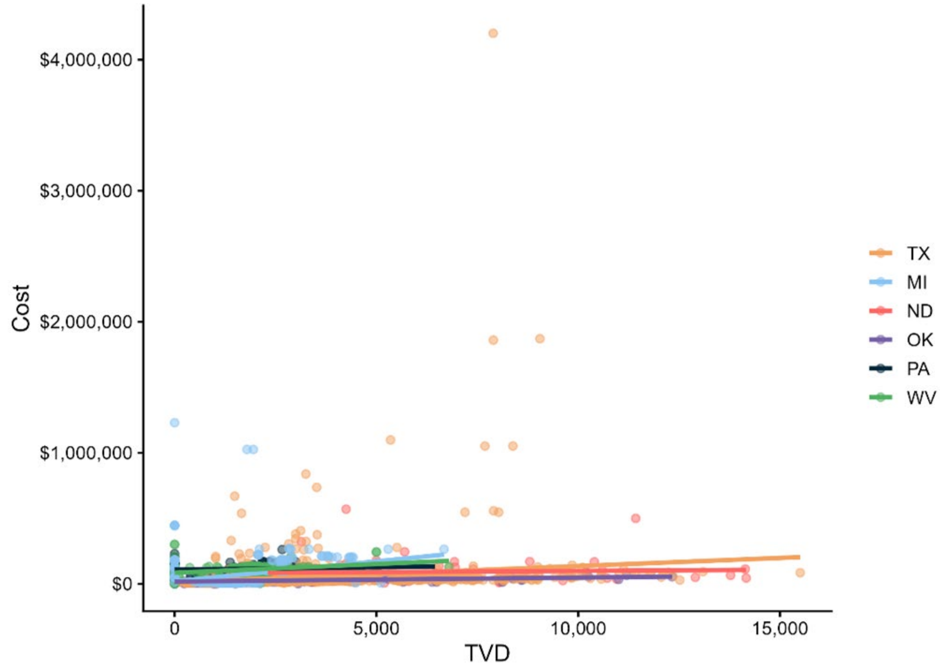
State	Number of wells	Methane scan conducted	Methane detected*	Methane quantified	Average emissions rate (g/hr)^	Human impact	Water impact	Community impact
Michigan	379	100%	5%	5.3%	361.8			0.3%
Oklahoma	89	0%						
Pennsylvania	222	100%	18%	0.0%		11%	5%	
Texas	898	20%	1%	0.1%	3.0			17%
North Dakota	106	0%						
West Virginia	203	0%						
Total	**1,897**	**41%**	**8%**	**12%**	**344.7**	**11%**	**1%**	**12%**

Notes: *Includes only sites where methane scanning occurred. ^Includes only sites where methane quantification occurred. Blank cells indicate data are not available.

With the exception of methane emissions data in West Virginia, we found no significant differences in the characteristics of the IIJA- versus state-funded wells. The West Virginia data shows that methane was not measured at any IIJA-funded sites, but was routinely measured at state-funded sites.

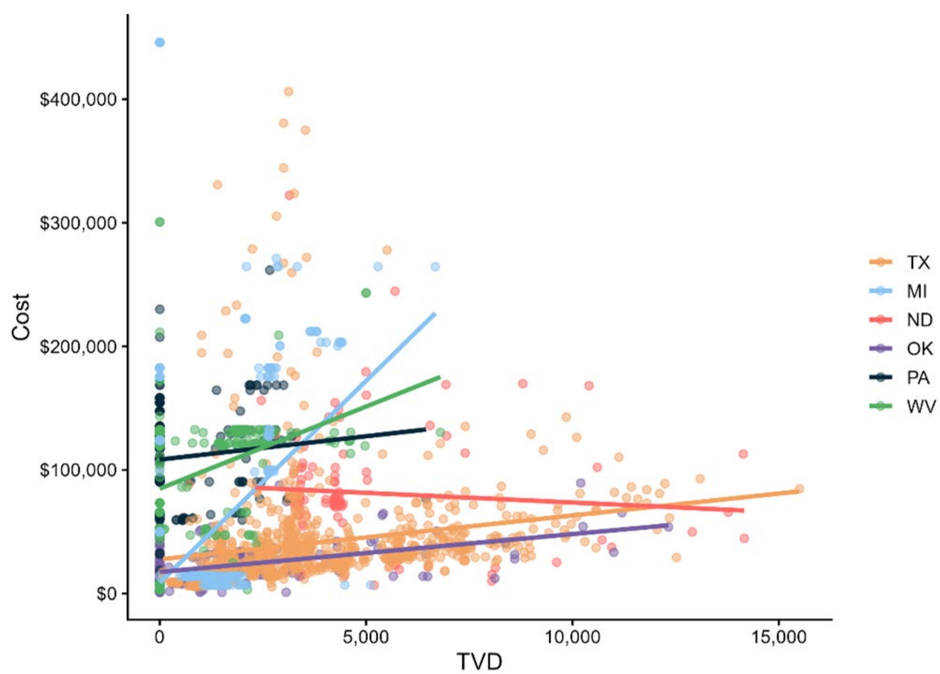
As noted in our results, a small number of high-cost wells have a substantial effect on overall program costs and our statistical analysis. Here, we illustrate the relationship between well depth and well cost for our three specifications: our full dataset (Figure A1), one dataset that removes the costliest 1 percent of wells (Figure A2), and a third that removes both the costliest 1 percent and all wells where sites were restored but no wells were plugged (Figure A3).

Figure A1. TVD Versus Decommissioning Costs for All Sites (Specification 1)



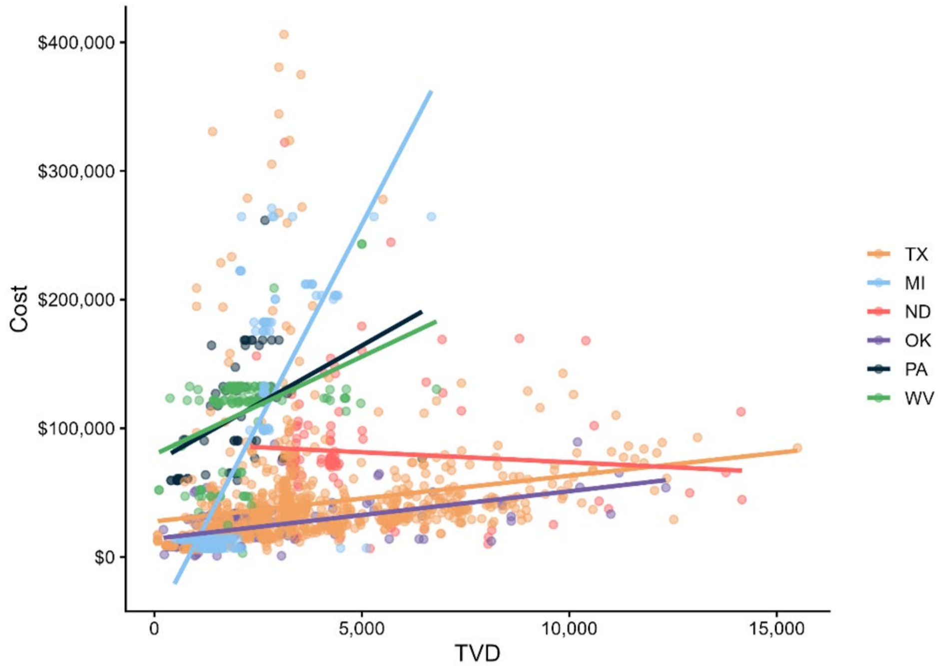
Note: TVD = Total vertical depth

Figure A2. TVD Versus Decommissioning Costs when Removing Most Expensive 1 Percent (Specification 2)



Note: TVD = Total vertical depth

Figure A3. TVD Versus Decommissioning Costs When Removing Top 1 Percent and Sites Where No Well Was Plugged (Specification 3)



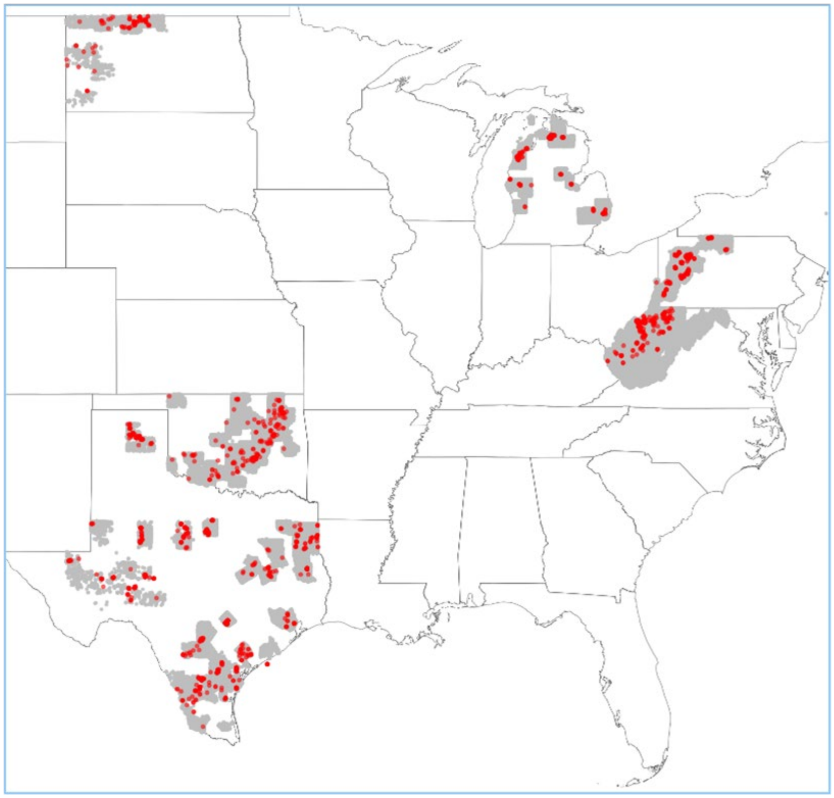
Note: TVD = Total vertical depth

A1.2. Property Value Analysis

To estimate the potential effects of well plugging on local property values, we use the "Tax Assessor" data product (Version 5.0) from ATTOM Data, accessed by Raimi through a University of Michigan license to the Dewey Data service (ATTOM Data 2025). This data product includes records gathered from county tax assessors on a wide variety of attributes for properties, including the property type (e.g., residential, agricultural, commercial, industrial), characteristics (e.g., square footage, number of bedrooms), and—crucially for us—the estimated market values for each parcel, the size of each parcel, and geolocation information.

Figure A4 illustrates the locations of all well sites in our dataset along with the locations for which we observe residential property values.

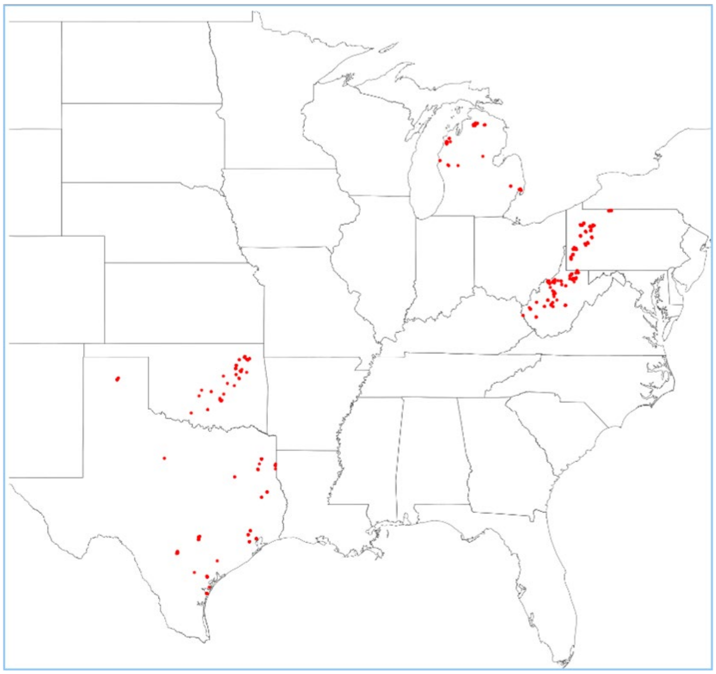
Figure A4. Well Sites and Property Locations



Note: Well sites shown in red. Property value observations in gray.

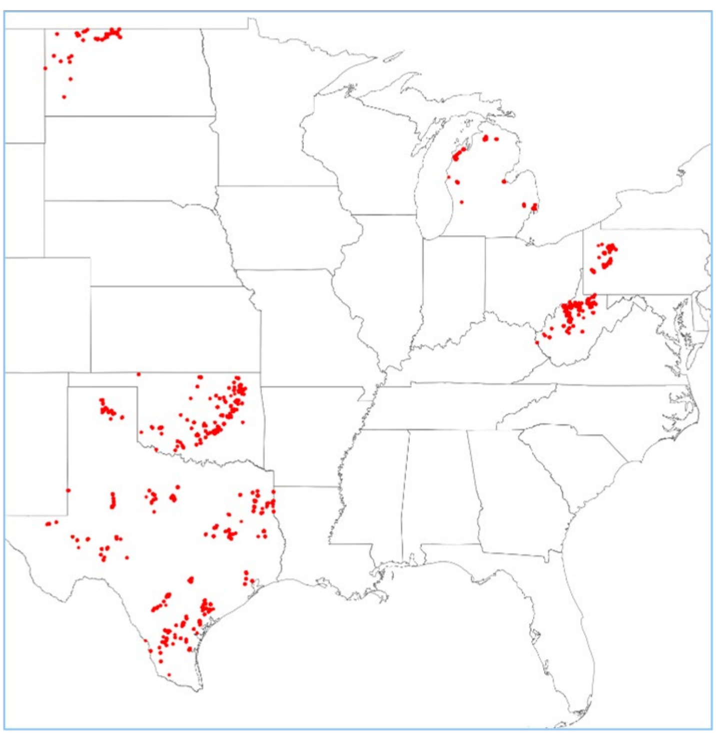
We used R Studio (libraries sf and tigris) to create a map, then identify properties within 100 meters of a well site. Property locations were provided by ATTOM Data via point coordinates of latitude and longitude. These points correspond to the centroid of the property parcel as recorded by county assessors and aggregated by ATTOM Data. Figure A5 illustrates the locations where wells were within 100 meters of a residential property. In general, we find fewer matches in the most rural regions within our sample of wells (e.g, North Dakota, West Texas). Figure A6 illustrates the overlap between well sites and agricultural properties within 1,000 meters of those sites.

Figure A5. Well Sites Within 100 Meters of a Residential Property



Note: Well sites shown in red.

Figure A6. Well Sites Within 1,000 Meters of an Agricultural Property



Note: Well sites shown in red.

To ensure the reliability of the underlying geospatial data, we spot checked a number of wells to verify that well locations were within close proximity to residential properties. We used the R package leaflet for this analysis. Our checks validated the approach. Below we provide three representative examples.

First, an injection well drilled in Cleveland County, Oklahoma in 1981 (API number 3502720476). This well was plugged but the site was not fully remediated, as can be seen by the presence of storage tanks at the site. The plugging cost was roughly $42,000. Three residential properties appear nearby, only one of which has a centroid within 100 meters of the well site.

Figure A7. An Injection Well in Cleveland County, OK

Note: Pink dot denotes well location. Blue dot denotes centroid of residential property.

Second, a natural gas well (API number 3700502486) plugged in August 2023 in Armstrong County, Pennsylvania. No drill data is available for this well, so we do not know its age at the time of decommissioning. This well appears to be in a densely populated neighborhood, with plugging costs of roughly $132,000. In field notes associated with this well, an inspector notes that 8 inches of casing were visible above the ground. This site was fully decommissioned, with plugging and surface restoration.

Figure A8. A Natural Gas Well in Armstrong County, PA

Note: Pink dot denotes well location. Blue dot denotes centroid of residential properties.

Third, a 40-year-old oil well in Gregg County, Texas (API number 4218386534). Decommissioning this site cost roughly $375,000 and field notes show that a “community impact” was reported. However, no other impacts (e.g., methane emissions, water contamination) were reported at this site. There are no detailed records that explain what this community impact may have been.

Figure A9. An Oil Well in Gregg County, TX

Note: Pink dot denotes well location. Blue dot denotes centroid of residential property.

A1.3. Ecosystem Services

As noted in the main text, we initially sought to use analysis from Haden Chomphosy et al. (2021) to estimate the ecosystem service and agricultural productivity benefits from decommissioning. However, a closer analysis of this work raised several concerns.

First, the authors draw from a 2016 analysis (Trainor et al. 2016) to assume that reclamation on average covers roughly 5 acres per site. However, this number is substantially larger than most conventional well sites (see examples in our Appendix Figures A6, A7, and A8), in part because the 2016 analysis includes not only well pads, but also the footprints of connecting roads and pipeline infrastructure, which—to the best of our knowledge—have not been addressed by state plugging programs funded by the IIJA. The authors assume 50 years of future agricultural benefits using a 3 percent discount rate, which is substantially lower than benchmark private sector discount rates (e.g., 7 percent), thereby inflating the benefits of reclamation. The authors also calculate agricultural benefits as gross revenue (i.e., sales) rather than profitability, which overstates private benefits by at least an order of magnitude (many farms are unprofitable, and average percentage returns are typically in the single digits) (Langemeier 2020; US Department of Agriculture Economic Research Service 2026). The authors also multiply these gross revenues by 1.67 to account for indirect economic benefits, further inflating their estimates.

A1.4. Methane Data

State data show that methane scans were conducted using a variety of means, some of which resulted in precise quantification of emissions but many of which did not. Methane scanning often employed optical gas imaging or remote methane leak detectors. At a number of sites in Pennsylvania and Michigan, inspectors used audiovisual and olfactory means to scan for methane, noting a shimmer detected in the air, strong odors, or audible leaks.

While Pennsylvania, Michigan, Texas, and West Virginia all provided data on methane scanning, only Michigan, West Virginia, and Texas reported measured pre-plugging methane emissions for at least some wells. Pennsylvania data included many wells that were observed to be emitting methane, but there was no standard methodology for quantifying emissions rates at these wells. In some cases, inspectors reported methane emissions in parts per million, other times reporting the concentration of methane in the air as its percentage of its lower explosive limit.[9] We exclude Pennsylvania from our methane analysis due to the difficulty of standardizing this data, at the guidance of officials from the Pennsylvania Department of Environmental Protection.

9 The lower explosive limit indicates the concentration at which a gas in the air may explode or ignite in the presence of an ignition source. The Pennsylvania Department of Environmental Protection reported to us that a 100-percent lower explosive limit reading is equivalent to ~5 percent methane in the air. Methane measurements may exceed 100-percent lower explosive limit.