"The Fiscal and Economic Impacts of Federal Onshore Oil and Gas Lease Moratorium and Drilling Ban Policies"

by

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Disclaimer

The opinions, findings, and conclusions expressed in the report are those of the authors and are not necessarily those of the University of Wyoming, the Wyoming Energy Authority, or the State of Wyoming.

Executive Summary

This study estimates the investment and production losses from policies to restrict oil and gas development on federal lands. The first policy is a moratorium on all new federal leases. The second involves an outright drilling ban on all onshore federal lands. The scope of this inquiry includes a study region that includes eight states: Wyoming, New Mexico, Colorado, Utah, Montana, North Dakota, California, and Alaska. These lost opportunities are estimated by first projecting how drilling and production activity is likely to evolve from 2021 through 2040 and then identifying what portion would be affected by the two policies.

These projections are driven by forecasts of oil and natural gas prices, which are presented in Figure ES1. These prices are averages across the states in the study region. Prices in Figure ES1 before 2020 are historical observations while prices after 2019 are forecasts, which are based upon the reference case established by the Energy Information Administration. Also presented in Figure ES1 are historical observations and our forecasts for oil and gas well completions in the study region. Over the next five years, oil and gas well completions are projected to increase modestly. They are then expected to rise after 2025 but remain below previous peaks, see Figure ES1.

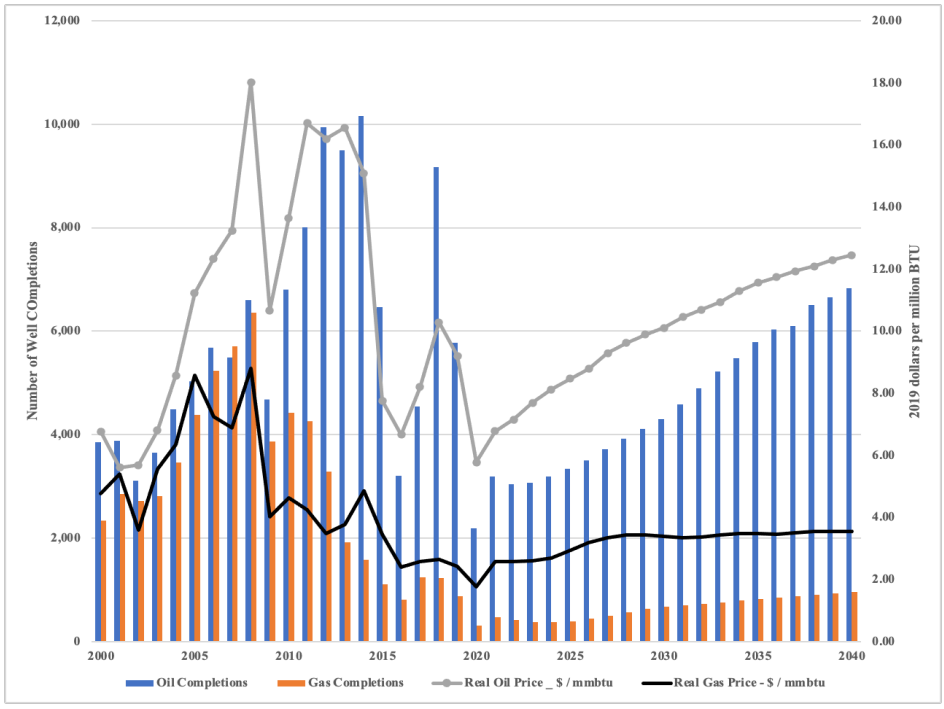

Figure ES1: History and forecast of oil and gas well completions and prices in study region

To project oil and gas production associated with these well completion forecasts, the unique features of recent oil and gas production technology must be captured. Hydraulic fracturing and horizontal drilling have unlocked large deposits of oil and gas that were previously thought to be unrecoverable. As is well known, this so-called unconventional oil and gas revolution that began a decade ago has transformed the US oil and gas sector. The pace of production gains is without precedent in the history of world oil.

At the core of this phenomenon is a new type of well, one that produces at high rates just after initial production but with steep production declines thereafter. This steep production decline curve has raised the importance of drilling new wells to offset the production declines from previously completed wells. This study captures this production treadmill by modeling how drilling activity responds to price, how the composition of the stock of producing wells adjusts overtime as production from previously drilled wells declines over time, as old wells are abandoned, and as new wells are added. This vintage production model provides insights into the role of the production treadmill in understanding past production trends and into how policies to restrict federal oil and gas development could affect future production.

An illustration of this vintage production model appears in Figure ES2. This diagram plots oil production for the study region, including history over the past two decades and projections from 2020 through 2040. There are four areas identified in the chart. The first two include production from wells drilled before the year 2000 and those after 2000 until 2019. Notice that the spike in production in 2019, which was 1,797.45 million barrels or 4.9 million barrels per day in the study region, was almost entirely supplied by wells drilled after 2000. The second two areas are projections based upon our drilling forecasts and production decline curve analysis. The first area in grey is new production from non-federal lands in the study region. The last area in yellow is projected production from federal lands, which is the amount of production that could be lost if policies to restrict oil and gas development were adopted.

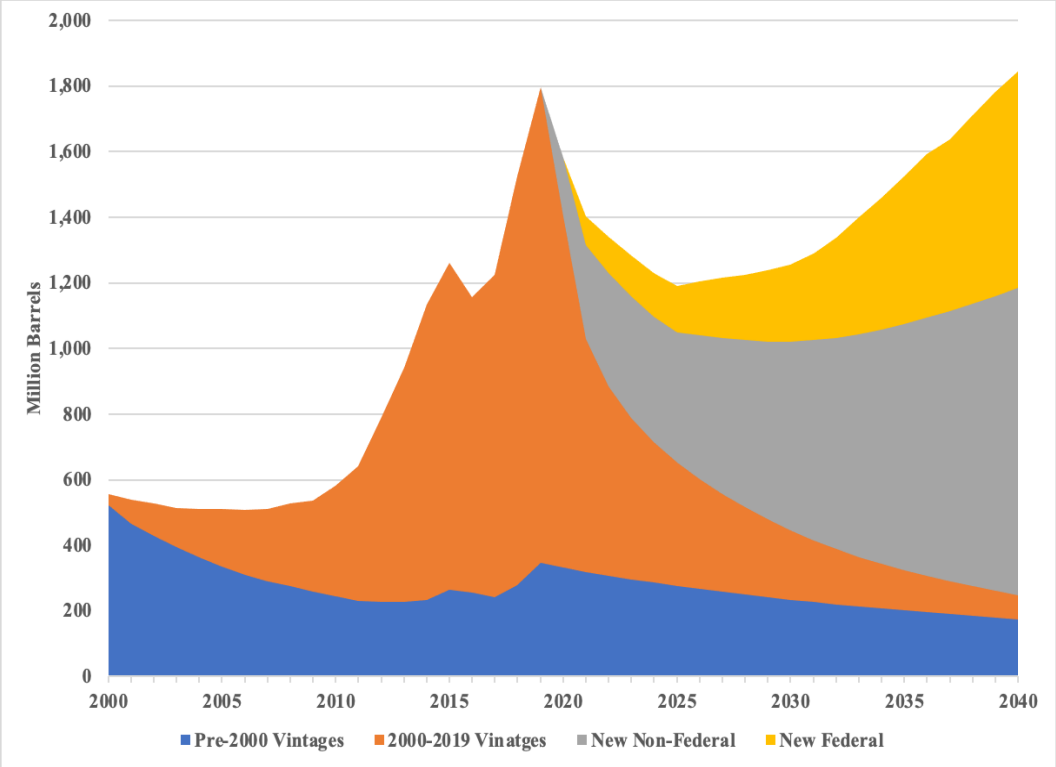

Figure ES2: History and forecast of oil production in study region

Oil production is expected to decline over the next five years in part due to low prices but then recover with additional well completions after 2030. The corresponding diagram for natural gas appears in Figure ES3. Unlike oil, natural gas production is well below previous peak levels achieved in the study region. These production forecasts assume 1.2 percent annual gains in initial production in the study region except for Alaska and California, which are projected to continue declining at recent rates. The 1.2 percent gain in initial production implies that wells drilled 20 years from now will produce 25 percent more oil or gas than a well drilled today. In contrast, wells drilled today have initial production rates 7-10 greater than those drilled 10 years ago. Hence, these productivity growth forecasts are conservative.

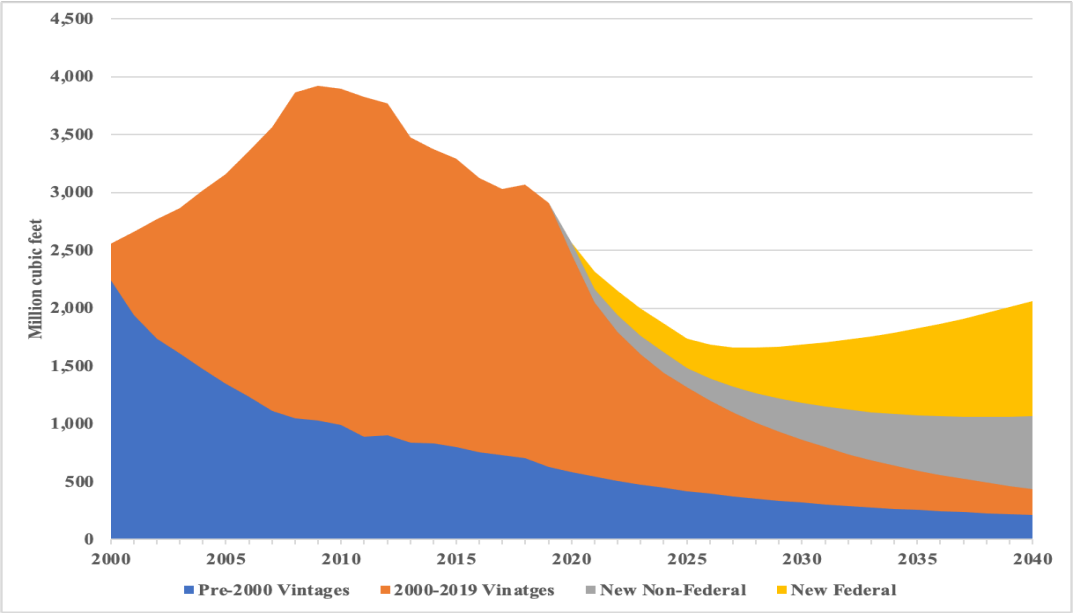

Figure ES3: History and forecast of natural gas production in study region

Under a leasing moratorium the yellow wedges gradually disappear over a five year period as drilling and production fall with a declining inventory of leases. With a drilling ban, the wedges disappear completely starting in 2021. These policies result in losses in drilling investment, which are reported in five year increments in Table ES1. Under both policies, the investment losses initially are largest in Wyoming and New Mexico. During the 2021-2025 period, the average annual losses in drilling investment under a lease moratorium are $2.625 billion and $2.311 billion in New Mexico and Wyoming, respectively. Under a drilling ban, these losses are $2.74 billion in Wyoming and $3.141 billion in New Mexico annually during the first five years of a drilling ban. Once again, these losses represent what could have been spent on developing oil and gas in these states were it not for the leasing moratorium or drilling ban.

The investment losses in the other states, particularly Colorado, Utah, North Dakota, and Alaska are smaller but range several hundred million per year during the first five years, see Table ES1. The differences in investment losses across states largely depends upon the extent of federal ownership in each state. Roughly 60 percent of oil and gas is developed on federal lands in New Mexico. In contrast, federal lands in Wyoming account for nearly all natural gas and 50 percent of oil.

Table ES1: Average annual investment losses in millions of dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$2,311	$4,762	$6,917	$8,770
New Mexico	$2,625	$3,594	$4,681	$5,988
Colorado	$586	$1,095	$1,508	$1,870
Utah	$248	$406	$547	$698
North Dakota	$279	$358	$467	$601
Montana	$56	$112	$169	$224
California	$317	$650	$985	$1,307
Alaska	$412	$1,525	$6,932	$13,451
Total Average	$6,835	$12,503	$22,206	$32,908
5-Year Total	$34,176	$62,517	$111,028	$164,541
	Drilling Ban			
Wyoming	$2,740	$4,913	$7,073	$8,952
New Mexico	$3,141	$3,710	$4,787	$6,113
Colorado	$700	$1,129	$1,542	$1,909
Utah	$293	$419	$560	$712
North Dakota	$336	$370	$477	$613
Montana	$66	$115	$173	$229
California	$369	$671	$1,007	$1,334
Alaska	$456	$1,573	$7,471	$13,845
Total Average	$8,100	$12,900	$23,090	$33,707
5-Year Total	$40,501	$64,499	$115,449	$168,535

The investment losses accumulate over time because drilling activity without the policy interventions is projected to increase with higher prices. After 2031, oil development in the Artic Wildlife Refuge (ANWR) is expected to occur and this explains why investment losses spike during the last two periods for Alaska, see Table ES1. Overall, the leasing moratorium reduces oil and gas investment in the study region by $34.1 billion cumulatively over the near term (2021-2025) and these losses build over time, reaching $164.5 billion from 2036 to 2040. Under a drilling ban these cumulative losses are larger, $40.5 billion near term and $168 billion during the last five years from 2036 through 2040. Lower investment directly lowers gross national product so these investment losses may have national economic implications for steel and other oil and gas support industries outside the study region, which are beyond the scope of this study.

Lower investment under these policies results in lost oil and gas production in the study region. For instance, during the first five years under a leasing moratorium, lost oil and gas production in Wyoming is on average $872 million. In contrast, production losses in New Mexico are much higher at $3.2 billion because New Mexico has more productive wells and oil drilling activity is expected to be much higher than in Wyoming. Under a leasing moratorium,

Alaska has the third largest losses at $469 million per year during the first five years. Colorado, with about a third of its natural gas produced from federal land, has annual losses of $265 million, while North Dakota, another state with productive wells but with only 8 percent of its oil produced on federal lands, has annual losses of $426 million. The total average annual value of oil and gas production lost under a moratorium on federal leases is $5.5 billion during the first five years and this more than doubles during each five year increment thereafter. Total cumulative losses are $27.5 billion during 2021 to 2025 and increase to $245 billion during 2036 to 2040. Clearly, a leasing moratorium entails significant near term losses in oil and gas production and if pursued in the future, even larger long-term losses.

Table ES2: Average annual oil and gas production losses in millions of dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$872	$2,405	$4,246	$6,310
New Mexico	$3,206	$6,703	$10,125	$14,370
Colorado	$265	$599	$963	$1,353
Utah	$142	$334	$525	$760
North Dakota	$426	$832	$1,232	$1,718
Montana	$45	$140	$254	$384
California	$66	$205	$339	$445
Alaska	$469	$2,355	$9,902	$23,698
Total Average	$5,491	$13,573	$27,587	$49,039
5-Year Total	$27,456	$67,865	$137,937	$245,194
	Drilling Ban			
Wyoming	$1,055	$2,510	$4,364	$6,458
New Mexico	$4,394	$7,182	$10,533	$14,792
Colorado	$336	$627	$990	$1,385
Utah	$177	$351	$541	$780
North Dakota	$605	$902	$1,281	$1,764
Montana	$53	$146	$260	$392
California	$84	$218	$350	$456
Alaska	$506	$2,412	$10,378	$24,239
Total Average	$7,210	$14,347	$28,699	$50,266
5-Year Total	$36,051	$71,735	$143,494	$251,328

Under a drilling ban the production losses are larger and front loaded compared to those under a lease moratorium. For example, during the first five years, a drilling ban reduces oil and gas output by $7.2 billion per year, with 76 percent of these losses occurring in New Mexico and Wyoming. The next largest losses are in North Dakota, Alaska, Colorado, and Utah in that order, see Table ES2. Like the leasing moratorium, average annual losses under a drilling ban escalate over time, reaching $50 billion per year during the 2036 to 2040 period. Cumulative losses are $36 billion during the first five years of the ban and escalate to $250 billion during the last five

years. So in addition to the loss of economic stimulus that oil and gas investment provides for the overall economy, these policies reduce the economy's ability to produce oil and gas and as consequence generate income for individuals and governments.

Lower production reduces oil and gas tax revenues, which in this study includes severance and ad-valorem taxes, federal royalty payments, and lease bonus payments. These tax revenues fund higher education, primary and secondary schools, health care, conservation districts, and other programs sponsored by state and local governments.

Under the leasing moratorium, oil and tax revenues fall $1.6 billion per year during the first five years. The lost tax revenue in New Mexico alone is estimated to average $946 million per year, see Table ES3. Wyoming loses $304 million per year in oil and gas revenues. The next largest loss of tax revenues occurs in North Dakota with $136 million in annual losses during the first five years under the leasing moratorium. Cumulative losses in oil and tax revenues under the lease moratorium are $8.1 billion during the first five years and rise to $55 billion during the 2036 to 2040 period.

Table ES3: Average annual oil and gas tax revenue losses in millions of dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$304	$722	$1,227	$1,773
New Mexico	$946	$1,765	$2,624	$3,681
Colorado	$59	$126	$200	$279
Utah	$27	$59	$92	$132
North Dakota	$136	$249	$358	$489
Montana	$40	$93	$146	$203
California	$17	$48	$77	$100
Alaska	$100	$454	$1,887	$4,436
Total Average	$1,629	$3,517	$6,610	$11,093
5-Year Total	$8,144	$17,583	$33,050	$55,466
	Drilling Ban			
Wyoming	$345	$746	$1,254	$1,807
New Mexico	$1,221	$1,876	$2,718	$3,778
Colorado	$73	$132	$205	$285
Utah	$33	$62	$95	$135
North Dakota	$175	$264	$369	$499
Montana	$42	$94	$148	$205
California	$20	$50	$79	$102
Alaska	$106	$465	$1,971	$4,532
Total Average	$2,015	$3,688	$6,838	$11,344
5-Year Total	$10,074	$18,441	$34,188	$56,718

Tax revenue losses under a drilling ban average $2 billion per year during the first five years. Revenue losses in New Mexico exceed $1.2 billion and Wyoming's losses are $345 million per year. Longer term, these losses escalate because the number of producing wells decline and, therefore, the tax base erodes. These annual losses exceed $3.7 billion per year from 2025 to 2030, $6.8 billion per year from 2031 to 20235, and $11.3 billion per year from 2036 to 2040, see Table ES3. The sharp increase in the last period is due to the loss of output and revenues in Alaska from foregone oil development in ANWR.

These tax revenue estimates depend in part upon future productivity growth in the oil and gas industry. The greater productivity, the larger the potential loss from leasing or drilling restrictions. If productivity in the industry increases by 3 percent per year, tax revenues losses are from 5 to 25 percent higher over time. Higher oil and gas prices also increase these potential losses. For example, if oil prices increase 10 percent, oil tax losses from these restrictions rise 20 percent near term and up to 27 percent longer term, if the price increase persists. The response of natural gas tax revenue losses to an equal percentage change in its price is even greater, upwards of 35 percent. If oil prices increase in the future as they likely may in a few years, a leasing moratorium or drilling ban would eliminate the option to capitalize on these higher prices.

Lower investment and production under these policies will reduce income, employment, and value added, which is the state equivalent of gross domestic product. These impacts are estimated in this study by using economic multipliers from the Bureau of Economic Analysis (BEA) in the US Department of Commerce. These so-called Type I multipliers include the direct and the indirect impacts from oil and gas spending on the supply chain supporting oil and gas drilling and extraction. The value added impacts are presented in Table ES4 below.

Based upon the BEA multipliers, the lease moratorium reduces value added by $9.2 billion per year during the initial five years. Under a drilling ban these losses increase to $11.5 billion per year. The Wyoming and New Mexico economies bear most of the burden of these losses., initially. Longer term, Alaska has the most to lose from $12 to $27 billion per year in lost value added after 2031.

The fiscal and economic losses estimated in this study are subject to several uncertainties. For the economic impact estimates, uncertainties revolve around the economic multipliers. This study confirms a finding reported in the peer reviewed literature that econometric multipliers are lower than the BEA multipliers. The losses in oil and gas tax revenues, however, do not depend upon multipliers. Instead, these fiscal losses are sensitive to prices and productivity growth.

If there has been one consistent surprise over the past decade, it has been the remarkable productivity growth of the 21st century oil and gas industry. This study assumes a conservative rate of productivity growth. Based upon historical trends, this rate could be much higher, making future wells more productive and the foregone opportunities that much higher under federal restrictions. Higher oil and gas prices have the same effect.

Finally, the economic losses from leasing and drilling bans may not be confined to federal lands. Lower drilling activity on federal lands may have spillover effects on state and private lands. There are two reasons for these spillovers. The first arises from the pattern of land ownership, in which tracts of federal, state, tribal, and federal lands are interspersed in a checkerboard pattern. The second reason stems from a so-called, "communitization" requirement meaning that any drill spacing unit with a least one federal or Indian lease can be combined "in the public interest" with private or state land for the purposes of development. Hence, federal regulations could apply to private and state lands subject to a communitization agreement. The result is that in the checkerboard or other lands with significant federal acreage, rules like a drilling ban could apply to state and private land as well. If spillovers do emerge then the fiscal and economic losses would rise linearly with the shares of private and state lands tied to federal regulation. In other words, a 10 percent spillover effect would increase fiscal and economic losses by 10 percent.

Table ES4: Average annual value added losses in millions of dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$2,286	$5,183	$8,112	$11,003
New Mexico	$4,379	$7,809	$11,265	$15,522
Colorado	$698	$1,392	$2,035	$2,660
Utah	$310	$590	$856	$1,164
North Dakota	$542	$924	$1,322	$1,807
Montana	$75	$190	$320	$462
California	$295	$658	$1,018	$1,347
Alaska	$648	$2,883	$12,478	$27,701
Total Average	$9,234	$19,628	$37,406	$61,667
5-Year Total	$46,169	$98,141	$187,029	$308,335
	Drilling Ban			
Wyoming	$2,727	$5,369	$8,312	$11,245
New Mexico	$5,677	$8,268	$11,660	$15,942
Colorado	$851	$1,444	$2,085	$2,718
Utah	$374	$614	$878	$1,191
North Dakota	$726	$988	$1,369	$1,853
Montana	$88	$197	$328	$472
California	$348	$683	$1,044	$1,377
Alaska	$708	$2,960	$13,220	$28,394
Total Average	$11,498	$20,521	$38,896	$63,190
5-Year Total	$57,490	$102,606	$194,480	$315,952

Advocates of restricting oil and gas development on federal lands argue that greenhouse gas emissions would be reduced. This position is debatable because foreign nations, such as Saudi Arabia or Russia, could easily replace the lost production and probably with greater

environmental impact than American oil producers. Even if one assumes that there would be no supply response and emissions are reduced, the question becomes at what cost are these emission reductions achieved? Using the losses in value added reported above, the cost per ton of avoided emissions under the drilling ban is on average $196 per ton. Using econometric multipliers, the cost per ton is $64 per ton. By comparison, the carbon price from the Regional Greenhouse Gas Initiative in California is roughly $15 per ton. Hence, policies to restrict development of oil and gas on federal lands are an expensive way to reduce greenhouse gas emissions.

In summary, the fiscal and economic losses from these policies ban are significant. Total lost investment from 2021 to 2040 is $372 billion under a lease moratorium and $389 under a drilling ban. Lost investment translates to lost production, which is $478 and $503 billion under a lease moratorium and a drilling ban respectively. Fiscal losses are significant accumulating to $114 billion under a lease moratorium. A drilling ban generates losses in oil and gas tax revenues of $119 billion over the next 20 years, creating a difficult situation for resource dependent states, such as New Mexico, Wyoming, and Alaska. Finally, these policies reduce economic growth, causing losses of $640 billion and $671 billion under a lease moratorium and drilling ban respectively.

Table ES5: Total fiscal and economic losses in billions of dollars

	Lease Moratorium	Drilling Ban
Oil & Gas Sector		
Investment	$372	$389
Production	$478	$503
Tax Payments	$114	$119
Value Added in Study Region	$640	$671

A moratorium on new leases for oil and gas development on federal lands or a drilling ban would significantly reduce oil and tax revenues and economic growth in the study region. These fiscal impacts could be much greater if the lost wells were more productive and oil and gas prices turn out to be higher than those assumed in this study.

The United States is now the largest oil and gas producer in the world, deterring OPEC from cutting production to increase prices. Halting oil and gas development on federal lands reduces an important source of incremental supply to world markets, thus increasing OPEC's market power and ultimately transferring income from consumers to foreign oil producers.

Even if in the unlikely event a leasing moratorium or a drilling ban were to reduce emissions, they would be achieved at great cost. There are many cost effective technologies and strategies to reduce greenhouse gas emissions. Restricting development of oil and gas on federal lands is not one of them.

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1. Introduction

Environmental concerns have motivated some policy makers to propose restricting development of oil and gas on federal lands. These proposals can take a variety of forms including regulations on oil and gas development activity, such as methane reduction rules and sage grouse management guidelines, to explicit policies restricting drilling and production, which are the focus of this study. Specifically, this study examines two policies: a moratorium on new leases and, secondly, an outright ban on drilling for oil and gas on federal lands. A lease moratorium will have a gradual impact on drilling activity because leases signed before the moratorium would still allow drilling to take place until lease expiration. In contrast, a drilling ban causes an immediate reduction in drilling activity today and in future years. Both policies will not affect production of oil and gas from existing wells. Instead, these policies reduce future well development and production. Hence, leasing moratoriums and drilling bans incur opportunity costs in the form of foregone income derived from oil and gas investment and production. The objective of this study is to estimate these opportunity costs.

The scope of this study includes onshore federal oil and gas production in the Rocky Mountain states of Wyoming, Colorado, New Mexico, and Utah; the northern great plains oil producing regions in North Dakota and Montana; California, and Alaska. Collectively these states produce nearly all federal oil and gas production. These states are quite diverse both in terms of the relative importance of oil and gas to their local economies, the size and productivity of their oil and gas properties, and their future growth prospects. Capturing this diversity is essential to obtaining a realistic estimate of the opportunity costs of oil and gas lease moratoriums and drilling bans.

Estimating these opportunity costs involves a projection of future drilling activity and production. If the oil and gas industry had no future, then a leasing moratorium or a drilling ban would entail no opportunity costs because there would be no future activity to forego. Indeed, oil and gas drilling ground to a halt in some states during the pandemic shutdown during spring 2020. Oil and gas development activity in some states, however, remained robust even during the shutdown and overall development is now rebounding with higher oil and gas prices. The challenge for this study is to project this future activity and, thereby, provide a basis for estimating the opportunity costs of restricting oil and gas development on federal lands.

Accordingly, this study estimates separate econometric models of oil and natural gas well completions using data over the past 20 years from each of the eight states in the study region. Our central finding is that drilling activity is quite sensitive to price, which appears consistent with recent experience. With detailed data on finding costs from a large sample of oil and gas firms, this study projects future drilling activity and investment expenditures for each state. These drilling forecasts provide a basis for projecting future oil and gas production from these wells. Production from wells is then projected using estimates of production decline curves estimated from thousands of well production records. This approach is essential to capture the high initial production and subsequent steep decline of modern oil and gas wells constructed using horizontal drilling and hydraulic fracturing. Indeed, a significant portion of oil and gas production is from new wells. Hence, ceasing construction of new wells due to a leasing moratorium or a drilling ban could lead to significant reductions in production.

The next section provides an overview of oil and gas drilling and production activity in the states with significant federal oil and gas production. Section three discusses the modelling framework along with the econometric findings on the price responsiveness of drilling activity and the shape of the production decline curves. Section four estimates the opportunity costs by state, including lost oil and gas investment expenditures, production revenues, and mineral tax income from severance and ad valorem taxes, federal royalties, and lease bonus payments. In addition, this study also estimates impacts on gross state product or value added, personal income, employment, and non-energy production and state and local taxes. These projections are contingent upon forecasts of oil and gas prices, which are based upon projections made by the US Energy Information Administration. The sensitivity of our findings to prices and future productivity growth is examined in section five. Since environmental protection is one of the justifications for the proposed policies, carbon abatement costs are estimated in section 6. The study concludes with a summary of our findings.

2. Overview of Onshore Federal Oil and Gas Development

There are several conventional oil and gas shale plays within the study region as illustrated in Figure 1 below. Within Wyoming, for instance, there is the Niobrara, Hilliard-Baxter-Mancos, and Mowry shale plays in addition to promising conventional fields that are producing additional oil and gas with the application of new technology. As the map also indicates, Colorado, Montana, Utah, New Mexico, Montana, and North Dakota also have extensive deposits of oil and gas in shale formations.

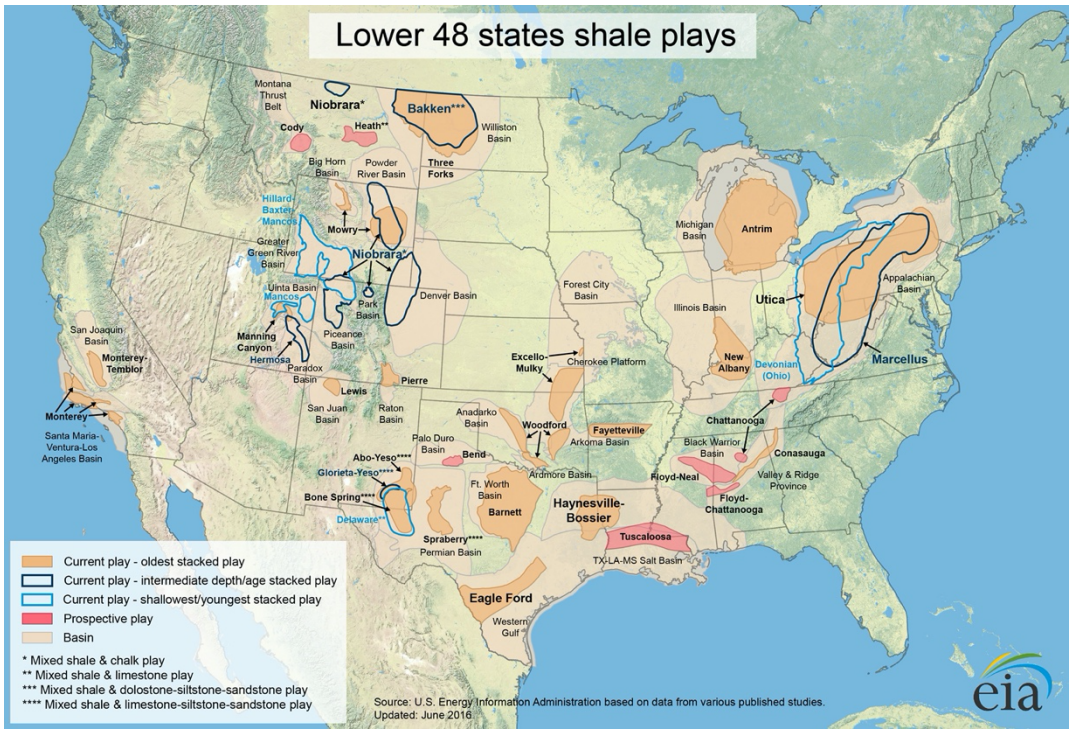

Figure 1: Lower 48 US states shale plays

These oil and natural gas deposits span federal, tribal, state, and private lands, illustrated in the map of federal and tribal and ownership displayed as Figure 2. Federal land ownership is extensive in the study region, comprising 46.7% of lands in Wyoming, 63.1% in Utah, 31.7% in New Mexico, and 36.2% in Colorado, based upon data reported by the Congressional Research Service (2020). While the shares of federal ownership of oil and gas resources in these states differ from these percentages as reported below, policies affecting federal lands can affect or spillover to affect development on private and state lands through “communitization” requirements meaning that any drill spacing unit (DSU) with a least one federal or Indian lease can be combined "in the public interest" with private or state land for the purposes of development, see Holland and Hart (2019). Hence, federal regulations would apply to private and state lands subject to a communitization agreement. The result is that in the checkerboard or other lands with significant federal acreage, a drilling ban could apply to state and private land.

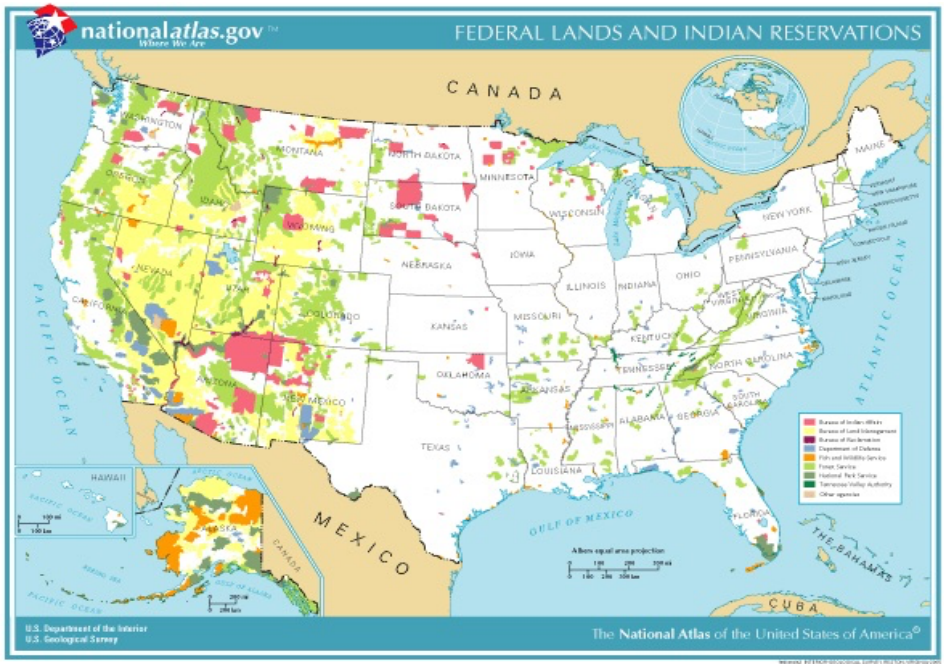

Figure 2: Lower 48 US states shale plays

The eight states examined in this study produced on average 37 and 32 percent of oil and natural gas production in the United States respectively from 2003 through 2019. Total federal oil production for these states has more than tripled since 2003, rising from 260 to 793 thousand barrels per day. These gains were led by New Mexico, Wyoming, and North Dakota, see Figure 3, which together produce 90 percent of total federal oil production.

Federal natural gas production increased from 8 to 8.9 billion cubic feet per day from 2003 to 2019, an increase of 10.9 percent. Federal lands in Wyoming remain the largest producer after peaking in 2009 during the coal bed methane boom, see Figure 4. New Mexico, Colorado, and Utah are the next three largest producers of natural gas from federal lands.

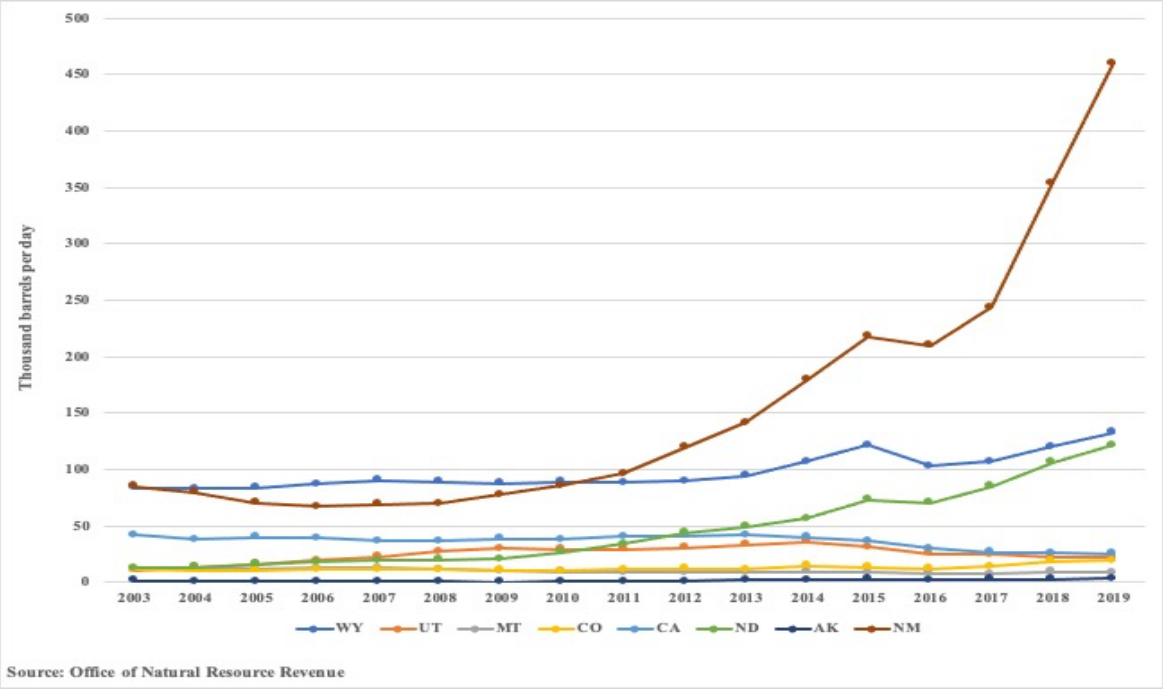

Figure 3: Federal oil production by state

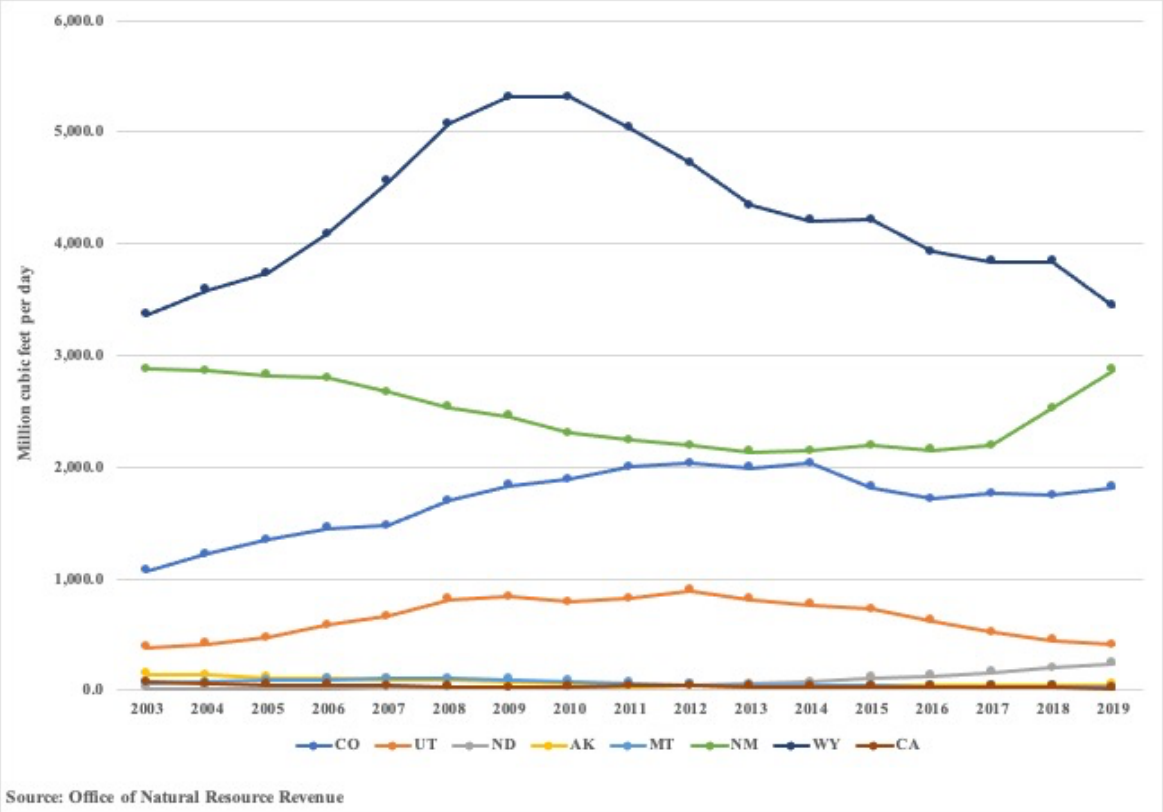

Figure 4: Federal natural gas production by state

3. Modelling Framework

Estimating the opportunity costs of policies to restrict oil and gas drilling on federal lands requires a projection of what that investment would likely be in its absence and how much future production could be lost. Accordingly, this section presents two sets of models – one for drilling and the other for production. In addition, this section presents a model to estimate how a moratorium on new leases would affect drilling activity.

3.1 Oil & Gas Well Completions

The model for oil and gas well completions used in this study is similar to the one by Hausman and Kellogg (2015) in which the logarithm of well completions is specified as a function of logarithms of real prices, lagged well completions, and state fixed effects. This econometric model is estimated using a panel data set of the eight states in the study region from 2001 to 2019 for a total of 152 observations. Two estimators are employed, ordinary least squares and two-stage least squares, which corrects the estimates for the possible endogeneity of prices. The instrumental variables used for the two-stage least squares estimation include heating and cooling degree days for the US, beginning crude oil inventories, the Baltic dry freight index, state fixed effects, and rest of the world petroleum consumption. All standard errors are corrected for heteroscedasticity.

The estimates for oil well completions are presented in Table 1. The coefficient on price is 0.501109 using ordinary least squares (OLS), which is the short-run supply elasticity. Both price and lagged completions are statistically significant using OLS. The two-stage least squares (2SLS) estimates are presented in the lower portion of Table 1 and indicate a short-run supply elasticity of 0.644075. The long-run price elasticity of oil supply is obtained by dividing the short-run supply elasticity by one minus the coefficient on lagged completions, 0.612791 (see table 1), yielding a value of 1.66. These supply elasticities are substantially larger than those found by Hausman and Kellogg (2015) who used monthly data from earlier this century. An alternative to this lagged adjustment model replaces lagged well completions with lagged prices. Using this specification, the long-run supply elasticity remained elastic at 1.3.

Table 1: Parameter estimates for oil well completions model

Dependent variable: log (oil well completions)				
	Ordinary Least Squares			
	Estimate	Standard Error	t-statistic	p-value
constant	-0.65525	0.572682	-1.14418	[.254]
log (oil price)	0.501109	0.139329	3.59659	[.000]
log (lagged completions)	0.671627	0.097047	6.92064	[.000]
Adjusted R^2	0.897925			
	Two-Stage Least Squares			
constant	-0.983532	1.03013	-0.954764	[.340]
log (oil & gas price)	0.644075	0.166574	3.86659	[.000]
log (lagged new leases)	0.612791	0.26453	2.31653	[.021]
Adjusted R^2	0.895751			
Number of observations 152, State fixed effects reported separately				
Standard errors are heteroscedastic-consistent				

The estimates for natural gas well completions are presented in Table 2. The OLS estimate for the short-run natural gas supply elasticity is very close to the OLS estimate for short-run oil supply elasticity. The 2SLS estimate for the natural gas supply elasticity, however, is larger than its oil counterpart at 0.879933, see Table 2, The implied long-run natural gas supply elasticity is 4.03, considerably larger than the oil supply elasticity. The 2SLS estimates are all significant at conventional levels of significance. Using lagged price instead of lagged well completions results in a long-run natural gas supply elasticity that is somewhat lower at 3.45.

Table 2: Parameter estimates for gas well completions model

Dependent variable: log (natural gas well completions)				
	Ordinary Least Squares			
	Estimate	Standard Error	t-statistic	p-value
constant	-0.280302	0.158314	-1.77054	[.079]
log (gas price)	0.503575	0.166718	3.02052	[.003]
log (lagged completions)	0.818180	0.058091	14.0845	[.000]
Adjusted R^2	0.925829			
	Two-Stage Least Squares			
constant	-0.712042	0.171498	-4.15189	[.000]
log (oil & gas price)	0.879330	0.333861	2.63382	[.008]
log (lagged new leases)	0.781821	0.149771	5.22009	[.000]
Adjusted R^2	0.922505			
Number of observations	152,	State fixed effects reported separately		
Standard errors are heteroscedastic-consistent				

The supply elasticities estimated here are noteworthy for state fiscal planners because they imply that swings oil and natural gas prices have disproportionate impacts on tax revenues. For example, 10 percent higher oil prices do not imply a 10 percent increase in oil tax revenues but instead a 16.6 percent increase due to the supply response. The swings in mineral tax revenues due to natural gas prices is even larger. In contrast, the study by Gerking et al. (2000) finds that production is driven largely by reserves not prices. In contrast, the study by Kunce et. al (2003) finds that the long-run supply elasticity is nearly unitary. The larger supply elasticities found in this study may be a reflection of the unconventional oil and gas revolution in which hydraulic fracturing and horizontal drilling have expanded the resource base and increased the ability of producers to respond to market prices.

This study uses the 2SLS estimates for the econometric models for oil and gas well completions reported in Tables 1 and 2 to project well completions for each of the eight states given forecasts for oil and natural gas prices. These conditional forecasts of well completions, provide a basis to project oil and natural gas production using the methods described in the following section.

3.2 New Oil & Gas Production

At any given point in time, there are thousands of wells producing oil and gas. This inventory includes many different "vintages" of wells from those drilled in the current year to wells completed in previous years that are still producing. If incremental production from new wells does not change much from year to year and if the rate of production decline from old

wells is gradual, then the impact of new wells on total incremental production is likely to be small. With unconventional oil and gas production, however, new wells are much more productive than those drilled in the past. If the productivity of new wells is greater than production from all previous vintages, then total production increases, assuming all other factors are constant. If new well completions stop completely, then total production likely will fall. The importance of new production is illustrated in Figure 5, which compares production from wells drilled after 2000 to those before. Notice that production from wells completed after 2000 make up a larger share of total production in each year so that by 2019 most of total production is from these newer wells.

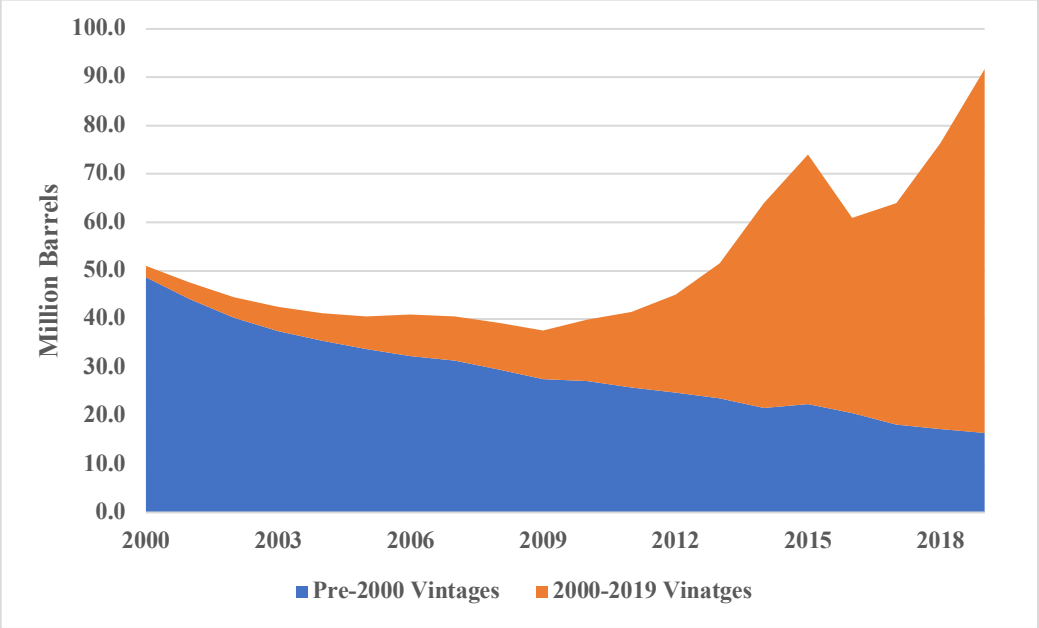

Figure 5: Composition of Wyoming oil production, 2000 - 2019

A more detailed look at this process is illustrated in Figure 6 that plots production decline curves for vintages of Wyoming wells completed after 2010 when unconventional technology gained widespread adoption in the oil industry. These decline curves are constructed using well records available forom DrillingInfo, Inc. For instance, in 2010 there were 229 oil wells completed in Wyoming with average first year production of 10,623 barrels. After increasing slightly to 12,021 wells in the second year of production, output from this 2010 vintage steadily declines to 6,843 barrels during the tenth year of their operation (see Figure 6).

As unconventional production technology improved for subsequent vintages, first-year production steadily increases. The production decline curves shift up and become steeper, providing more output earlier after reaching roughly similar production levels after five years as wells drilled in earlier years using old technology. First year average oil production per well in Wyoming, for example, steadily increases up to 71,780 barrels in 2019. In other words, the average well drilled during 2019 in Wyoming produced 7 times more oil during the first year than wells drilled ten years earlier.

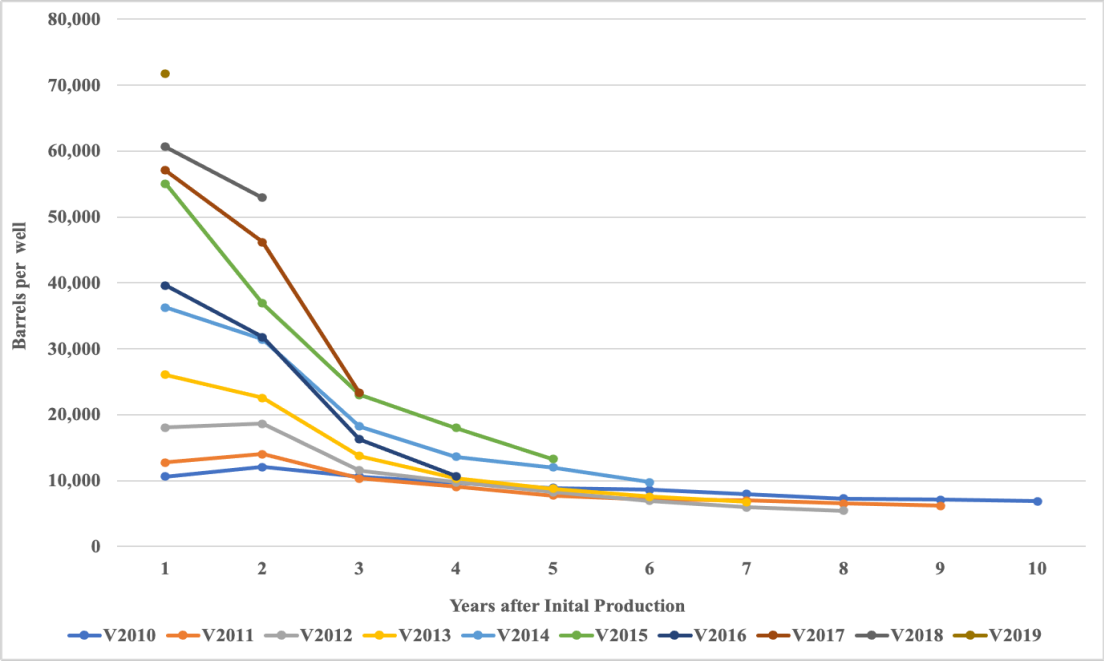

Figure 6: Wyoming production decline curves by vintage, 2010 – 2019

This pattern of increasing first year production is also observed for other states. For example, the average annual rate of change in average oil output per well in New Mexico was 14.1 percent and 15.9 percent in Colorado, see Table 3. With the exception of California and Alaska where production from conventional reservoirs dominates, average annual rates of change in first year production exceed 8 percent for oil. The productivity gains in natural gas are smaller, see Table 3, highlighting the importance of modelling oil and gas well separately.

Table 3: Average annual rates of change in first year production

	Oil	Gas
Wyoming	9.6%	2.2%
New Mexico	14.1%	6.5%
Utah	9.7%	3.2%
Colorado	15.9%	6.1%
North Dakota	8.7%	NA
Montana	9.2%	0.7%
California	-1.5%	-9.4%
Alaska	-1.2%	-2.3%

This study models future production possibilities by constructing production decline curves for oil and gas well completions for each state based upon data after 2010, which again marks the start of the adoption of unconventional oil and gas production technology. To capture the upward shift in the production decline curve, the average of the last three years is our estimate of initial production. Subsequent rates of production decline are based upon historical averages from vintages after 2010.

The estimated oil production decline curves for each state are presented in Table 4. Notice that oil wells from North Dakota have the highest initial production followed by New Mexico and Alaska. The natural gas production decline curves in Table 5 are reported for the Rocky Mountain states because most natural gas production from North Dakota, Montana, California, and Alaska is associated with oil production.

Table 4: Estimated oil production decline curves for 2020 by state

	Thousand barrels per well							
Year	WY	NM	CO	UT	ND	MT	CA	AK
1	63.7	103.7	54.7	36.9	120.1	72.2	9.0	103.7
2	33.6	46.0	16.2	20.0	54.5	55.7	7.7	46.0
3	25.8	32.0	10.2	14.7	38.0	39.8	6.9	32.0
4	21.4	25.5	7.9	12.1	30.4	32.6	6.2	25.5
5	18.7	21.4	6.8	10.0	25.7	28.6	5.5	21.4
6	16.9	18.7	6.0	8.9	23.0	25.4	4.9	18.7
7	15.6	16.4	5.9	8.0	20.4	22.7	4.5	16.4
8	15.0	14.8	5.7	7.2	19.7	20.7	4.1	14.8
9	14.4	13.7	5.5	7.1	16.9	17.8	3.8	13.7
10	13.9	12.7	5.3	6.9	14.5	15.3	3.4	12.7
11	13.4	11.8	5.2	6.7	12.4	13.2	3.1	11.8
12	12.9	10.9	5.0	6.6	10.6	11.4	2.9	10.9
13	12.4	10.1	4.9	6.5	9.1	9.8	2.6	10.1
14	12.0	9.4	4.7	6.3	7.8	8.4	2.4	9.4
15	11.5	8.7	4.6	6.2	6.7	7.3	2.2	8.7
16	11.1	8.0	4.4	6.0	5.7	6.3	2.0	8.0
17	10.7	7.4	4.3	5.9	4.9	5.4	1.8	7.4
18	10.3	6.9	4.2	5.8	4.2	4.6	1.7	6.9
19	9.9	6.4	4.0	5.6	3.6	4.0	1.5	6.4
20	9.5	5.9	3.9	5.5	3.1	3.4	1.4	5.9
Sum	352.8	390.5	169.3	192.9	431.0	404.5	77.8	390.5

Table 5: Estimated natural gas production decline curves for 2020 by state

	Million cubic feet per well			
Year	WY	NM	CO	UT
1.0	397.1	388.5	252.0	200.7
2.0	365.3	403.5	284.6	191.2
3.0	200.8	242.8	153.9	106.3
4.0	141.8	160.1	111.7	80.0
5.0	111.7	138.0	86.3	63.7
6.0	92.6	114.0	74.8	53.6
7.0	79.1	102.4	64.7	47.1
8.0	69.1	90.4	60.0	41.2
9.0	62.1	84.8	54.5	37.5
10.0	55.8	84.0	51.1	34.3
11.0	50.1	83.2	48.0	31.3
12.0	44.9	82.3	45.0	28.6
13.0	40.3	81.5	42.3	26.2
14.0	36.2	80.7	39.7	23.9
15.0	32.5	79.9	37.2	21.9
16.0	29.1	79.1	35.0	20.0
17.0	26.2	78.3	32.8	18.3
18.0	23.5	77.5	30.8	16.7
19.0	21.1	76.7	28.9	15.3
20.0	18.9	76.0	27.1	14.0
Sum	1,898.0	2,603.7	1,560.3	1,071.8

To the extent that recent experience provides a guide, this study assumes that future production decline curves will shift over time but retain the same shape. In other words, average first year production will change but future subsequent rates of production decline will follow the curves implicit in Tables 4 and 5. Initial oil production is assumed to increase at 1.2 percent per annum for all states other than Alaska and California where initial production rates decline 1.2 and 2 percent per annum, respectively.

With an assumed trajectory for oil and natural gas prices, the drilling models predict the number of well completions in each year. The production associated with these initial completions and the output in all future years for each vintage are then computed. Production in each year is the sum of production across all vintages. This approach is designed to capture how policies affecting oil and gas investment affects current and future production.

3.3 Effects of New Federal Leases

Modelling the effects of a drilling ban is straight-forward, simply requiring model simulation with no new well completions on federal lands. Losses from the drilling ban, therefore, are simply a function of projected investment and production without the ban. In contrast, a moratorium on new federal leases requires a model that estimates the effect of new leases on well completion activity. Information on new leases, however, are unavailable in the database used to estimate the models for oil and gas well completions and production. As a result, this study uses data from the US Department of Interior on all new federal leases and well spuds, including oil and gas wells combined. The model is similar to the completion models except new leases and average oil and natural gas prices are explanatory variables.

The estimated parameters are presented in Table 6. The 2SLS estimate for the short and long-run supply elasticities are very similar to the previous estimates. Lagged new leases are highly significant, see Table 6.

Table 6: Parameter estimates for federal lease effects

Dependent variable: log (federal well spuds)				
	Ordinary Least Squares			
	Estimate	Standard Error	t-statistic	p-value
constant	0.0801	0.3891	0.2058	[.837]
log (oil & gas price)	0.1894	0.1590	1.1907	[.236]
log (lagged new leases)	0.1608	0.0349	4.6124	[.000]
log (lagged spuds)	0.7608	0.0592	12.8537	[.000]
Adjusted R^2	0.746144			
	Two-Stage Least Squares			
constant	-0.619176	0.434298	-1.42569	[.154]
log (oil & gas price)	0.555292	0.237367	2.33939	[.019]
log (lagged new leases)	0.155531	0.034565	4.49968	[.000]
log (lagged spuds)	0.754981	0.061377	12.3008	[.000]
Adjusted R^2	0.741109			
Number of observations	152			
Standard errors are heteroscedastic-consistent				

This regression model is used to simulate the effects of no new leases on well spuds, which are displayed in Figure 7. During the first year, no new leases reduce well spuds by 62 percent, see Figure 7. After the fifth year, well spuds fall by 95 percent. This finding is consistent with the five year average term for most oil and gas leases.

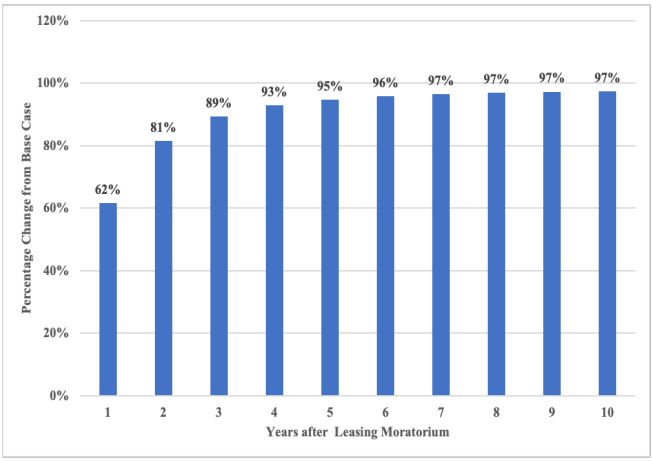

Figure 7: Simulated reduction in well spuds after a lease moratorium

4. Fiscal and Economic Impacts by State

To estimate the fiscal and economic impacts associated with the drilling and production outcomes under different policies, some additional data and assumptions are required. To estimate the value of lost oil and gas investment, average exploration and development costs, or finding costs are collected for 19 and 13 independent producers of oil and gas respectively. Average finding costs for these companies are plotted in Figure 8.

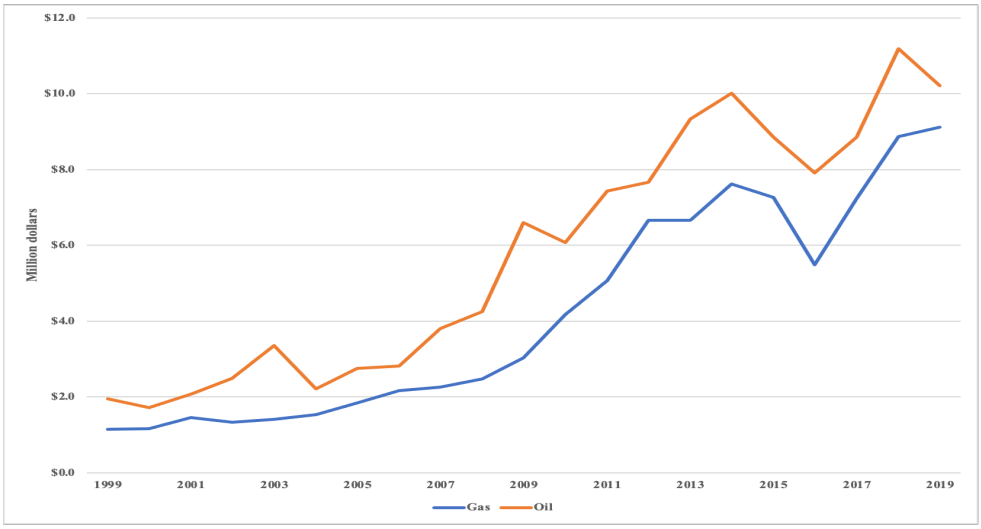

Figure 8: Finding costs for natural gas and oil

Similarly, to estimate the value of production, prices for natural gas and oil, which differ for each state, are projected based upon the short-term and long-term forecasts from the US Energy Information Administration (2020). The average price forecasts are in Figure 9.

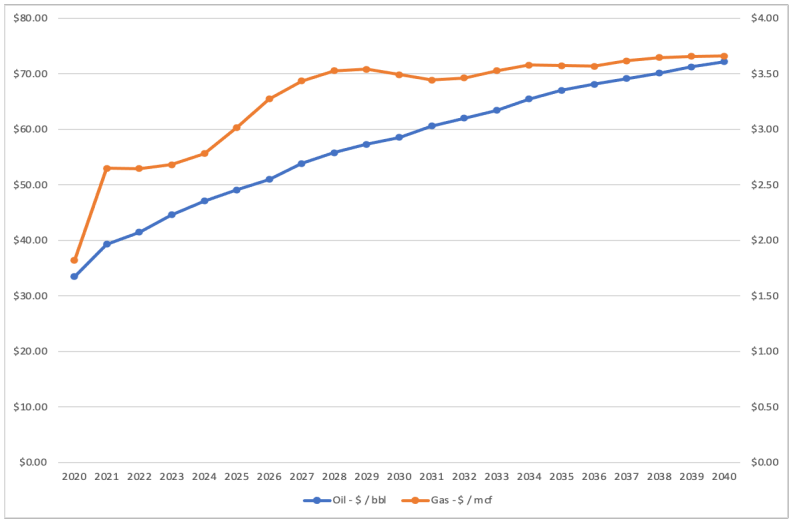

Figure 9: Average price forecasts for natural gas and oil

The drilling model provides estimates of the number of well completions. As demonstrated by the historic production patterns, not all of these completed wells will continue producing. Accordingly, this study allows for a decline in the number of producing wells over time within each vintage. These decline rates in the number of producing wells are presented for each state in Table 7.

Table 7: Projected decline rates for the number of wells by state

	Oil	Gas
Wyoming	-3.1%	-1.0%
New Mexico	-1.9%	-3.1%
Colorado	-4.9%	-2.9%
Utah	-4.7%	-1.2%
North Dakota	-1.8%	-1.8%
Montana	-3.3%	-3.3%
California	-9.2%	-9.2%
Alaska	-1.9%	-1.9%

The well completion and production models apply for each state across all land types. To isolate the effects of policies restricting development on federal and tribal lands, the federal shares of completions and production are multiplied by total drilling investment and production. These shares are available from State Oil and Gas Commissions from Wyoming, Utah, and New Mexico for well completions. Production shares are computed from data published by the US Office of Natural Resource Revenue. The federal shares of well completions for oil and gas in Colorado, California, Montana, Alaska, and North Dakota are assumed to equal their corresponding production shares, see Table 8.

Table 8: Federal shares of well completions and production

	Well Completions		Production	
State	Oil	Gas	Oil	Gas
Alaska	0.6%	0.6%	0.6%	0.6%
California	5.7%	5.0%	5.7%	5.0%
Colorado	3.8%	35.1%	3.8%	35.1%
Montana	14.4%	24.1%	14.4%	24.1%
New Mexico	61.0%	65.4%	51.5%	58.9%
North Dakota	8.3%	8.6%	8.3%	8.6%
Utah	17.3%	77.8%	23.4%	56.8%
Wyoming	62.8%	96.8%	49.6%	81.5%

The fiscal impacts of federal oil and gas policies are computed using the tax rates reported in Table 9. State and local taxes derived from personal income and non-energy production tax rates are computed based upon data from the US Bureau of Economic Analysis. Oil and gas taxes include effective severance and ad valorem taxes and federal mineral royalties, reported by Region Track (2018) as well as lease bonus payments and rents, which are discussed in the Appendix.

Table 9: Tax rates by state in percent

State	Production Taxes	State & Local Taxes	Oil & Gas Taxes*
Alaska	5.55%	0.35%	17.80%
California	6.33%	8.21%	18.70%
Colorado	5.91%	5.19%	18.90%
Montana	6.04%	6.11%	22.50%
New Mexico	6.82%	3.88%	23.10%
North Dakota	7.27%	2.42%	22.00%
Utah	5.60%	6.77%	16.00%
Wyoming	7.41%	0.92%	22.60%

*Include severance and ad valorem taxes and federal royalties

Economic impacts are estimated using two sets of economic multipliers from the US Bureau of Economic Analysis (BEA) – one for drilling investment and another for extraction of oil and gas. Type I multipliers are used in this study to capture the direct and supply chain impacts associated with oil and gas investment and production. The impact of using alternative multipliers is discussed in the following section. Value added or payments to labor and capital is a measure of net economic contribution, which is defined as gross output or revenues less interindustry transactions.

The BEA multipliers for value added, personal income, and employment are presented in Table 10. The value added and personal income multipliers are per dollar of gross output. For example, value added in Wyoming increase $0.6963 for every dollar of drilling investment. The employment multipliers are in terms of jobs per million of gross output. So, for example, if extraction of oil and gas increase by 10 million dollars, 58.44 jobs are supported.

Table 10: Type I multipliers from the US Bureau of Economic Analysis

	Drilling			Extraction		
State	Value Added	Income	Jobs *	Value Added	Income	Jobs*
Alaska	0.6884	0.3256	3.9021	0.7782	0.3395	3.0729
California	0.7677	0.3856	4.5442	0.7728	0.3539	5.8038
Colorado	0.8043	0.4030	5.5485	0.8542	0.3957	3.8240
Montana	0.7160	0.3371	5.7949	0.7837	0.3368	3.2258
New Mexico	0.7105	0.3337	5.3499	0.7841	0.3351	4.4180
North Dakota	0.7205	0.2810	3.4760	0.7999	0.2844	4.5556
Utah	0.7889	0.3918	6.4751	0.8070	0.3673	7.5450
Wyoming	0.6963	0.3253	4.4017	0.7761	0.3334	5.8440
* Per million dollars of output						

The projections of drilling investment translate to impacts on value added, income, and employment via the drilling multipliers in Table 10. Similarly, projections of the value of federal production drive their corresponding economic impacts using the extraction multipliers. The sum of the impacts from changes in investment and production constitute the economic impacts of policies to restrict oil and gas development ton federal lands. The fiscal and economic impacts of leasing moratoriums and drilling bans are now presented for each state in the following sub-sections.

4.1 Wyoming Impacts

Projections of Wyoming well completions for oil and gas appear in Figure 10. After a sharp reduction during 2020, in which oil well completions fell from 410 in 2019 to 79 thus far in 2020, oil well completions are projected to recover to 178 during 2021 and gradually increase thereafter. Gas well completions fell from 279 in 2019 to 18 during the first 10 months of 2020. Like oil, gas well completions will recover modestly over the next five years. Given the expectation that natural gas prices will recover faster than oil prices longer term, gas well completions outpace oil well completions beyond 2025. Nearly all natural gas well completions and 63 percent of oil well completions occur on federal lands in Wyoming.

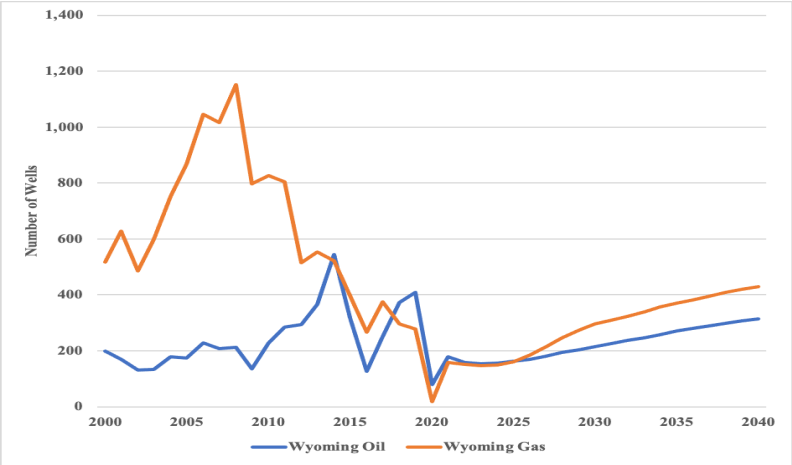

Figure 10: History and forecasts for Wyoming oil and gas well completions

The corresponding production forecasts appear in Figures 11 and 12 for oil and natural gas respectively. New federal production is highlighted in yellow in both figures, which represents the amount of future production at risk from leasing moratoriums and drilling bans. Three points are important. First, future federal oil production is the difference between Wyoming oil production increasing and from production barely reaching its recent peak in 2019. Secondly, future federal gas production could reverse the trend of declining Wyoming gas production. And finally, under a leasing moratorium or drilling ban, lost federal production expands over time and, as a consequence, so would the fiscal and economic impacts.

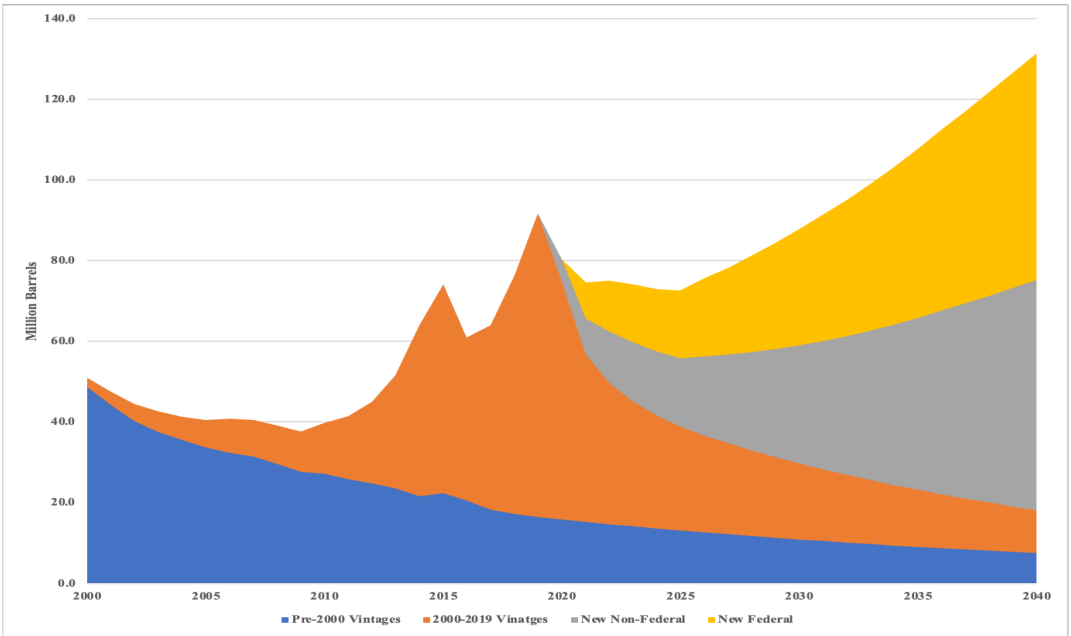

Figure 11: History and forecasts for Wyoming oil production

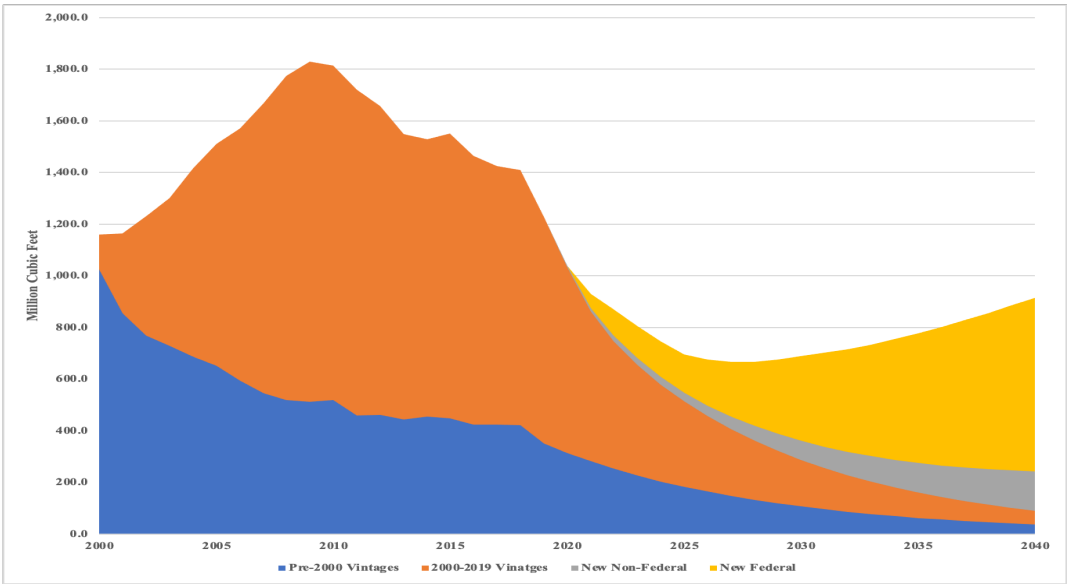

Figure 12: History and forecasts for Wyoming natural gas production

Based upon these investment and production forecasts, a federal leasing moratorium would result in a $1.671 billion reduction in oil and gas investment during the first year. These investment losses escalate to $2.952 billion by 2025, see Table 11. Losses in oil and gas output escalate to $798 and $532 million respectively by 2025. A leasing moratorium reduces annual oil and gas tax revenues by $417 million in 2025 and $20.1 billion over the entire period.

Table 11: Average annual Wyoming oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$1,671	$166	$107	$182
2022	$2,084	$408	$269	$248
2023	$2,306	$573	$370	$311
2024	$2,544	$691	$444	$361
2025	$2,952	$798	$532	$417
2026-30	$4,762	$1,372	$1,033	$722
2031-35	$6,917	$2,469	$1,778	$1,227
2036-40	$8,770	$3,758	$2,552	$1,773
Cumulative	$113,801	$40,629	$28,537	$20,129
	Drilling Ban			
2021	$2,707	$362	$203	$248
2022	$2,558	$551	$347	$298
2023	$2,583	$682	$427	$348
2024	$2,738	$777	$487	$390
2025	$3,114	$872	$569	$442
2026-30	$4,913	$1,440	$1,070	$746
2031-35	$7,073	$2,544	$1,820	$1,254
2036-40	$8,952	$3,851	$2,606	$1,807
Cumulative	$118,387	$42,423	$29,515	$20,755

Under a drilling ban, the losses in oil and gas investment and production are substantially larger, reaching $3.1 billion of lost investment during 2025 and $872 and $569 million in lost oil and gas production respectively. As a result, oil and gas tax revenues are significantly lower with losses of $248 million in 2021 and $442 million in 2025.

If a drilling ban were to remain in effect, Wyoming would suffer significant oil and tax revenue losses over time, averaging $746 million in annual losses during 2026 to 2030, see last column Table 11. Annual tax revenue losses would be $1.2 billion during the 2031 to 2035 period and rise to $1.8 billion from 2036 to 2040. Total oil and gas tax revenues losses amount to $20.7 billion under the drilling ban over the entire 20-year forecast horizon.

While these potential losses are in the future, their magnitude illustrates the significant opportunity costs in terms of lost mineral tax revenues associated with a leasing moratorium or a

drilling ban. Indeed, these policies could create a difficult situation for the State of Wyoming, potentially placing financial support for education, health care, and other public services in jeopardy.

These losses in the oil and gas sector adversely affect the Wyoming economy. During the first year under a leasing moratorium value added is $1.375 billion lower, see Table 12, which drags down personal income by $635 million and lowers employment by 8,950 positions.

Under a drilling ban, the loss in value added increases to $2.3 billion in 2021 and rises to $3.3 billion during 2025, see Table 12. Annual personal income losses exceed $1 billion during the first five years and escalate over time. By 2025, losses in personal income total $1.495 billion. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales taxes associated from lower economic activity, see Table 12. With lower levels of economic activity due to a drilling ban, the level of employment is 15,217 lower in 2021 and 22,129 lower in 2025.

Table 12: Average annual Wyoming economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs***
2021	$108	$1,375	$635	8,950
2022	$155	$1,976	$904	13,128
2023	$183	$2,338	$1,065	15,665
2024	$208	$2,652	$1,207	17,828
2025	$242	$3,088	$1,405	20,772
2026-30	$406	$5,183	$2,353	35,020
2031-35	$635	$8,112	$3,669	55,262
2036-40	$861	$11,003	$4,961	75,475
Cumulative	$10,400	$132,920	$60,135	NA
	Drilling Ban			
2021	$182	$2,323	$1,069	15,217
2022	$194	$2,478	$1,132	16,505
2023	$208	$2,659	$1,211	17,848
2024	$226	$2,887	$1,313	19,439
2025	$257	$3,287	$1,495	22,129
2026-30	$420	$5,369	$2,437	36,294
2031-35	$650	$8,312	$3,759	56,638
2036-40	$880	$11,245	$5,070	77,142
Cumulative	$10,818	$138,264	$62,553	NA

Overall, either a moratorium on new federal leases or an outright drilling ban would constitute a significiant shock to the Wyoming economy, reducing tax revenues, income, and

employment. Moreover, these policies amount to a significiant degradation of the Wyoming's long-term capacity to earn income from oil and gas resources under federal lands.

4.2 New Mexico

Projections for New Mexico oil and gas well completions appear in Figure 13. After a sharp reduction during 2020, in which oil well completions fell from 875 in 2019 to 501 thus far in 2020, oil well completions are projected to recover to 532 during 2021 and gradually increase thereafter. Gas well completions fell from 311 in 2019 to 151 during the first 10 months of 2020. Unlike oil, gas well completions will continue at low levels over the next five years. Oil well completions will significantly outpace gas well completions beyond 2025. There has been a long-term downward trend for natural gas well completions in New Mexico and this is expected to continue. This does not necessarily translate to lower natural gas production in the state because there is a considerable amount of associated natural gas produced in New Mexico. The shares of well completions on federal lands in New Mexico are 61 and 65 percent for oil and gas respectively.

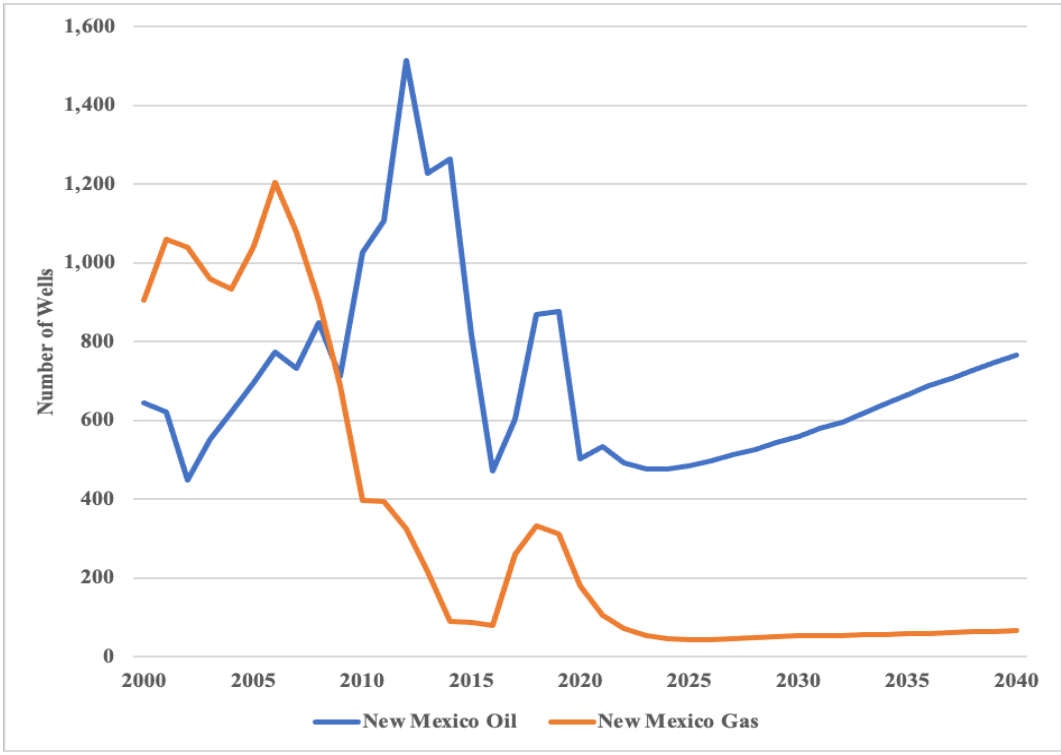

Figure 13: History and forecasts for New Mexico oil and gas well completions

The corresponding production forecasts appear in Figures 14 and 15 for oil and natural gas respectively. New federal production is highlighted in yellow in both figures, which represents the amount of future production at risk from leasing moratoriums and drilling bans. Like Wyoming, future federal oil production is the difference between New Mexico oil production increasing and from production barely reaching its recent peak in 2019. In addition, under a leasing moratorium or drilling ban, lost federal production expands over time and, as a consequence, so would the fiscal and economic impacts.

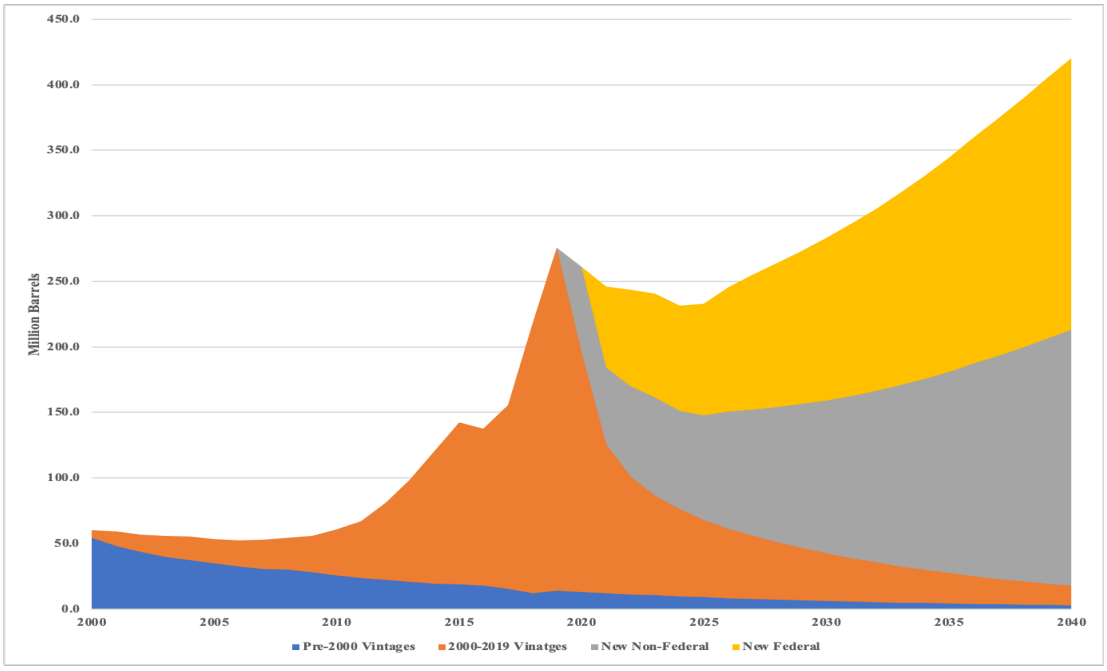

Figure 14: History and forecasts for New Mexico oil production

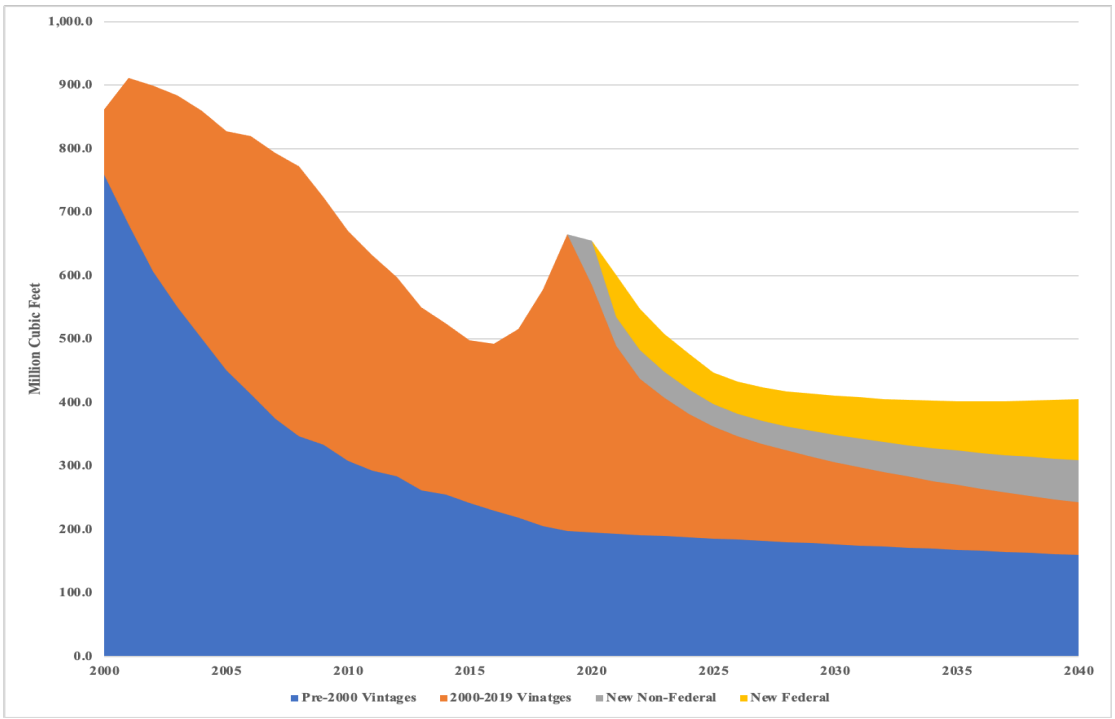

Figure 15: History and forecasts for New Mexico natural gas production

Based upon these investment and production forecasts, a federal leasing ban would result in a $2.107 billion reduction in oil and gas investment during the first year, see Table 13. These

losses in investment spending escalate to $3 billion in 2025, see Table 13. Losses in oil and gas output escalate to $3.7 billion and $825 million respectively in 2025. These losses are considerably higher than Wyoming's losses because oil wells in New Mexico are more productive (see Table 4) and there are more well completions. A leasing moratorium reduces annual oil and gas tax revenues by $1.2 billion in 2025.

Table 13: Average annual New Mexico oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$2,107	$1,006	$170	$639
2022	$2,529	$2,330	$450	$803
2023	$2,660	$2,977	$608	$987
2024	$2,828	$3,288	$695	$1,085
2025	$2,999	$3,683	$825	$1,217
2026-30	$3,594	$5,322	$1,380	$1,765
2031-35	$4,681	$8,078	$2,047	$2,624
2036-40	$5,988	$11,486	$2,884	$3,681
Cumulative	$84,442	$137,714	$34,306	$45,080
	Drilling Ban			
2021	$3,413	$2,886	$607	$1,174
2022	$3,104	$3,417	$736	$1,120
2023	$2,979	$3,711	$812	$1,204
2024	$3,044	$3,836	$862	$1,250
2025	$3,163	$4,131	$974	$1,355
2026-30	$3,710	$5,664	$1,518	$1,876
2031-35	$4,787	$8,376	$2,157	$2,718
2036-40	$6,113	$11,804	$2,989	$3,778
Cumulative	$88,751	$147,200	$37,310	$47,965

Under a drilling ban, the losses in oil and gas investment and production are substantially larger, reaching $3.2 billion of lost investment during 2025 and $4.1 and $974 million in lost oil and gas production. As a result, oil and gas tax revenues are significantly lower with losses of $1.17 billion in 2021 and $1.35 billion in 2025.

If a drilling ban were to remain in effect, New Mexico would suffer significant tax revenue losses over time, averaging $1.87 billion in annual losses during 2026 to 2030, see last column Table 13. Annual tax revenue losses would be $2.7 billion during the 2031 to 2035 period and rise to $3.8 billion from 2036 to 2040. The cumulative loss under a lease moratorium is $45 billion and this rises to $48 billion under a drilling ban.

While these potential losses are in the future, their magnitude illustrates that there are significant opportunity costs in terms of lost mineral tax revenues associated with a leasing

moratorium or a drilling ban. Indeed, these policies could create a fiscal crisis for the State of New Mexico, potentially placing in jeopardy financial support for education, health care, and other public services, especially for local governments and special districts.

These losses in the oil and gas sector spill over to New Mexico economy. During the first year under a leasing moratorium value added is $2.4 billion lower, see Table 14, which drags down personal income by $1.1 billion and lowers the level of employment by 16,466.

Under a drilling ban, the loss in value added increases to $5.2 billion in 2021 and rises to $6.2 billion during 2025, see Table 14. Annual personal income losses exceed $2.3 billion during the first five years under a drilling ban and escalate over time. By 2025, losses in personal income total $2.8 billion. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from slower economic growth, see Table 14. With lower levels of economic activity due to a drilling ban, employment losses are 33,693 in 2021 and escalate to 39,482 by 2025.

Table 14: Average annual New Mexico economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$169	$2,419	$1,097	16,466
2022	$275	$3,976	$1,775	25,810
2023	$325	$4,700	$2,089	30,065
2024	$354	$5,132	$2,278	32,724
2025	$391	$5,666	$2,511	35,962
2026-30	$538	$7,809	$3,445	48,842
2031-35	$775	$11,265	$4,955	69,779
2036-40	$1,067	$15,522	$6,814	95,522
Cumulative	$13,413	$194,877	$85,822	NA
	Drilling Ban			
2021	$358	$5,164	$2,310	33,693
2022	$377	$5,462	$2,427	34,953
2023	$391	$5,663	$2,510	35,919
2024	$403	$5,846	$2,590	37,040
2025	$431	$6,251	$2,767	39,482
2026-30	$569	$8,268	$3,645	51,579
2031-35	$802	$11,660	$5,127	72,145
2036-40	$1,096	$15,942	$6,997	98,054
Cumulative	$14,296	$207,733	$91,446	NA

* Average annual change in employment, cannot be cumulated.

Overall, either a moratorium on new federal leases or an outright drilling ban would constitute a significiant investment and production shock to the economy of New Mexico,

reducing tax revenues, income, and employment. Moreover, these policies deprive New Mexico from developing its abundant oil and gas resources in the Permian Basin.

4.3 Colorado

Projections for oil and gas well completions in Colorado appear in Figure 16. After a sharp reduction during 2020, in which oil well completions fell from 1,179 in 2019 to 422 thus far in 2020, oil well completions are projected to recover to 658 during 2021 and gradually increase thereafter. Gas well completions fell from 269 in 2019 to 109 during the first 10 months of 2020. Unlike oil, gas well completions will continue at low levels over the next five years. Oil and gas well completions will grow beyond 2025, see Figure 15. The shares of well completions on federal lands in Colorado are only 3.8 percent for oil and 31.5 percent for natural gas.

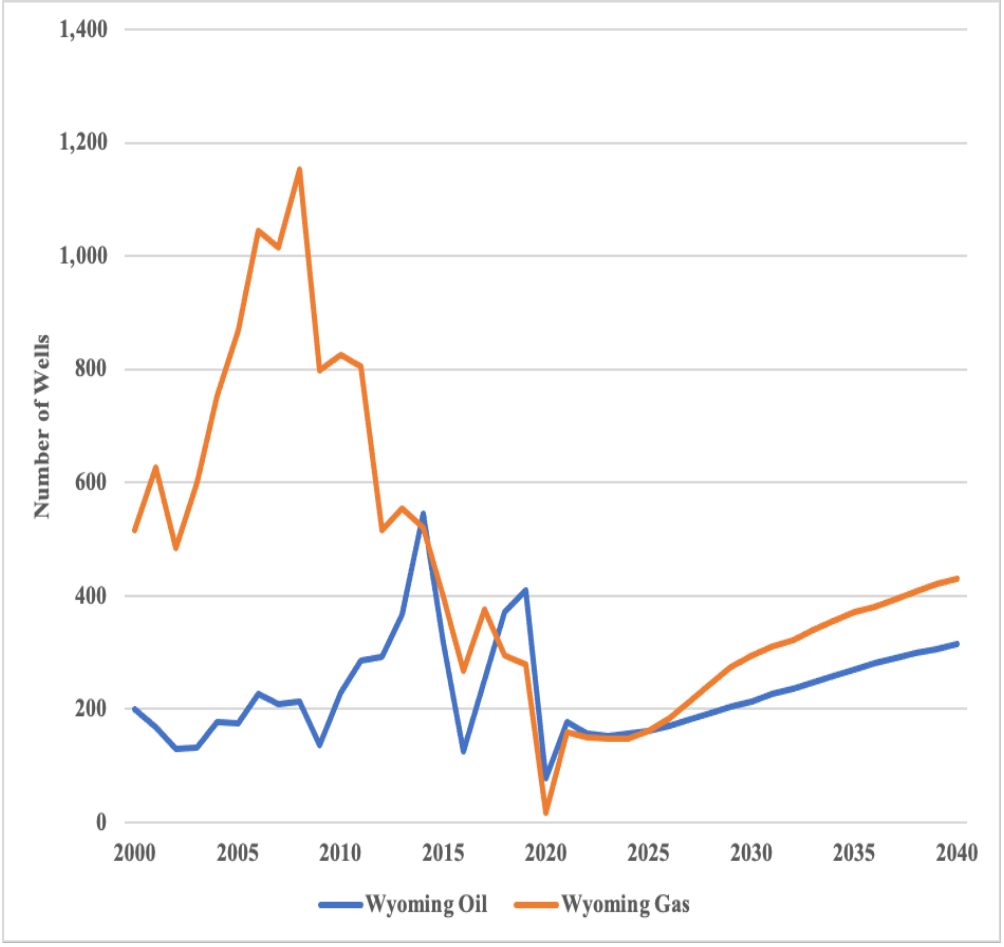

Figure 16: History and forecasts for Colorado oil and gas well completions

The corresponding production forecasts for Colorado appear in Figures 17 and 18 for oil and natural gas respectively. New federal production is highlighted in yellow in both figures, which represents the amount of future production at risk from leasing moratoriums and drilling bans. Unlike New Mexico and Wyoming, future federal oil production in Colorado is relatively small. In contrast, natural gas production on federal lands in Colorado is significant and is projected here to remain so in the years ahead.

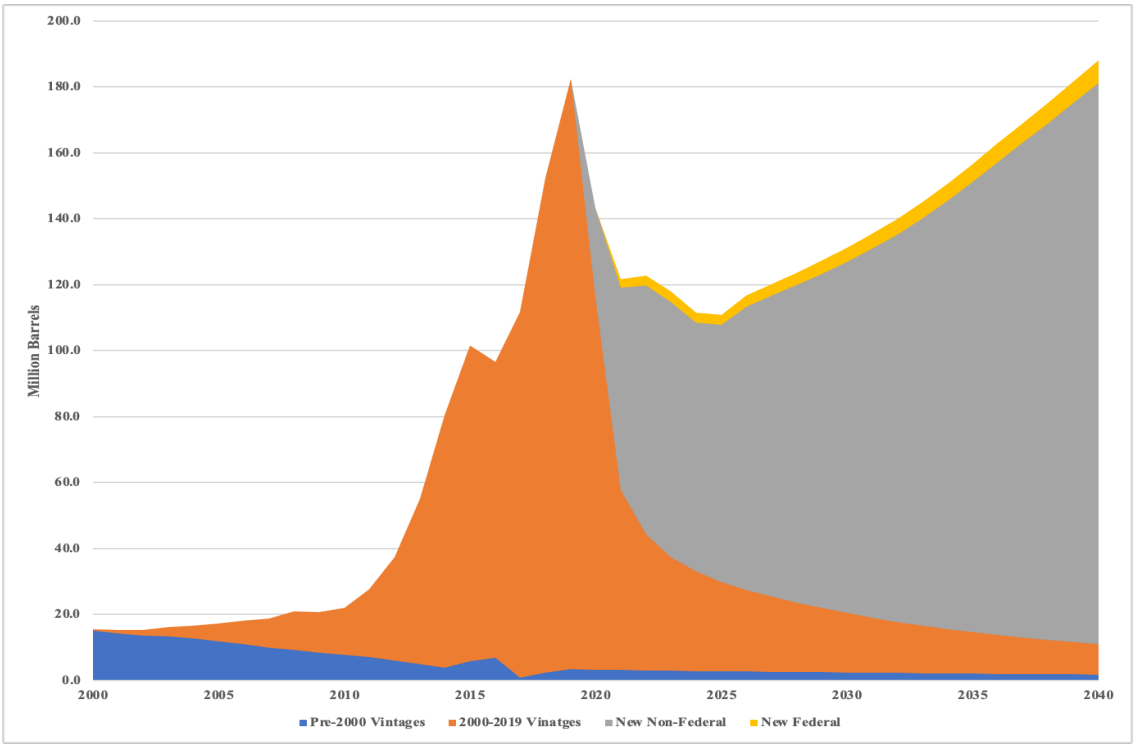

Figure 17: History and forecasts for Colorado oil production

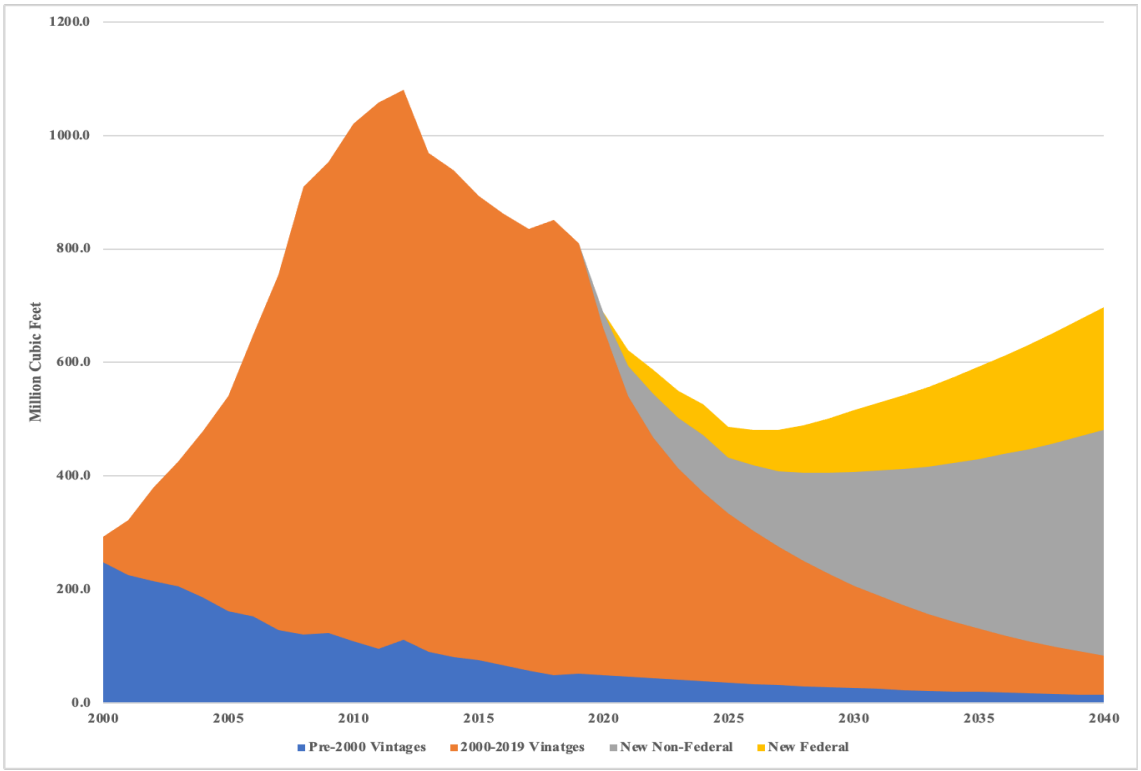

Figure 18: History and forecasts for Colorado natural gas production

Based upon these investment and production forecasts, a federal leasing ban would result in a $461 million reduction in oil and gas investment in Colorado during the first year. These investment losses escalate to $708 million by 2025, see Table 15. Losses in federal oil and gas output escalate to $197 million and $169 million respectively by 2025, see Table 15. A leasing moratorium reduces annual oil and gas tax revenues by $79 million in 2025, which primarily affects rural local governments and special districts for conservation and health care.

Table 15: Average annual Colorado oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$461	$61	$35	$27
2022	$557	$140	$94	$53
2023	$584	$168	$126	$64
2024	$622	$184	$154	$73
2025	$708	$197	$169	$79
2026-30	$1,095	$287	$312	$126
2031-35	$1,508	$444	$519	$200
2036-40	$1,870	$612	$741	$279
Cumulative	$25,293	$7,462	$8,441	$3,323
	Drilling Ban			
2021	$747	$145	$92	$53
2022	$683	$185	$133	$69
2023	$654	$196	$153	$75
2024	$670	$204	$175	$81
2025	$746	$212	$187	$85
2026-30	$1,129	$298	$328	$132
2031-35	$1,542	$455	$535	$205
2036-40	$1,909	$626	$759	$285
Cumulative	$26,399	$7,839	$8,850	$3,471

Under a drilling ban, the losses in oil and gas investment and production are larger, reaching $746 million of lost investment during 2025 and $212 and $187 million in lost oil and gas production respectively. As a result, oil and gas tax revenues are lower with losses of $53 million in 2021 and $85 million in 2025.

If a drilling ban were to remain in effect, Colorado would suffer tax revenue losses over time, averaging $132 million in annual losses during 2026 to 2030, see last column Table 12. Annual tax revenue losses would be $205 million during the 2031 to 2035 period and rise to $285 million from 2036 to 2040. The cumulative loss in oil and gas tax revenue is $3.5 billion over the entire 20 year period, if a drilling ban remained in place.

While these potential losses are in the future, their magnitude illustrates that there are significant opportunity costs in terms of lost mineral tax revenues associated with a leasing moratorium or a drilling ban. Specifically, these policies could create a fiscal crisis for rural counties in Western Colorado, which is the center of federal gas production in Colorado, potentially placing in jeopardy financial support for education, health care, and other public services, especially for local governments and special districts.

These losses in the oil and gas sector spill over to Colorado economy. During the first year under a leasing moratorium value added is $453 million lower, see Table 16, which leads to lower personal income by $224 million and lowers employment by 2,926.

Under a drilling ban, the loss in value added increases to $804 million in 2021 and rises to $941 million during 2025, see Table 16. Annual personal income losses exceed $400 million during the first five years under a drilling ban and escalate over time. In 2025, losses in personal income are $459 million. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from lower economic activity, see Table 16. With lower levels of economic activity due to a drilling ban, employment losses are 5,053 in 2021 and increase to 5,666 by 2025.

Table 16: Average annual Colorado economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$37	$453	$224	2,926
2022	$52	$648	$317	3,984
2023	$58	$721	$352	4,364
2024	$64	$789	$385	4,745
2025	$71	$882	$430	5,325
2026-30	$112	$1,392	$678	8,364
2031-35	$164	$2,035	$989	12,046
2036-40	$214	$2,660	$1,289	15,550
Cumulative	$2,737	$33,927	$16,486	NA
	Drilling Ban			
2021	$65	$804	$395	5,053
2022	$66	$822	$401	5,010
2023	$67	$824	$402	4,965
2024	$70	$862	$420	5,164
2025	$76	$941	$459	5,666
2026-30	$117	$1,444	$703	8,663
2031-35	$168	$2,085	$1,013	12,339
2036-40	$219	$2,718	$1,317	15,886
Cumulative	$2,863	$35,489	$17,243	NA

* Average annual change in employment, cannot be cumulated.

Overall, either a moratorium on new federal leases or an outright drilling ban would reduce tax revenues, income, and employment in Colorado. Moreover, these policies amount to a degradation of the Colorado's long-term capacity to earn income from the oil and gas resources under federal lands. Moreover, given the location of federal oil and gas producing properties in Colorado, rural governments and special districts wil likely bear most of the burden from the inevitable losses in tax revenues and employment.

4.4 Utah

Projections of oil and gas well completions in Utah appear in Figure 19. After a sharp reduction during 2020, in which oil well completions fell from 162 in 2019 to 82 thus far in 2020, oil well completions are projected to recover to 142 during 2021 and gradually increase thereafter. Gas well completions fell from 11 in 2019 to only one during the first 10 months of 2020. Unlike oil, gas well completions will continue at low levels over the next five years. Oil well completions will significantly outpace gas well completions beyond 2025. There has been a long-term downward trend for natural gas well completions in Utah and this is expected to continue. This does not necessarily translate to lower natural gas production in the state because there is a considerable amount gas produced as a by-product of oil production. The shares of well completions on federal lands in Utah are 17 and 78 percent for oil and gas respectively.

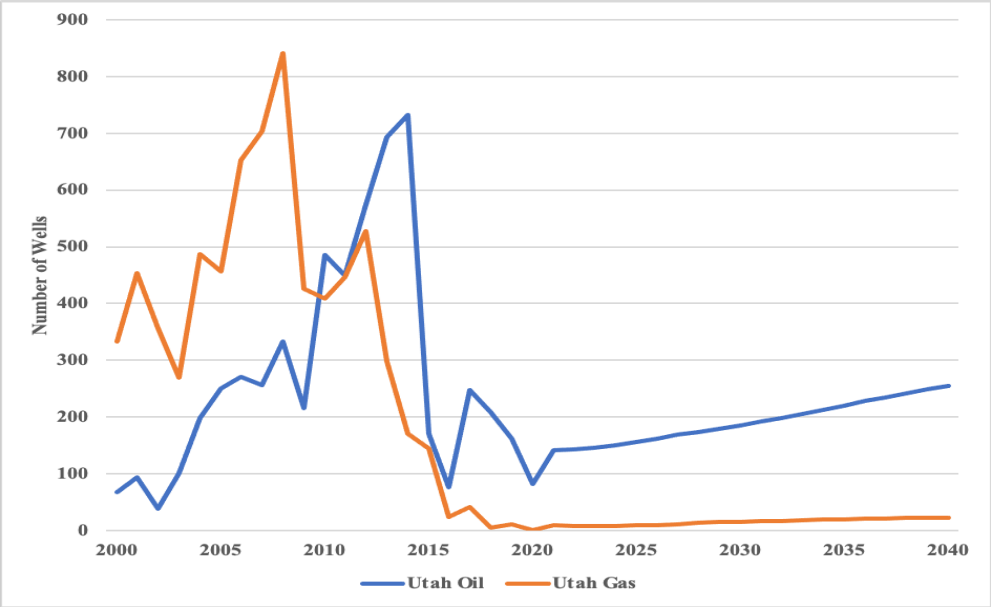

Figure 19: History and forecasts for Utah oil and gas well completions

The corresponding production forecasts appear in Figures 20 and 21 for oil and natural gas respectively. New federal production is highlighted in yellow in both figures, which represents the amount of future production at risk from leasing moratoriums and drilling bans. Unlike Wyoming and New Mexico, future federal oil production is relatively small in Utah and is unlikely to change to expected path of total production. Nevertheless, under a leasing moratorium or drilling ban, lost federal production expands over time and, as a consequence, so would the fiscal and economic impacts.

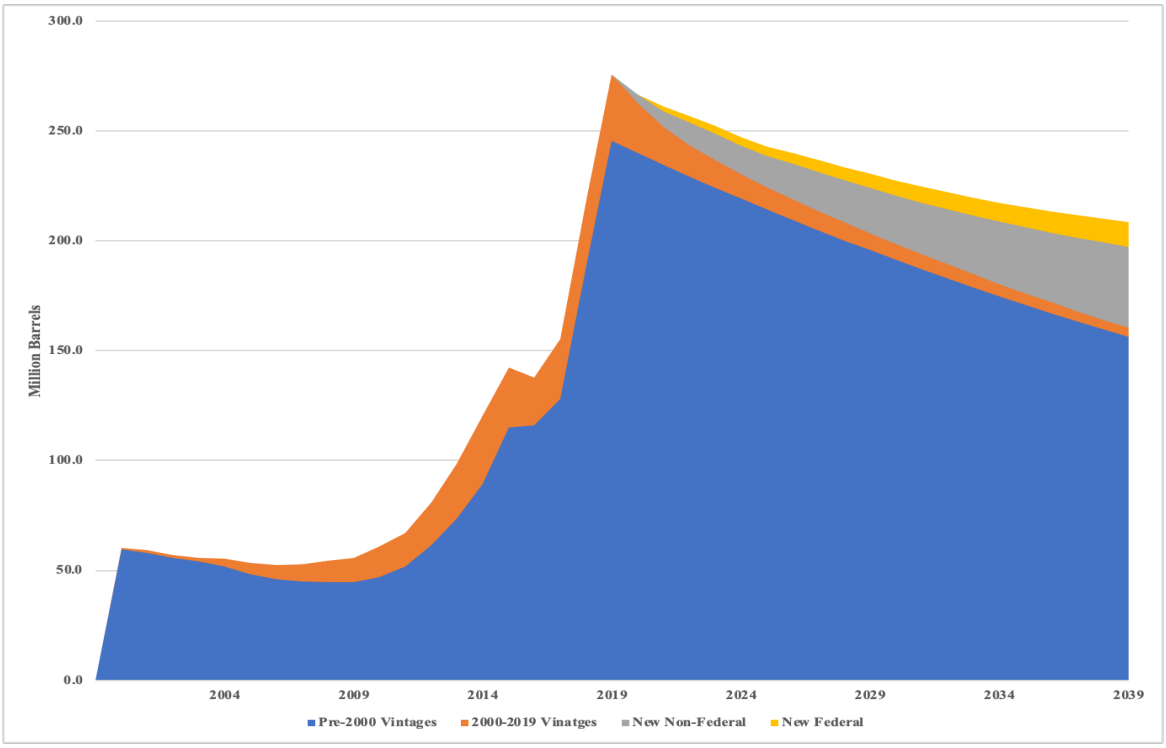

Figure 20: History and forecasts for Utah oil production

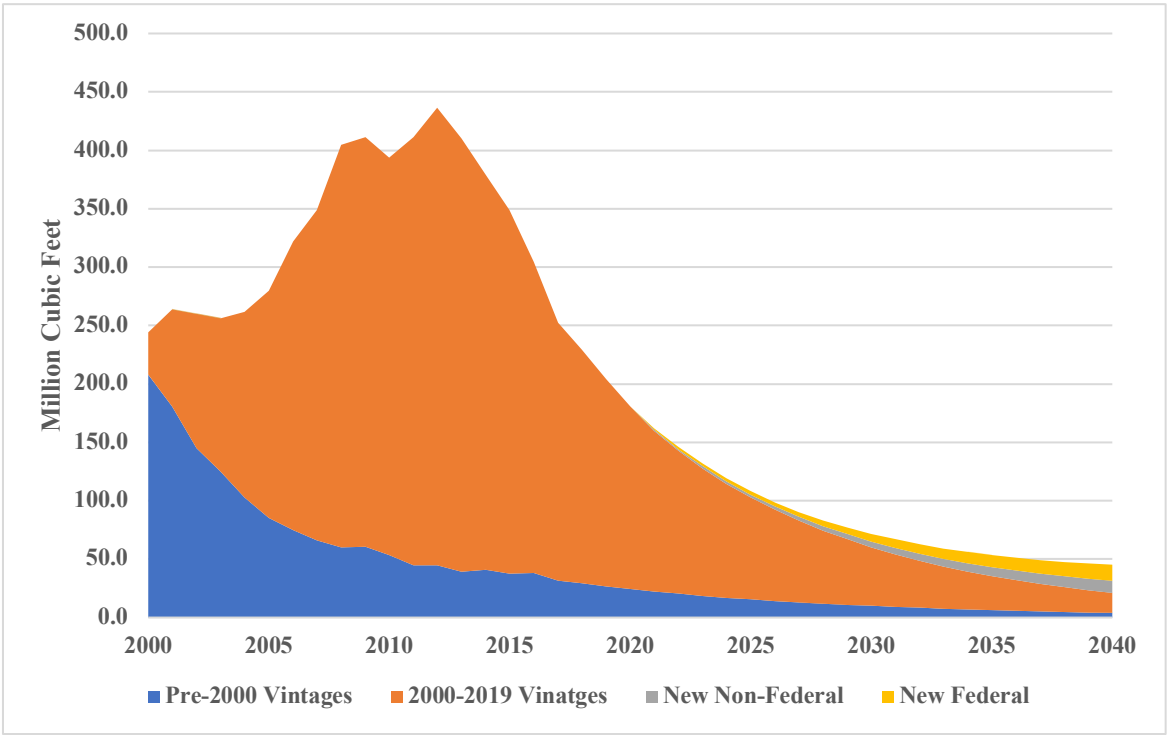

Figure 21: History and forecasts for Utah natural gas production

Based upon these investment and production forecasts, a federal leasing ban would result in a $169 million reduction in oil and gas investment during the first year. These losses in investment spending escalate to $310 million by 2025, see Table 17. Losses in oil and gas output escalate to $187 million and $29 million respectively in 2025. A lease moratorium reduces annual Utah oil and gas tax revenues by $39 million in 2025.

Table 17: Average annual Utah oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$169	$40	$5	$14
2022	$226	$97	$13	$21
2023	$254	$136	$19	$29
2024	$281	$160	$23	$34
2025	$310	$187	$29	$39
2026-30	$406	$283	$51	$59
2031-35	$547	$443	$82	$92
2036-40	$698	$642	$118	$132
Cumulative	$9,497	$7,458	$1,347	$1,553
	Drilling Ban			
2021	$273	$93	$11	$23
2022	$277	$135	$18	$28
2023	$284	$163	$23	$34
2024	$303	$181	$26	$37
2025	$327	$204	$31	$42
2026-30	$419	$297	$54	$62
2031-35	$560	$457	$85	$95
2036-40	$712	$658	$121	$135
Cumulative	$9,921	$7,834	$1,409	$1,623

Under a drilling ban, the losses in oil and gas investment and production are somewhat larger, reaching $327 million lost investment during 2025 and $204 and $31 million in lost oil and gas production. As a result, lost oil and gas tax revenues are $23 million in 2021 and $42 million in 2025.

If a drilling ban were to remain in effect, Utah tax revenue losses increase over time, averaging $62 million in annual losses during 2026 to 2030, see last column Table 17. Annual tax revenue losses would be $95 million during the 2031 to 2035 period and rise to $135 million from 2036 to 2040. Total cumulative losses in oil and gas tax revenues under a leasing moratorium are $1.5 billion in Utah and rise to $1.6 billion under a drilling ban.

While these potential losses are in the future, they are emblematic of the opportunity costs in terms of lost mineral tax revenues associated with a leasing moratorium or a drilling ban.

Like Colorado, most of Utah's federal natural gas properties are located in rural areas, where oil and gas income provide a lifeline of financial support for education, health care, and other public services, especially for local governments and special districts.

These losses in the oil and gas sector spill over to the Utah economy. During the first year under a leasing moratorium value added is $169 million lower, see Table 18, which drags down personal income by $81 million and lowers the employment level by 1,426.

Under a drilling ban, the loss in value added increases to $299 million in 2021 and rises to $448 million during 2025, see Table 18. Annual personal income losses exceed $142 million during the first five years under a drilling ban and escalate over time. By 2025, losses in personal income total $207 million. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from lower economic activity, see Table 18. With lower levels of economic activity due to a drilling ban, employment losses are 2,553 in 2021 and escalate to 3,895 by 2025. Overall, either a moratorium on new federal leases or an outright drilling ban would result in lost opportunities for the economy of Utah.

Table 18: Average annual Utah economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$16	$169	$81	1,426
2022	$25	$267	$125	2,293
2023	$31	$325	$151	2,810
2024	$35	$370	$172	3,206
2025	$39	$419	$194	3,634
2026-30	$55	$590	$271	5,151
2031-35	$80	$856	$391	7,506
2036-40	$109	$1,164	$528	10,256
Cumulative	$1,366	$14,598	$6,674	NA
	Drilling Ban			
2021	$28	$299	$142	2,553
2022	$32	$342	$160	2,945
2023	$35	$374	$174	3,242
2024	$38	$406	$188	3,526
2025	$42	$448	$207	3,895
2026-30	$58	$614	$282	5,360
2031-35	$82	$878	$401	7,708
2036-40	$111	$1,191	$541	10,494
Cumulative	$1,431	$15,285	$6,986	NA

* Average annual change in employment, cannot be cumulated.

4.5 North Dakota

Projections of North Dakota oil well completions are in Figure 22. After a sharp reduction during 2020, in which oil well completions fell from 1,197 in 2019 to 565 in 2020, oil well completions are projected to be 517 during 2021, gradually decline to 2025, and then increase gradually afterward. Nearly all natural gas produced in North Dakota is in association with oil. The shares of well completions on federal lands in North Dakota is slightly over 8 percent.

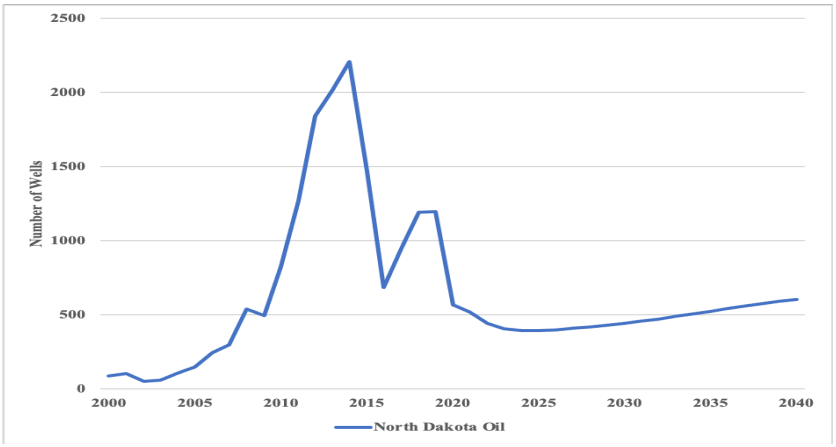

Figure 22: History and forecasts for North Dakota oil well completions

The corresponding oil production forecasts appear in Figures 23. New federal production is highlighted in yellow, representing the amount of future production at risk from leasing moratoriums and drilling bans. Federal oil production is relatively small in North Dakota and is unlikely to change to expected path of total production. Nevertheless, under a leasing moratorium or drilling ban, lost federal production expands over time.

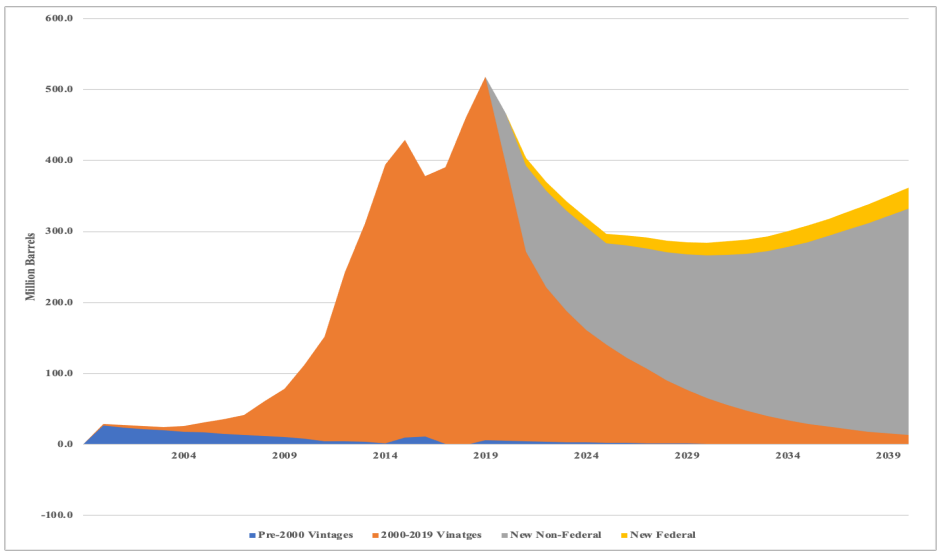

Figure 23: History and forecasts for North Dakota oil production

Based upon these investment and production forecasts, a federal leasing ban would result in a $238 million reduction in oil and gas investment in North Dakota during the first year. These losses in investment spending escalate to $308 million in 2025, see Table 19. Losses in oil and gas output escalate to $529 million and $48 million respectively by 2025. A leasing moratorium reduces annual North Dakota oil and gas tax revenues by $181 million in 2025.

Table 19: Average annual North Dakota oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$238	$143	$10	$36
2022	$274	$350	$28	$135
2023	$282	$441	$37	$156
2024	$295	$503	$43	$172
2025	$308	$529	$48	$181
2026-30	$358	$757	$75	$249
2031-35	$467	$1,128	$105	$358
2036-40	$601	$1,577	$141	$489
Cumulative	$8,526	$19,273	$1,773	$6,161
	Drilling Ban			
2021	$385	$466	$38	$113
2022	$337	$537	$45	$180
2023	$316	$569	$49	$187
2024	$318	$602	$52	$196
2025	$325	$610	$56	$201
2026-30	$370	$819	$82	$264
2031-35	$477	$1,172	$109	$369
2036-40	$613	$1,619	$145	$499
Cumulative	$8,982	$20,836	$1,923	$6,538

Under a drilling ban, the losses in oil and gas investment and production increase, reaching $325 million lost investment during 2025 and $610 and $56 million in lost oil and gas production. As a result, oil and gas tax revenues are lower with losses of $113 million in 2021 and $201 million in 2025.

If a drilling ban were to remain in effect, North Dakota tax revenue losses increase over time, averaging $264 million in annual losses during 2026 to 2030, see last column Table 19. Annual tax revenue losses would be $369 million during the 2031 to 2035 period and rise to $499 million from 2036 to 2040. The cumulative loss in oil and gas tax revenue is $6.5 billion under a drilling ban, greater than the $6.1 billion revenue loss from a lease moratorium.

These losses in the oil and gas sector spill over to North Dakota economy. During the first year under a leasing moratorium value added is $294 million lower, see Table 20, which reduces personal income by $110 million and lowers employment levels by 1,524.

Under a drilling ban, the loss in value added increases to $681 million in 2021 and rises to $767 million during 2025, see Table 20. Annual personal income losses exceed $250 million during the first five years under a drilling ban and escalate over time. By 2025, losses in personal income total $281 million. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from less economic activity, see Table 20. With lower levels of economic activity due to a drilling ban, employment losses are 3,637 in 2021 and escalate to 4,162 by 2025.

Table 20: Average annual North Dakota economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$15	$294	$110	1,524
2022	$25	$500	$185	2,677
2023	$30	$585	$215	3,156
2024	$33	$649	$238	3,513
2025	$35	$683	$251	3,698
2026-30	$47	$924	$337	5,036
2031-35	$67	$1,322	$482	7,236
2036-40	$91	$1,807	$657	9,916
Cumulative	$1,163	$22,978	$8,381	NA
	Drilling Ban			
2021	$35	$681	$252	3,637
2022	$36	$709	$260	3,824
2023	$37	$721	$264	3,910
2024	$38	$752	$275	4,086
2025	$39	$767	$281	4,162
2026-30	$50	$988	$360	5,392
2031-35	$69	$1,369	$499	7,497
2036-40	$94	$1,853	$674	10,167
Cumulative	$1,249	$24,676	$8,996	NA

* Average annual change in employment, cannot be cumulated.

Overall, either a moratorium on new federal leases or an outright drilling ban would result in lost opportunities for the economy of North Dakota. Moreover, these policies reduce North Dakota's opportunities to earn income from the oil and gas resources under federal lands.

4.6 Montana

Projections of Montana oil well completions are in Figure 24. After a sharp reduction during 2020, in which oil well completions fell from 44 in 2019 to 10 during 2020, oil well completions are projected to be 37 during 2021 and increase thereafter. Nearly all future natural gas produced in Montana is likely to be in association with oil. The shares of oil well completions on federal lands in Montana is slightly over 14 percent.

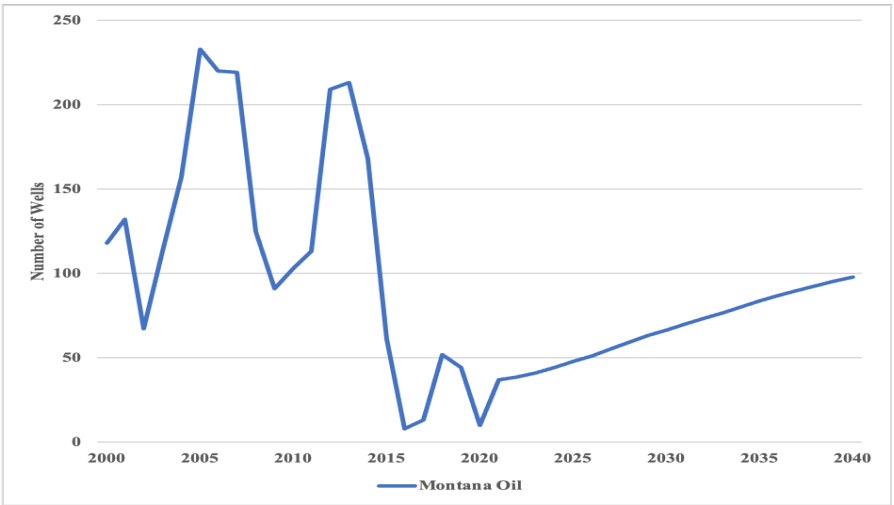

Figure 24: History and forecasts for Montana oil well completions

The corresponding oil production forecasts appear in Figures 25. New federal production is highlighted in yellow, which represents the amount of future production at risk from leasing moratoriums and drilling bans.

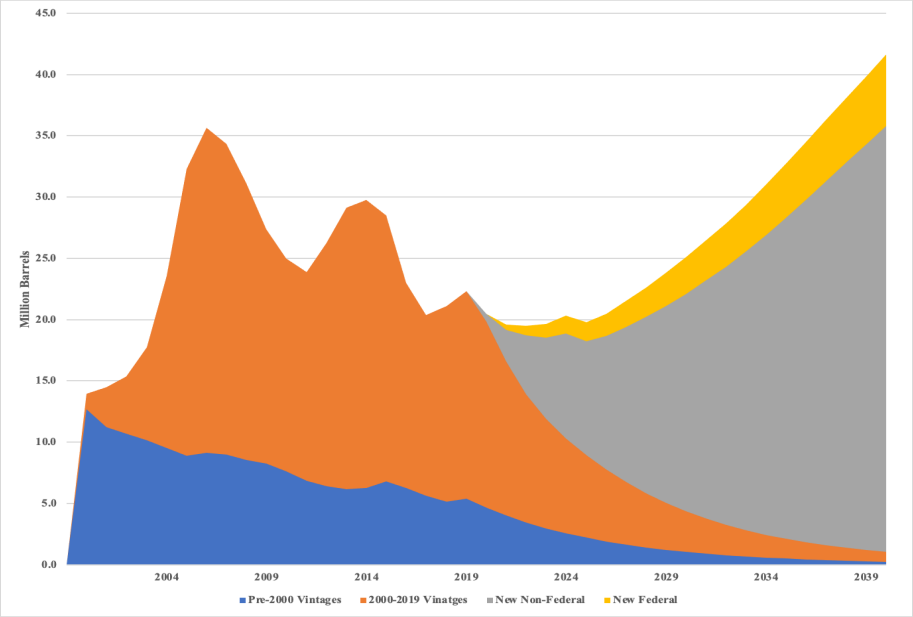

Figure 25: History and forecasts for Montana oil production

Based upon these investment and production forecasts, a federal leasing ban would result in a $32 million reduction in oil and gas investment in Montana during the first year. These losses in investment spending escalate to $78 million by 2025, see Table 19. Losses in oil and gas output are $65 million and $12 million respectively by 2025. A leasing moratorium reduces annual Montana oil and gas tax revenues by $61 million in 2025.

Table 21: Average annual Montana oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$32	$7	$1	$4
2022	$46	$23	$3	$36
2023	$58	$39	$6	$44
2024	$68	$56	$11	$54
2025	$78	$65	$12	$61
2026-30	$112	$119	$21	$93
2031-35	$169	$220	$34	$146
2036-40	$224	$334	$50	$203
Cumulative	$2,809	$3,560	$553	$2,407
	Drilling Ban			
2021	$51	$16	$2	$6
2022	$56	$31	$4	$38
2023	$65	$46	$8	$46
2024	$74	$63	$12	$55
2025	$83	$71	$13	$62
2026-30	$115	$124	$22	$94
2031-35	$173	$226	$34	$148
2036-40	$229	$342	$51	$205
Cumulative	$2,915	$3,682	$572	$2,439

Under a drilling ban, the losses in oil and gas investment reach $83 million during 2025. Lost oil and gas production are $71 and $13 million in 2025. As a result, losses in oil and gas tax revenues are $62 million in 2025.

If a drilling ban were to remain in effect, Montana tax revenue losses increase over time, averaging $94 million in annual losses during 2026 to 2030, see last column Table 21. Annual tax revenue losses would be $148 million during the 2031 to 2035 period and rise to $205 million from 2036 to 2040. Cumulative oil and gas tax revenue losses are $2.4 billion under the drilling ban.

These losses in the oil and gas sector have implications for the Montana economy. During the first year under a leasing moratorium, value added is $29 million lower, see Table 22, which reduces personal income by $13 million and lowers employment by 210.

Under a drilling ban, the loss in value added increases to $50 million in 2021 and rises to $124 million during 2025, see Table 22. Annual personal income losses exceed $23 million during the first five years under a drilling ban and escalate over time. By 2025, the annual loss in personal income total $56 million. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from lower economic activity, see Table 22. With lower levels of economic activity due to a drilling ban, employment losses are 354 in 2021 and 747 in 2025.

Table 22: Average annual Montana economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$3	$29	$13	210
2022	$5	$53	$24	348
2023	$7	$77	$35	479
2024	$9	$101	$46	612
2025	$10	$117	$52	702
2026-30	$17	$190	$85	1,100
2031-35	$28	$320	$142	1,798
2036-40	$40	$462	$205	2,539
Cumulative	$459	$5,234	$2,332	NA
	Drilling Ban			
2021	$4	$50	$23	354
2022	$6	$68	$31	439
2023	$8	$88	$40	546
2024	$10	$111	$50	665
2025	$11	$124	$56	747
2026-30	$17	$197	$88	1,139
2031-35	$29	$328	$146	1,841
2036-40	$41	$472	$209	2,593
Cumulative	$476	$5,421	$2,416	NA

* Average annual change in employment, cannot be cumulated.

While these economic impacts are much smaller those those estimated for other states so too is federal oil and gas production in Montana. Like the previosuly mentioned states, federal oil and gas production in Montana is in rural areas and while these economic losses may seem minor to the overall Montana economy, they will have an impact on rural communities and local governments reliant upon mineral tax revenue.

4.7 California

Projections of oil well completions in California are in Figure 26. After a sharp reduction during 2020, in which oil well completions fell from 1,036 in 2019 to 510 thus far in 2020, oil well completions are projected to be 1,008 during 2021 and increase gradually thereafter. Most

of these wells are small compared to those in other states. Nearly all future natural gas produced in California is likely to be in association with oil. The shares of oil well completions on federal lands in California is 5.7 percent.

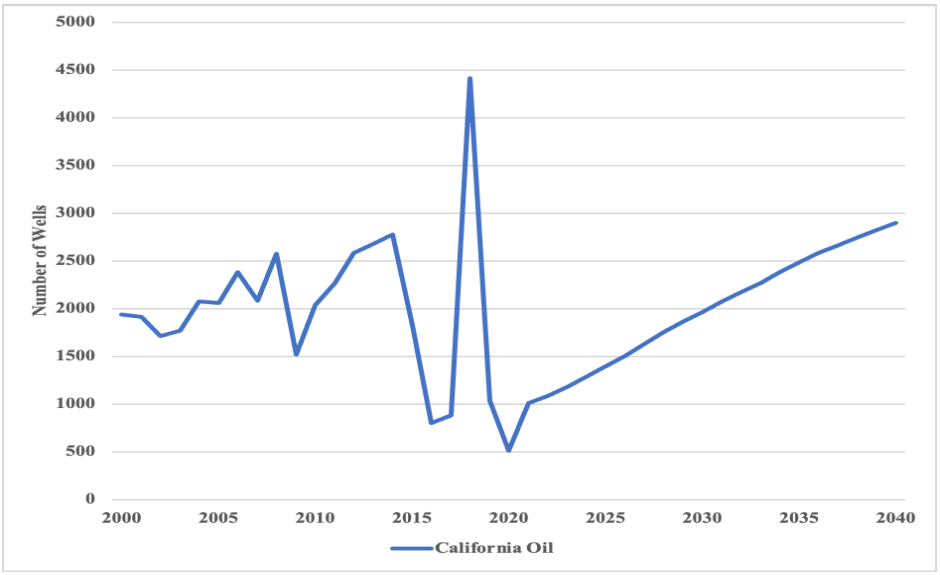

Figure 26: History and forecasts for California oil well completions

The corresponding oil production forecasts appear in Figures 27. New federal production is highlighted in yellow, which represents the amount of future production at risk from leasing moratoriums and drilling bans. Future federal oil production in California is forecast to continue declining until eventually hitting a plateau and then increasing slightly. Consequently, federal production losses from a leasing moratorium or drilling ban are projected to increase over time.

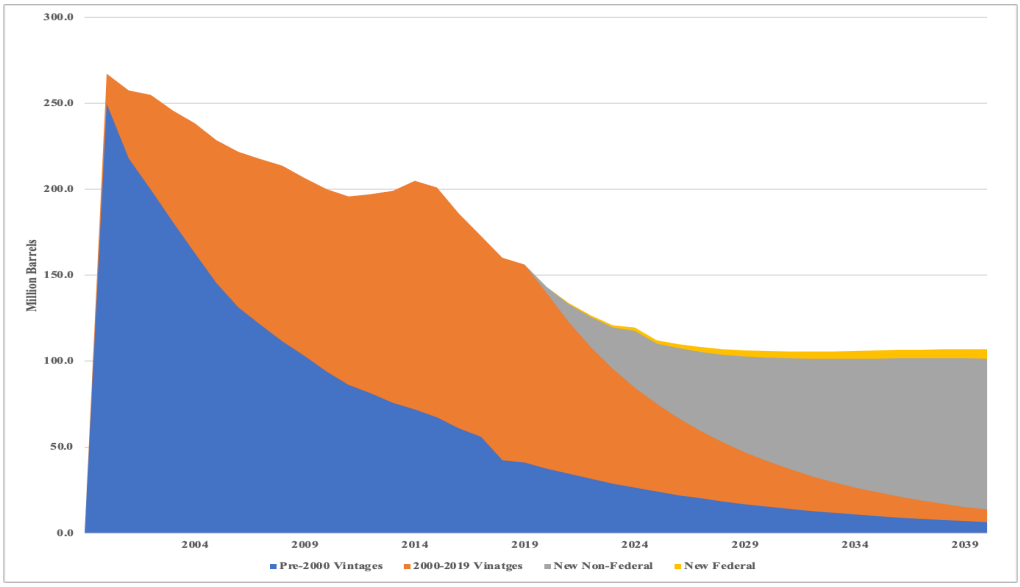

Figure 27: History and forecasts for California oil production

Based upon these investment and production forecasts, a federal leasing ban would result in a $169 million reduction in oil and gas investment in California during the first year. These losses in investment spending escalate to $450 million by 2025, see Table 23. Losses in oil and gas output escalate to $109 million and $8 million respectively in 2025. A leasing moratorium reduces annual California oil and gas tax revenues by $28 million in 2025. These losses are proportionately smaller than losses in other states because California wells are less productive.

Table 23: Average annual California oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$169	$11	$1	$3
2022	$252	$34	$3	$11
2023	$325	$60	$4	$17
2024	$390	$95	$7	$25
2025	$450	$109	$8	$28
2026-30	$650	$189	$16	$48
2031-35	$985	$313	$26	$77
2036-40	$1,307	$411	$34	$100
Cumulative	$16,295	$4,874	$404	$1,207
	Drilling Ban			
2021	$275	$29	$2	$6
2022	$310	$52	$4	$15
2023	$364	$76	$5	$20
2024	$420	$111	$8	$28
2025	$475	$122	$9	$31
2026-30	$671	$200	$17	$50
2031-35	$1,007	$323	$27	$79
2036-40	$1,334	$421	$35	$102
Cumulative	$16,901	$5,112	$426	$1,256

Under a drilling ban, the losses in oil and gas investment and production are somewhat larger reaching $475 million of lost investment during 2025 and $122 and $9 million in lost oil and gas production. As a result, oil and gas tax revenues are lower with losses of $6 million in 2021 and $31 million in 2025.

If a drilling ban were to remain in effect, like the other states California tax revenue losses increase over time, averaging $50 million in annual losses during 2026 to 2030, see last column Table 23. Annual tax revenue losses would be $79 million during the 2031 to 2035 period and rise to $102 million from 2036 to 2040. Cumulative losses in oil and gas tax revenues in California are $1.3 billion under the drilling ban.

During the first year under a leasing moratorium, value added is $139 million lower, see Table 24, which reduces personal income by $69 million and reduces employment by 838. Under a drilling ban, the loss in value added increases to $235 million in 2021 and rises to $466 million during 2025, see Table 24. Annual personal income losses exceed $117 million during the first five years under a drilling ban and escalate over time. By 2025, the annual loss in personal income total $230 million. Compounding the loss in oil and gas tax revenues are additional tax losses arising from lower sales and income taxes associated from lower economic activity, see Table 24. With lower levels of economic activity due to a drilling ban, employment losses are 1,429 in 2021 and escalate to 2,920 by 2025.

Table 24: Average annual California economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$16	$139	$69	838
2022	$25	$222	$110	1,359
2023	$34	$299	$148	1,848
2024	$43	$379	$187	2,366
2025	$49	$436	$215	2,725
2026-30	$74	$658	$323	4,144
2031-35	$115	$1,018	$500	6,444
2036-40	$152	$1,347	$661	8,521
Cumulative	$1,874	$16,589	$8,151	NA
	Drilling Ban			
2021	$27	$235	$117	1,429
2022	$32	$281	$139	1,730
2023	$39	$342	$169	2,126
2024	$47	$414	$204	2,598
2025	$53	$466	$230	2,920
2026-30	$77	$683	$336	4,310
2031-35	$118	$1,044	$512	6,609
2036-40	$155	$1,377	$676	8,709
Cumulative	$1,949	$17,255	$8,477	NA

* Average annual change in employment, cannot be cumulated.

These losses comprise a small fraction of the California economy but again like the other states, rural oil and gas producing areas would be affected and potentially local governments who depend upon revenues and business activity supported by the oil and gas industry in general and federal production specifically.

4.8 Alaska

Projections of Alaska oil well completions are in Figure 28. After a sharp reduction during 2020, in which oil well completions fell from 875 in 2019 to 23 during 2020, oil well

completions are projected to be 110 during 2021 and remain at low levels until potential oil development in the Artic Wildlife Refuge (ANWR). The drilling and production forecast for ANWR is based upon the medium production scenario developed by EIA (2018) in which oil production begins in 2031 and reaches 713 thousand barrels per day in 2040.

This forecast also includes oil field development in the National Petroleum Reserve (NPR), based upon the medium development scenario in the environmental impact study by the Bureau of Land Management (2020). For this federal area, oil production is anticipated to begin during 2021 and peak in 2037 at 213 thousand barrels per day.

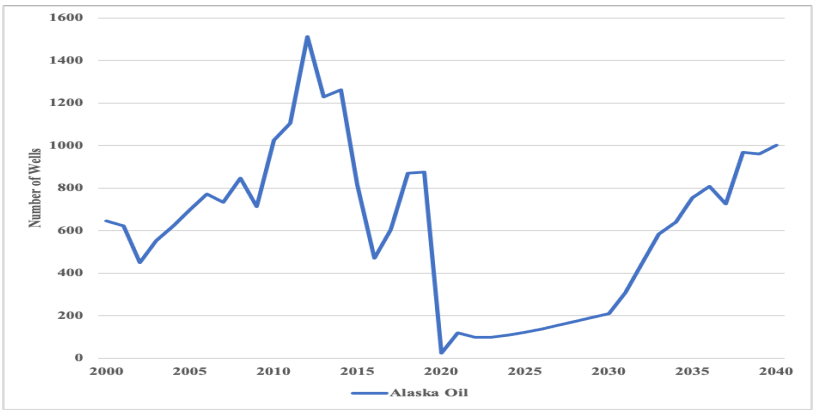

Figure 28: History and forecasts for Alaska oil well completions

The corresponding oil production forecasts appear in Figures 29. New federal production is highlighted in yellow, which represents the amount of potential future production from NPR and ANWR at risk from leasing moratoriums and drilling bans. Given that federal oil and gas leases make up less than one percent of total production, the losses from other federal production is negligible.

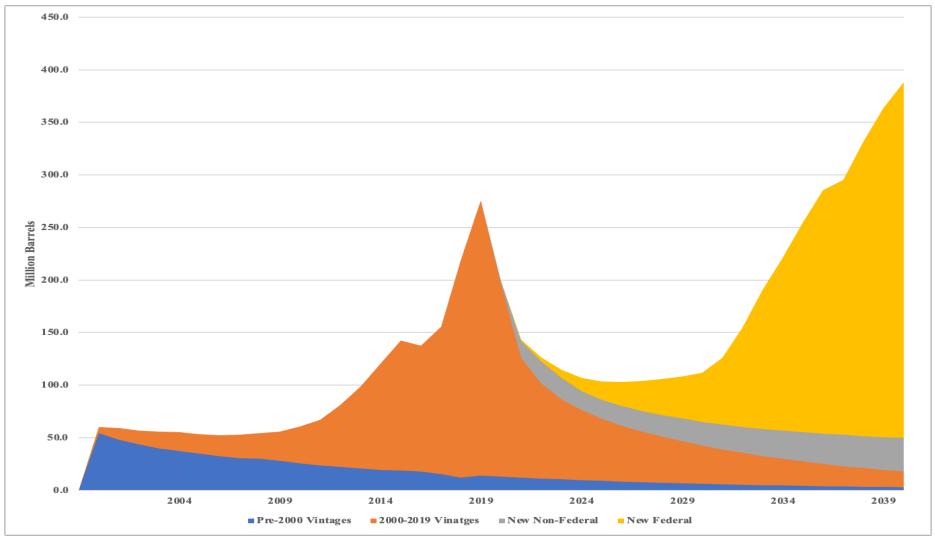

Figure 29: History and forecasts for Alaska oil production

Based upon these investment and production forecasts, a federal leasing ban would result in $800 million reduction in oil and gas investment in Alaska in 2025. These losses in investment spending escalate to $1.5 billion during 2031-2035, see Table 25. Losses in annual oil and gas output are $817 and $204 million respectively during 2025. As a result, oil and gas tax revenues are over $200 million lower in 2025. These tax revenue losses get much larger after 2026, more than doubling to an average annual loss of $454 million during 2026 to 2030, $1.9 billion during 2031- to 2035 and $4.4 billion per year during 2036 to 2040, see Table 25.

Table 25: Average annual Alaska oil and gas sector losses in million dollars

	Lease Moratorium			
Period	**Investment**	**Oil Output**	**Gas Output**	**O&G Taxes**
2021	$63	$33	$10	$18
2022	$210	$147	$38	$48
2023	$393	$328	$79	$89
2024	$592	$556	$133	$141
2025	$800	$817	$204	$204
2026-30	$1,525	$1,859	$495	$454
2031-35	$6,932	$7,909	$1,993	$1,887
2036-40	$13,451	$19,089	$4,610	$4,436
Cumulative	$111,599	$146,166	$35,955	$34,384
	Drilling Ban			
2021	$103	$54	$10	$22
2022	$258	$180	$38	$54
2023	$440	$368	$80	$96
2024	$637	$598	$133	$149
2025	$844	$862	$204	$212
2026-30	$1,573	$1,917	$495	$465
2031-35	$7,471	$8,385	$1,993	$1,971
2036-40	$13,845	$19,629	$4,610	$4,532
Cumulative	$116,728	$151,720	$35,957	$35,373

Under a drilling ban, these lost investment opportunities and lower production get even larger. Cumulative losses in oil and gas tax revenues under the drilling ban are $35.3 billion. If ANWR and NPR were not developed, these investment, production, and tax revenues would be lost as well as the economic gains derived from them, which are presented in Table 26.

Under a drilling ban, the annual loss in value added is $1.4 billion during 2025 and rise to $3 billion per year from 2026 to 2031, mainly due to the loss of output from the NPR. These losses are much larger if the ANWR were not developed, rising to $13.2 billion per year during 2031 to 2035 and $28.4 billion from 2036 to 204, see Table 26. Annual personal income losses are $6 billion during 2031-35 and escalate to over $12.7 billion during 2036-40. Employment losses are also significant.

Table 26: Average annual Alaska economic losses in million dollars

	Lease Moratorium			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$2	$77	$35	379
2022	$8	$288	$131	1,388
2023	$17	$588	$266	2,787
2024	$27	$943	$427	4,426
2025	$39	$1,345	$607	6,259
2026-30	$83	$2,883	$1,296	13,188
2031-35	$359	$12,478	$5,619	57,478
2036-40	$794	$27,701	$12,425	125,308
Cumulative	$6,273	$218,551	$98,167	NA
	Drilling Ban			
2021	$4	$121	$55	598
2022	$10	$348	$158	1,678
2023	$19	$651	$295	3,093
2024	$29	$1,008	$456	4,733
2025	$41	$1,410	$637	6,568
2026-30	$85	$2,960	$1,331	13,551
2031-35	$380	$13,220	$5,956	61,046
2036-40	$814	$28,394	$12,737	128,509
Cumulative	$6,500	$226,406	$101,723	NA

* Average annual change in employment, cannot be cumulated.

Overall, either a moratorium on new federal leases or an outright drilling ban would result in significant economic lossses to the state of Alaska. These policies would forestall upcoming development of oil and gas resources in the National Petroleum Reserve and further delay, if not terminate, development of even more significant resources in the Artic Wildlife Refuge. Limiting access to these reources, would significantly reduce oil and gas tax revenues to the State of Alaska and diminish income and employment opportunities for Alaskans.

4.9 Summing Up

A leasing moratorium or a drilling ban on federal lands reduces investment and future production of oil and gas. The findings reported above are based upon conservative forecasts of drilling activity and future production for each state assuming moderate productivity growth and relatively low oil and gas prices in the future. This section compares tax revenue and personal income impacts across states.

A leasing moratorium or a drilling ban reduce oil and gas tax revenues, which include severance and ad valorem taxes, federal royalties, and lease bonus payments. During the first five years under these policies, two states - New Mexico and Wyoming - incur 77 to 82 percent

of the total losses in oil and gas tax revenues under a leasign moratorium and drilling ban respectively. Under a leasing moratorium, New Mexico incurs average annual losses in oil and gas tax revenues of $946 million, see Table 27. These losses exceed $1.2 billion under a drilling ban. Wyoming faces oil and gas revenue losses of $304 million under a leasing moratorium and $345 million per year under a drilling ban from 2021 through 2025. North Dakota incurs the third largest revenue shortfall, $136 million under a leasing moratorium and $175 million under a drilling ban during the first five years. Overall, across all eight states, a leasing moratorium reduces average annual oil and gas tax revenues by $1.6 billion during the 2021-2025 period for a five-year total of $8.1 billion. Under a drilling ban the five-year total loss increases to $10 billion during the first five years.

Table 27: Average annual losses in oil & gas tax revenues in million dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$304	$722	$1,227	$1,773
New Mexico	$946	$1,765	$2,624	$3,681
Colorado	$59	$126	$200	$279
Utah	$27	$59	$92	$132
North Dakota	$136	$249	$358	$489
Montana	$40	$93	$146	$203
California	$17	$48	$77	$100
Alaska	$100	$454	$1,887	$4,436
Total Average	$1,629	$3,517	$6,610	$11,093
5-Year Total	$8,144	$17,583	$33,050	$55,466
	Drilling Ban			
Wyoming	$345	$746	$1,254	$1,807
New Mexico	$1,221	$1,876	$2,718	$3,778
Colorado	$73	$132	$205	$285
Utah	$33	$62	$95	$135
North Dakota	$175	$264	$369	$499
Montana	$42	$94	$148	$205
California	$20	$50	$79	$102
Alaska	$106	$465	$1,971	$4,532
Total Average	$2,015	$3,688	$6,838	$11,344
5-Year Total	$10,074	$18,441	$34,188	$56,718

If these policies are pursued long term, the foregone opportunities increase because these policies shutdown investment and, thereby, prevent the monetization of oil and gas resource under federal lands. Oil and gas resources are assets that generate income over long periods of time. Leasing moratoriums or drilling bans shutdown the development of these income earning assets.

Unconventional production technology, specifically hydraulic fracturing and horizontal drilling, has dramatically improved the productivity of oil and gas production and, as a consequence, raised the opportunity cost of policies that hinder their development. The rising losses in oil and gas revenues in Table 27, which are driven by lost oil and gas production over time, reflect these rising opportunity costs. Leasing moratoriums and drilling bans reduce investment with long lasting effects. Royalties and severance taxes from a well that would have been drilled are lost not just this year but for all future years.

Table 28 summarizes the impacts on personal income from the leasing and drilling policies across all states in the study region. The leasing moratorium and drilling ban reduce average annual personal income by $4.1 and $5.1 billion respectively during the first five years. The corresponding losses in employment appear in Table 29 indicating an average annual job loss of 58,676 under the leasing moratorium and 72,818 under the drilling ban during the first five years.

Table 28: Average annual personal income losses in million dollars

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	$1,043	$2,353	$3,669	$4,961
New Mexico	$1,950	$3,445	$4,955	$6,814
Colorado	$341	$678	$989	$1,289
Utah	$145	$271	$391	$528
North Dakota	$200	$337	$482	$657
Montana	$34	$85	$142	$205
California	$146	$323	$500	$661
Alaska	$293	$1,296	$5,619	$12,425
Total	$4,152	$8,789	$16,746	$27,542
5-Year Total	$20,761	$43,947	$83,732	$137,708
	Drilling Ban			
Wyoming	$1,244	$2,437	$3,759	$5,070
New Mexico	$2,521	$3,645	$5,127	$6,997
Colorado	$415	$703	$1,013	$1,317
Utah	$174	$282	$401	$541
North Dakota	$266	$360	$499	$674
Montana	$40	$88	$146	$209
California	$172	$336	$512	$676
Alaska	$320	$1,331	$5,956	$12,737
Total	$5,152	$9,182	$17,413	$28,221
5-Year Total	$25,761	$45,909	$87,066	$141,104

Table 29: Average annual employment losses in number of jobs

	Leasing Moratorium			
	2021-25	**2025-30**	**2031-35**	**2036-40**
Wyoming	15,269	35,020	55,262	75,475
New Mexico	28,205	48,842	69,779	95,522
Colorado	4,269	8,364	12,046	15,550
Utah	2,674	5,151	7,506	10,256
North Dakota	2,914	5,036	7,236	9,916
Montana	470	1,100	1,798	2,539
California	1,827	4,144	6,444	8,521
Alaska	3,048	13,188	57,478	125,308
Total	58,676	120,846	217,550	343,088
	Drilling Ban			
Wyoming	18,228	36,294	56,638	77,142
New Mexico	36,217	51,579	72,145	98,054
Colorado	5,172	8,663	12,339	15,886
Utah	3,232	5,360	7,708	10,494
North Dakota	3,924	5,392	7,497	10,167
Montana	550	1,139	1,841	2,593
California	2,161	4,310	6,609	8,709
Alaska	3,334	13,551	61,046	128,509
Total	72,818	126,288	225,823	351,555

5. Sensitivity Analysis

Studies of this nature are subject to a number of uncertainties around key parameters. For the estimates of tax revenues losses, prices and productivity are key unknowns. The greater the productivity, the larger the potential loss. If productivity in the industry increases by 3 percent per year, tax revenues losses are from 5 to 25 percent higher over time, see Table 30.

Higher oil and gas prices also increase these potential losses. For example, if oil prices increase 10 percent, oil tax losses rise 20 percent near term and up to 27 percent longer term, if the price increase persists. The response of natural gas tax revenue losses to an equal percentage change in its price is even greater, upwards of 35 percent.

The economic losses from leasing and drilling bans may not be confined to federal lands. Lower drilling activity on federal lands may have spillover effects on state and private lands. There are two reasons for these spillovers. The first arises from the pattern of land ownership, in which tracts of federal, state, tribal, and federal lands are interspersed in a checkerboard pattern. The second reason stems from a so-called, “communitization” requirement meaning that any drill spacing unit (DSU) with a least one federal or tribal lease can be combined "in the public

interest" with private or state land for the purposes of development, see Holland and Hart (2019). Hence, federal regulations would apply to private and state lands subject to a communitization agreement. The result is that in the checkerboard or other lands with significant federal acreage, rules like a drilling ban could apply to state and private land.

Table 30: Changes in oil & gas tax revenues with higher productivity

	Leasing Moratorium			
State	**2021-25**	**2025-30**	**2031-35**	**2036-40**
Wyoming	4.3%	9.6%	15.7%	22.9%
New Mexico	5.2%	12.2%	20.4%	30.1%
Colorado	3.8%	8.6%	13.9%	20.0%
Utah	5.3%	12.1%	20.2%	29.4%
North Dakota	5.2%	12.3%	20.8%	31.1%
Montana	5.3%	12.0%	20.3%	30.3%
California	3.0%	6.3%	10.2%	14.8%
Alaska	2.9%	6.8%	25.0%	25.0%
Total	4.9%	11.4%	19.7%	26.8%
	Drilling Ban			
Wyoming	3.9%	9.4%	15.7%	22.9%
New Mexico	4.2%	11.7%	20.1%	29.8%
Colorado	3.3%	8.5%	13.8%	20.0%
Utah	4.7%	11.9%	20.0%	29.3%
North Dakota	4.1%	11.7%	20.5%	30.9%
Montana	4.9%	11.8%	20.3%	30.2%
California	2.6%	6.1%	10.1%	14.8%
Alaska	2.6%	6.7%	25.0%	25.0%
Total	4.1%	11.0%	19.6%	26.7%

Estimating these so-called spillovers is complicated because individual wells by land type need to be mapped and then their spud dates need to be compared to determine if a greater number of federal well spuds are associated with greater well spuds on adjacent state and private lands, controlling for other factors affecting drilling activity, such as oil and gas prices. Moreover, if federal lands are restricted then incentives to drill on state and private lands would increase, if they are accessible. To estimate the net spillover effect, this inquiry estimated a vector autoregression of drilling activity by land type. The results were inconclusive. Perhaps because the historical record may not provide enough information for estimating these spillover effects. Nevertheless, these spillovers may be an important to monitor if oil and gas development on federal lands is restricted. If spillovers did emerge then the fiscal and economic losses estimated in this study would rise linearly with the shares of private and state lands affected by federal regulation. In other words, a 10 percent spillover effect would increase fiscal and economic losses by 10 percent.

For the economic impact estimates, there are uncertainties surrounding the economic multipliers. The BEA multipliers used here are based upon input-output analysis that assumes fixed prices and no substitution between factor inputs. In reality, prices and factor intensities shift with economic shocks. Moreover, people move across state lines as employment

opportunities ebb and flow. Another approach to economic impact analysis is to econometrically estimate multipliers from historical data, such as the study by Freyer and Mansur (2017). The results of this estimation are presented in Appendix B.

The average BEA value added multiplier for oil and gas drilling is 0.7366 for the study region while the estimate in Table 31 is 0.22373, 60 percent lower. Similarly, the estimated multiplier for oil and gas extraction in Table 31 is 0.280216, which is 75 percent lower than the BEA multiplier. Explaining why there are such wide differences between input-output based and econometric multipliers remains a topic for additional research.

In summary, higher prices and greater productivity growth tend to increase the estimated tax revenues losses under federal restrictions. In short, the losses are greater from restricting more valuable assets. If spillovers exist in which federal restrictions also restrict development on state and private lands, then fiscal and economic losses would increase. Given these countervailing sensitivities, the fiscal losses presented in this study may be higher than the estimates presented above. On the other hand, econometric multipliers suggest that the economic impacts on value added, employment, and income may be lower than the estimates presented above using the widely used BEA multipliers.

6. Carbon Abatement Costs

Finally, advocates of a restricting oil and gas development on federal lands federal argue that greenhouse gas emissions would be reduced, which is debatable because foreign nations, such as Saudi Arabia or Russia could easily replace the lost production at probably higher net environmental impact.

Even if one assumes that there would be no oil supply response and emissions are lower from restricting development of oil and gas on federal lands, the question is at what cost? Using the losses in value added reported above using BEA Type I multipliers, the cost per ton of avoided emissions under the lease moratorium and the drilling ban are between $177 and $215 per ton, see Table 31.

Table 31: Carbon abatement costs

	BEA	Econometric
Period	Lease Moratorium	
2021-25	$189	$64
2026-30	$177	$58
2031-35	$182	$59
2036-40	$190	$61
	Drilling Ban	
2021-25	$215	$72
2026-30	$183	$60
2031-35	$187	$61
2036-40	$193	$62

Using the econometric multipliers, the cost per ton ranges between $58 to $72 per ton. By comparison, the carbon price from the Regional Greenhouse Gas Initiative in California is currently around $15 per ton. Hence, restricting development of oil and gas on federal lands is a very expensive way to reduce greenhouse gas emissions.

7. Summary and Conclusions

The investment and production losses from leasing and drilling restrictions for the study region are summarized in Table 32. Investment losses are between $4.9 to $8.6 billion and between $7.6 and $9.1 billion per year for no new leases and a drilling ban respectively during the first five years. Production losses are sizable and, as a result, oil and gas tax revenues decline noticeably. Cumulative loses in oil and gas tax revenues under a lease moratorium are $114 billion. A drilling ban drives these losses to $119 billion over the entire twenty year period. Clearly, policies to restrict federal oil and gas development have significant fiscal implications, especially in New Mexico and Wyoming, and particularly large losses longer term for Alaska.

Table 32: Total impacts on oil and gas sector in billion dollars

	Lease Moratorium			
Period	Investment	Oil Output	Gas Output	O&G Tax
2021	$4.9	$1.5	$0.3	$0.9
2022	$6.2	$3.5	$0.9	$1.4
2023	$6.9	$4.7	$1.2	$1.7
2024	$7.6	$5.5	$1.5	$1.9
2025	$8.6	$6.4	$1.8	$2.2
2026-30*	$12.5	$10.2	$3.4	$3.5
2031-35*	$22.2	$21.0	$6.6	$6.6
2036-40*	$32.9	$37.9	$11.1	$11.1
Cumulative	$372.3	$367.1	$111.3	$114.2
	Drilling Ban			
2021	$8.0	$4.1	$1.0	$1.6
2022	$7.6	$5.1	$1.3	$1.8
2023	$7.7	$5.8	$1.6	$2.0
2024	$8.2	$6.4	$1.8	$2.2
2025	$9.1	$7.1	$2.0	$2.4
2026-30*	$12.9	$10.8	$3.6	$3.7
2031-35*	$23.1	$21.9	$6.8	$6.8
2036-40*	$33.7	$38.9	$11.3	$11.3
Cumulative	$389.0	$386.6	$116.0	$119.4

Finally, the economic impacts using the BEA multipliers are summarized for the entire study region in Table 33. The losses in oil and tax revenues are compounded by additional tax revenues losses arising from lower income and value added. Cumulative losses in value added

under the lease moratorium are $640 billion. A drilling ban results in $670 billion in lost value added over the forecast period. Cumulative losses in personal income under the lease moratorium and drilling ban are $286 and $300 billion respectively. A moratorium on new federal oil and gas leases also reduce annual employment levels between 32,000 and 72,000 during the first five years and in the hundreds of thousands if these policies remain in effect in the long term. Employment losses are even greater under a drilling ban.

Table 33: Total economic impacts in billion dollars

	Leasing Ban			
Period	**Other Taxes**	**Value Added**	**Income**	**Jobs**
2021	$0.4	$5.0	$2.3	32,364
2022	$0.6	$7.9	$3.6	49,630
2023	$0.7	$9.6	$4.3	58,420
2024	$0.8	$11.0	$4.9	65,026
2025	$0.9	$12.6	$5.7	72,852
2026-30*	$1.3	$19.6	$8.8	107,703
2031-35*	$2.2	$37.4	$16.7	178,580
2036-40*	$3.3	$61.7	$27.5	289,782
Cumulative	$37.7	$639.7	$286.1	NA
	Drilling Ban			
2021	$0.7	$9.7	$4.4	62,535
2022	$0.8	$10.5	$4.7	67,084
2023	$0.8	$11.3	$5.1	71,650
2024	$0.9	$12.3	$5.5	77,252
2025	$0.9	$13.7	$6.1	85,568
2026-30*	$1.4	$20.5	$9.2	126,288
2031-35*	$2.3	$38.9	$17.4	225,823
2036-40*	$3.4	$63.2	$28.2	351,555
Cumulative	$39.6	$670.5	$299.8	NA

Overall this study finds that there are significant fiscal and economic losses associated with policies that restrict oil and gas development on federal lands. Advocates of these restrictions argue that these policies are justified because they reduce greenhouse gas emissions. Even if one believes that oil and gas producers around the world do not offset lost oil and gas production from federal lands, the costs of achieving these emission savings is quite high. From an economic viewpoint, restricting oil and gas development on federal lands is a very inefficient way to combat climate change. There are many other less costly strategies to reduce greenhouse gas emissions.

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Appendix A: Estimation of Lease Bonus and Rental Payments

Lease bonus and rental payments, other revenue, and rents have been significant in recent years for some states in the study region. For example, the Office of Natural Resource Revenue (2020) reported that these payments to New Mexico were $995.6 million during fiscal year 2019. Lease bonus payments were $203.9 million in Wyoming during the same period.

Lease bonus payments are estimated in the study in two steps. First, average lease bonus payments per acre are estimated based upon revenue data from ONRR (2020) and new lease acreage data from the US Department of Interior from 2016 through 2018. Average new acres leased is computed over the same period. Forecasts of new acres under lease are projected based upon the percentage change in well completions while leases bonus payments per acre as assumed to move with toil and natural gas prices. Future lease bonus payments are projected by multiplying projection acres under lease by the predictions for lease payments per acre.

Projected lease bonus and rental payments appear in Table A1. Notice that payments to New Mexico and Wyoming are projected to be lower than recent levels because oil and gas prices are relatively depressed and industry development activity is currently at low levels. These payments, however, recover as prices increase and drilling activity recovers in the absence of a leasing moratorium or a drilling ban. These projected payments are added to oil and gas tax revenues, which also include federal royalties, and severance and ad valorem taxes.

Table A1: Projected lease bonus and rental payments in million dollars

	AK	CA	CO	MT	ND	NM	UT	WY
2021	$10.5	$0.4	$8.5	$2.6	$2.1	$367.4	$6.8	$120.4
2022	$14.9	$4.3	$8.8	$30.0	$52.0	$160.3	$3.6	$94.8
2023	$16.0	$4.9	$8.9	$34.0	$50.9	$159.5	$3.9	$97.7
2024	$18.5	$5.7	$9.2	$38.5	$52.1	$165.0	$4.3	$104.2
2025	$21.9	$6.5	$9.9	$43.7	$54.6	$175.3	$4.6	$116.5
2026-2030	$35.1	$9.2	$13.2	$61.3	$65.9	$217.1	$6.0	$178.3
2031-2035	$124.0	$13.3	$18.1	$89.1	$86.8	$284.7	$8.0	$267.2
2036-2040	$217.8	$17.2	$23.1	$116.2	$111.2	$361.4	$10.2	$347.2

Appendix B: Econometric Multipliers

The estimates an econometric model in which the change in value added is regressed on oil and gas production and investment shocks are presented in Table B1.

Table B1: Parameter estimates for value added model

Dependent variable: log (change in value added)				
	Ordinary Least Squares			
	Estimate	Standard Error	t-statistic	p-value
log (new oil & gas production)	0.280216	0.083709	3.34750	[.001]
log (change in oil & gas investment)	0.222373	0.051028	4.35788	[.000]
Adjusted R^2	0.2789			
	Maximum Likelihood Autoregression			
log (new oil & gas production)	0.290083	0.085840	3.37933	[.001]
log (change in oil & gas investment)	0.198386	0.046758	4.24280	[.000]
Autoregressive parameter	0.166766	0.081190	2.05403	[.004]
Adjusted R^2	0.29357			
Number of observations	152,			
State fixed & time effects reported separately				

Both the production and investment shocks are statistically significant. The estimates are considerably smaller than the BEA Type I multipliers. These estimated multipliers are relatively close to those estimated by Freyer and Mansur (2017). Employment and income multipliers were also estimated with similar results.