

Emissions from Fossil Fuels Produced on US Federal Lands Present Opportunities for Climate Mitigation

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1 Title

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3 **Opportunities for Climate Mitigation**

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16
17 Abstract

18 *Between 2005 and 2019 emissions from fossil fuels produced on federal lands and*
19 *waters accounted for nearly a quarter of annual US energy emissions, roughly 1,400*
20 *million metric tons of carbon dioxide equivalent per year. Despite their magnitude,*
21 *emissions stemming from federal lands energy production have not historically featured*
22 *in US climate policy. To better understand their future role in the US's emissions profile,*
23 *we model coal, oil and natural gas production on federal lands and waters to 2030, and*
24 *then calculate associated lifecycle climate emissions. We estimate that total emissions*
25 *from fossil fuels produced on federal lands and waters decline 28% below 2010 levels*
26 *by 2030, which falls well short of the 45% global reduction target needed to be*
27 *consistent with avoiding a 1.5°C temperature rise. The Biden-Harris administration will*
28 *likely need to pursue a suite of actions if they hope to bring federal emissions in line*
29 *with ambitious climate targets. Several options, including a carbon adder on royalties*
30 *for new federal leases, can be quickly enacted without Congressional approval.*

31
32 Keywords

33 climate change; energy policy; climate policy; fossil fuels; public lands

34
35 Declarations

36 **Funding** (This work was partially funded by The Wilderness Society)

37 **Conflicts of interest/Competing interests** (Chase Huntley is a Vice President at The
38 Wilderness Society, a public lands conservation organization.)

39 **Availability of data and material** (Data used in Figure 1 is available upon request.)

40 **Code availability** (Figure 1 code is available upon request.)

41 **Authors' contributions** (Nathan Ratledge collected data, performed the production
42 modeling and wrote the paper. Laura Zachary collected data, performed emissions
43 calculations and wrote the paper. Chase Huntley helped to write the paper.)
44

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46 references = 569.
47
48
49

51 The US government is one of the world's largest energy asset managers, responsible
52 for overseeing fossil fuel development on over 2.4 billion acres of onshore and offshore
53 subsurface mineral rights (BLM 2020; BOEM 2020). Oil, gas, and coal extracted from
54 federal public lands and waters (hereinafter referred to as "federal lands") between 2005
55 and 2019 contributed an average 1,408 million metric tons of carbon dioxide equivalent
56 (MMTCO_{2e}) per year, 25% of annual US energy emissions. Despite their sizeable
57 contribution to the US's emissions profile, there is little research on future emissions
58 stemming from federal lands fuel production. Estimating these future trends is critical
59 for developing domestic climate and energy policy, particularly because federal lands
60 production can be regulated directly by the Department of the Interior without
61 Congressional approval (Leshy 2019; Pleune et al. 2020; Krupnick et al. 2016).
62

63 While the US government has acknowledged the large share of US emissions
64 stemming from federal fossil fuels, federal agencies have failed to track federal lands
65 emissions in any comprehensive, annually updated, or public way. In their one-time
66 2018 report, the United States Geological Survey (USGS) estimated that lifecycle
67 emissions from coal, oil and natural gas produced on federal lands and waters
68 accounted for 1,279 MMTCO_{2e} in 2014, 22.4% of US energy emissions (Merrill et al.
69 2018). The USGS report estimated federal lands emissions for 2005 to 2014 and the
70 report established a methodology that was meant to create a publicly available
71 database of estimated greenhouse gas (GHG) emissions associated with fossil fuels
72 from federal lands that would be updated every year. Under the Trump administration,
73 this annually updated database of federal lands emissions never happened. Our
74 research helps to fill this gap and also provides a forward-looking emissions estimate.
75 This work also helps to inform the Biden-Harris administration, who ordered a pause to
76 new oil and gas leases on public lands and offshore waters pending a review to ensure
77 that management of public resources is in line with national climate goals (Exec. Order
78 No. 14008, 2021).
79

80 Specifically, we extend the USGS's work (Merrill et al. 2018) by updating historic federal
81 emissions calculations thru 2019. We then impute future federal lands production to
82 2030 and estimate associated, lifecycle CO_{2e} emissions. These estimates provide a

83 novel, comprehensive assessment of near-term federal lands energy emissions and
84 indicate that, absent a change in policy or market shift, emissions from federal lands'
85 energy production will not play a proportionate role in meeting stringent climate targets,
86 nor demonstrate a leadership position for the federal government.

87

88 First, we aggregate historic coal, oil and gas production on federal lands from the Office
89 of Natural Resource Revenue. We then create an emissions profile to 2019 for each of
90 the five fuel sources, based on the methodology used in the Environmental Protection
91 Agency's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018* (hereon
92 EPA Inventory), which includes upstream, midstream and downstream emissions (US
93 EPA 2020).

94

95 We combine forecasts from the reference case scenario in the EIA's *Annual Energy*
96 *Outlook 2020* (US EIA 2020a) with the historic ONRR data to create panel data to 2030.
97 Using the combined ONRR and EIA data as control variables, we predict future onshore
98 coal, oil and gas production to 2030 via a regularized regression method, specifically
99 synthetic controls with elastic net (Doudchenko and Imbens 2016). We combine our
100 predicted onshore coal, oil and gas estimates with EIA's offshore oil and gas projections
101 to obtain total supply estimates from 2020 to 2030. Finally, we calculate CO₂e
102 emissions for our predicted figures to obtain a future federal lands emissions profile.

103

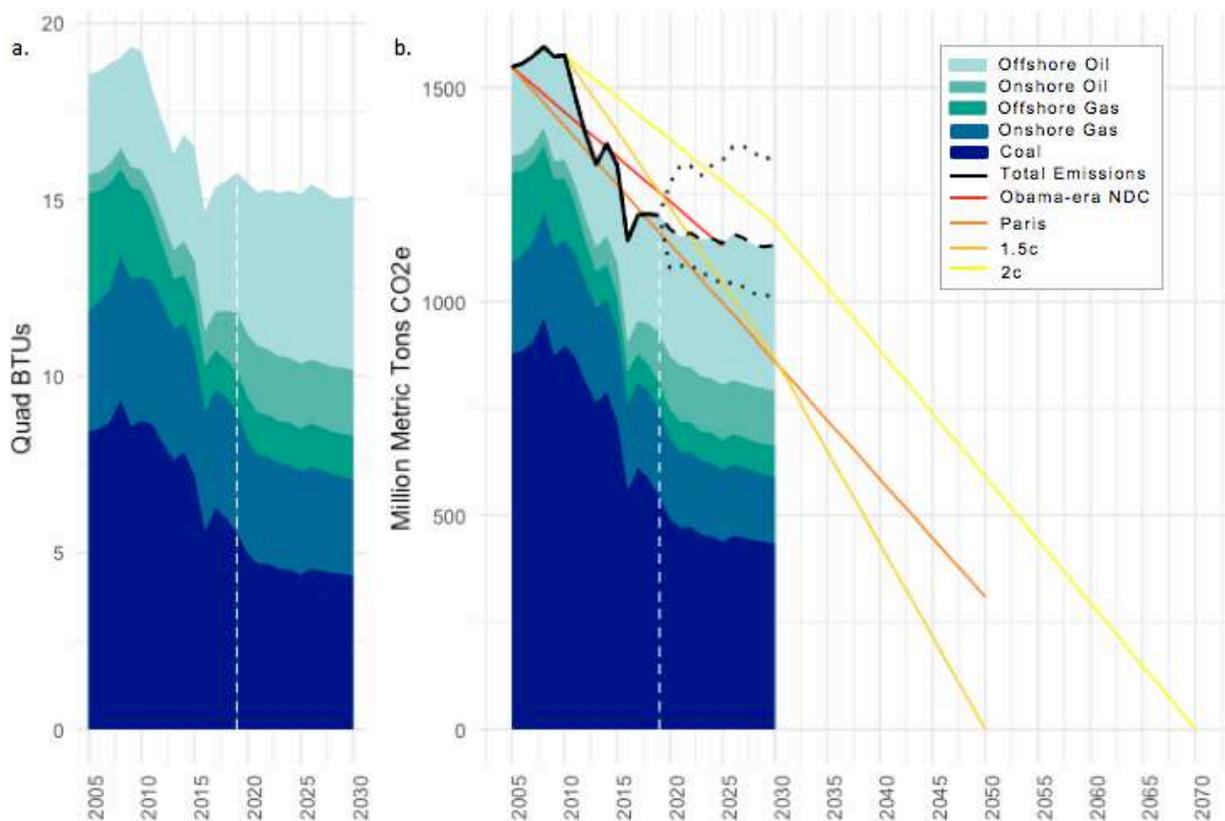
104 We find historic emissions stemming from federal fuels (2005-2019) averaged over
105 1,408 MMTCO₂e annually, nearly 25% of total US energy emissions. For perspective, if
106 federal fuels were a country, its emissions in 2018 would be ranked 6th - just below
107 Japan and tied with Brazil.¹ Over this 15-year period, federal coal emissions fell 38%
108 and natural gas emissions dropped by 37%. Federal oil emissions, however, rose by
109 60% due to onshore and offshore production growth. The estimated costs to society of
110 the lifecycle emissions stemming from fossil fuel development on US federal lands and
111 waters between 2005 to 2019 averaged \$58 billion per year in 2020 dollars. Altogether,
112 federal emissions for years 2005 thru 2019 carry an estimated cumulative cost of \$864
113 billion.

114

115 Looking forward, our model finds modest changes to total future federal energy
116 production between 2019 and 2030, decreasing by just 4%. Given the higher carbon
117 intensities of coal and oil compared to gas, changes by fuel type are of greater note
118 from an emissions perspective. Coal continues its decline, losing 22% of federal
119 production by 2030. Declines in onshore gas production are partially offset by
120 increases in offshore gas, -21% and +15% respectively. Both onshore and offshore oil

¹ Authors compare lifecycle emissions of fossil fuels extracted from public lands and waters in 2018 to country GHG emissions excluding land use change reported by Oliver and Peters (2019).

121 are expected to continue growing at 11% and 24% respectively, contributing an
 122 additional 198m barrels per year by 2030.
 123



124
 125
 126 **Figure 1. Production and emissions from fossil fuels produced on federal lands and waters.** a.
 127 Shaded areas illustrate historic (2005 - 2019) and projected (2020 - 2030) fuel production on federal
 128 lands. b. Shaded areas show historic (2005 - 2019) and projected (2020 - 2030) emissions from fossil
 129 fuels produced on federal lands. Total projected emissions from coal, oil and gas are depicted for the
 130 mean output by the black dashed line. The dotted black lines represent the 95% confidence interval. Four
 131 climate targets are shown with linear reduction trajectories and baselines calibrated to total federal
 132 emissions. Targets include the US's Obama-era Nationally Determined Contribution (NDC) [26-28% of
 133 2005 by 2025]; Paris Climate Agreement 2°C goal ('Paris') [80% of 2005 by 2050]; IPCC's Special
 134 Assessment report's 1.5°C pathway (1.5°C) [45% of 2010 by 2030, net zero by 2050]; and IPCC's Special
 135 Assessment report's 2°C pathway (2°C) [25% of 2010 by 2030, net zero by 2070].
 136

137 Total federal lands emissions drop from 1,550 to 1,140 MMTCO₂e between 2005 and
 138 2030. The majority of these emissions reductions occurred between 2005 and 2019.
 139 We project that emissions fall only 5.6% between 2019 and 2030, from 1,208 to 1,140
 140 MMTCO₂e.

141
 142 Coal emissions comprise the lion's share of historic emissions reductions, dropping by
 143 334 MMTCO₂e or 38%. Coal emissions are predicted to decrease by another 20%

144 below 2019 by 2030, an additional 110 MMTCO₂e. Projected onshore gas emissions
145 decrease by 46 MMTCO₂e, while offshore gas increases by nearly 9 MMTCO₂e in our
146 projections. Federal oil emissions, which primarily come from vehicle exhaust, increase
147 by a combined 78 MMTCO₂e in our model, nearly canceling out the bulk of federal fuel
148 emissions reductions from the coal industry's projected decline. The annual cost to
149 society – based on the social cost of carbon – of US federal fossil fuels between 2020
150 and 2030 range between \$60 to \$76 billion per year in 2020 dollars. Over the decade
151 the aggregate costs range from \$665 to \$840 billion.

152
153 From a climate goal perspective, total federal fuel emissions will decline 26% below a
154 2005 baseline and 28% from a 2010 baseline by 2030. Our mean estimate for federal
155 fossil fuel emissions has fallen adequately to play a commensurate role in meeting the
156 least stringent, near-term trajectory of the 2°C goal established by the IPCC. However,
157 the mean projections fall short of the more aggressive Paris and 1.5°C emissions
158 reduction pathways, supporting earlier analysis (Ratledge et al. 2019). The lowest
159 projections, shown by the lower dotted line in Figure 1b, also fail to meet the more
160 aggressive climate ambitions on the 2030 timeline. Average federal fuel emissions
161 estimates would need to decrease an additional 271 and 279 MMTCO₂e to meet linear
162 trend lines for the 1.5°C and Paris goals.

163
164 The vast majority of the historic and projected emissions reductions were made
165 between 2010 and 2016, when natural gas began rapidly replacing coal in the electricity
166 sector and before unconventional oil development had begun to grow on federal lands.
167 In essence, the low hanging fruit of federal lands emissions reductions have already
168 occurred and were due to market trends. Without new policies or market shifts, our
169 modeling predicts minimal additional gains in federal emissions reductions over the next
170 ten years.

171
172 In total, our projections underscore the commonly held belief that reaching near zero
173 emissions by 2050 will be challenging without additional policy interventions and more
174 rapid clean technology deployment. This thesis is reinforced in the federal fuels case
175 because some of the cheapest fuels in the US lie under federal lands, they are
176 effectively subsidized with leasing and production fees that have not been updated in
177 decades, and many already-leased parcels have ample future supply (US GAO 2019).

178
179 At the same time, the federal government - and the Office of the President - has the
180 unique ability to aggressively reduce CO₂e emissions stemming from federal lands. The
181 Department of the Interior has legal authority to employ a wide range of options - from
182 reducing methane waste, instituting a lease buyback program and requiring mitigation
183 measures at the drilling approval stage (Pleune et al. 2020) to adding a carbon fee on

184 production from new coal, oil and gas leases (Gerarden et al. 2020; Krupnick et al.
 185 2016; Prest 2020). If the US government is serious about leading on climate change
 186 mitigation, they should capitalize on the opportunity presented by overseeing energy
 187 management on federal lands and pursue many available authorities - including
 188 charging the full cost of development - to mitigate emissions from both existing leases
 189 and unleased land.

190
 191 _____

192

193 **Data and Methods**

194 We use publicly available data from the Office of Natural Resource Revenue to obtain
 195 coal, onshore oil, offshore oil, onshore gas and offshore gas production from 2005 to
 196 2019 for federal lands and waters, not including American Indian and Tribal lands
 197 (ONRR 2020). We also gather production data from the Energy Information
 198 Administration’s 2020 Annual Energy Outlook (AEO) Reference Case Scenario, which
 199 runs from 2020 to 2050 (US EIA 2020a).

200

201 The AEO provides projections for oil and gas production for offshore federal lands, but
 202 not onshore federal lands. To impute onshore production we combine historic data from
 203 ONRR with projected data from the AEO to create panel data. In total, we use 34
 204 control variables and covariates to predict three output variables.

205

206 To impute federal onshore coal, oil and gas we use a regularized synthetic controls
 207 method introduced by Doudchenko and Imbens (2016), referred as synthetic controls
 208 with elastic net. This approach combines the traditional synthetic controls method, per
 209 Abadie (2010), with regularized regression. Mathematically,

210

$$211 \widehat{Y}_{j,T}(0) = \widehat{\mu}^{en}(j; \alpha; \lambda) + \sum \widehat{\omega}_i^{en}(j; \alpha; \lambda) * Y_{i,T}^{obs} \quad (1.1)$$

212

213 where \widehat{Y} is the predicted value, $\widehat{\mu}$ is the intercept, λ is the penalty term, and α is how
 214 much weight to place on the Lasso and ridge term. ω is a weight for control
 215 observations, $Y_{i,T}^{obs}$. Predicted values are optimized via,

216

$$217 \underset{\mu, \omega}{\operatorname{argmin}} Q(\mu, \omega | Y_{t,pre}^{obs}, Y_{c,pre}^{obs}) = ||Y_{t,pre}^{obs} - \mu - \omega^T Y_{c,pre}^{obs}||_2^2 + \lambda \cdot \left(\frac{1-\alpha}{2} ||\omega||_2^2 + ||\omega||_1 \right). \quad (1.2)$$

218

219
 220 Essentially, each pre-period predicted variable is regressed separately on pre-period
 221 control variables and covariates, and penalized by an elastic net operator - providing
 222 coefficients for each control variable. These coefficients are applied to the post-period

223 control variables and covariates to estimate the post period predicted variable in each
224 future year.

225

226 We use cross validation to test our model, wherein we randomly selected control
227 variables and covariates and re-estimate held out 'predicted' variables in each bootstrap
228 run. We focus our performance test on three similar control variables supplied in the EIA
229 data – total US coal, oil and gas production, and predict their values from 2020 to 2030.
230 In 100 bootstrap samples per fuel type, we report a RMSE of .25, .68 and .49
231 respectively.

232

233 We apply this same randomly selected bootstrap approach to impute our three variables
234 of interest - federal coal, onshore oil and onshore gas.

235

236 We estimate associated lifecycle emissions of greenhouse gases (carbon dioxide,
237 methane, and nitrous oxide) from federal lands (coal, onshore natural gas, offshore
238 natural gas, onshore oil, and offshore oil) using calculation methods and assumptions
239 employed by the EPA Inventory (US EPA 2020). To calculate downstream emissions
240 we multiply production volumes by sector specific energy flows from EIA's Annual
241 Energy Review (US EIA 2020b) and apply sector specific emission factors derived by
242 multiplying average annual heat content by fuel type and consuming sector from EIA by
243 EPA's emission factors by gas or carbon content coefficient by fuel type (US EPA
244 2018). To calculate upstream and midstream emissions, we scale down EPA's
245 national-level, fuel- and segment-specific emissions data (US EPA 2020) using a ratio
246 of federal production (ONRR 2020) to EIA national production (US EIA 2020b).
247 Emission estimates weigh methane and nitrous oxide by their 100-year global warming
248 potential (IPPC 2007). Note that EPA revised its methane emissions methodology in
249 2019 to show a 1.1% leakage rate for the natural gas system, which is below top-down
250 estimates of 2.36% (Alvarez et al. 2018).

251

252 We calculate the social cost of avoided emissions using the average annual per ton
253 dollar value of avoided CO₂ emissions established by the Interagency Working Group
254 (IWG) on Social Cost of Greenhouse Gases under Executive Order 12866 (IWG 2016).
255 We use the IWG annual global values and a central 3% average discount rate to
256 account for the cost of climate impacts to future generations. All values are adjusted for
257 inflation, applying a cumulative rate of inflation of 24.8% to adjust from 2007 to 2020
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Figures

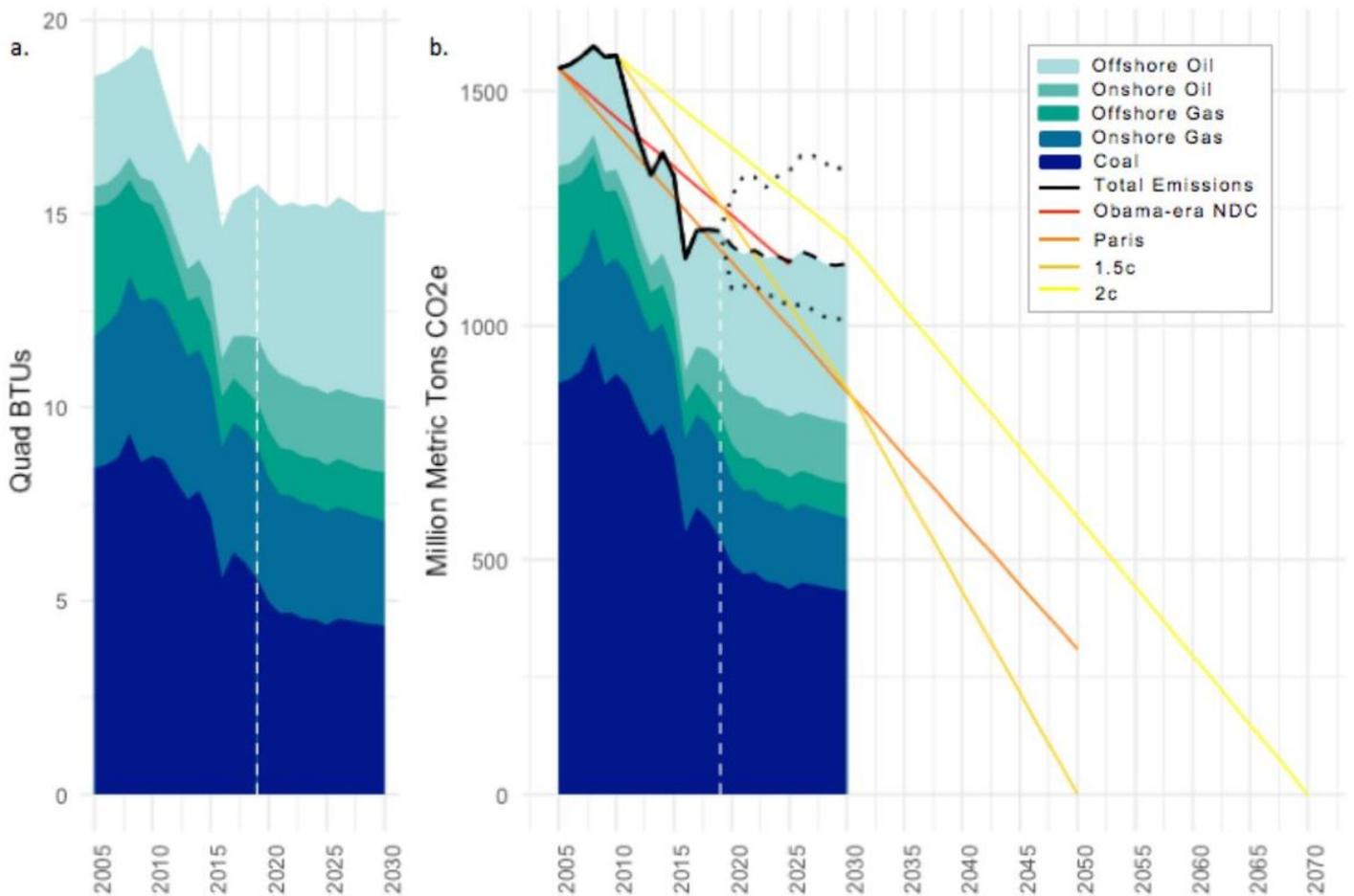


Figure 1

Production and emissions from fossil fuels produced on federal lands and waters. a. Shaded areas illustrate historic (2005 - 2019) and projected (2020 - 2030) fuel production on federal lands. b. Shaded areas show historic (2005 - 2019) and projected (2020 - 2030) emissions from fossil fuels produced on federal lands. Total projected emissions from coal, oil and gas are depicted for the mean output by the black dashed line. The dotted black lines represent the 95% confidence interval. Four climate targets are shown with linear reduction trajectories and baselines calibrated to total federal emissions. Targets include the US's Obama-era Nationally Determined Contribution (NDC) [26-28% of 2005 by 2025]; Paris Climate Agreement 2°C goal ('Paris') [80% of 2005 by 2050]; IPCC's Special Assessment report's 1.5°C pathway (1.5°C) [45% of 2010 by 2030, net zero by 2050]; and IPCC's Special Assessment report's 2°C pathway (2°C) [25% of 2010 by 2030, net zero by 2070].