

Federal lands greenhouse gas emissions and sequestration – a modified EPA methodology

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U.S. Geological Survey

U.S. Environmental Protection Agency
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Our task

- In January 2016, the Secretary of the U.S. Department of the Interior tasked the U.S. Geological Survey (USGS) with generating a publicly available and annually updated database of estimated greenhouse gas (GHG) emissions associated with the extraction and use (predominantly some form of combustion) of fossil fuels from Federal lands.
- We added a second component, the emissions and sequestration from ecosystems on Federal lands, to provide a more complete view of GHG emissions and sequestration on Federal lands.
- Estimates for three GHGs (CO_2 , CH_4 and N_2O) for the years 2005 to 2014 were released in November 2018 (Scientific Investigations Report 2018-5131).

What emissions are “from” Federal lands?

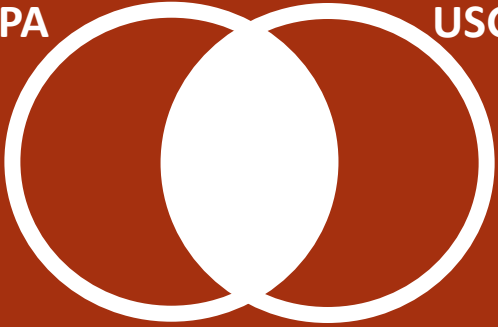
Fossil Fuel Associated: The USGS is estimating emissions associated with the production, transportation and end use combustion of fossil fuels originating only on Federal lands.

Ecosystems Associated: The USGS is estimating emissions and sequestration associated with primary productivity to net biome productivity occurring only on Federal lands.

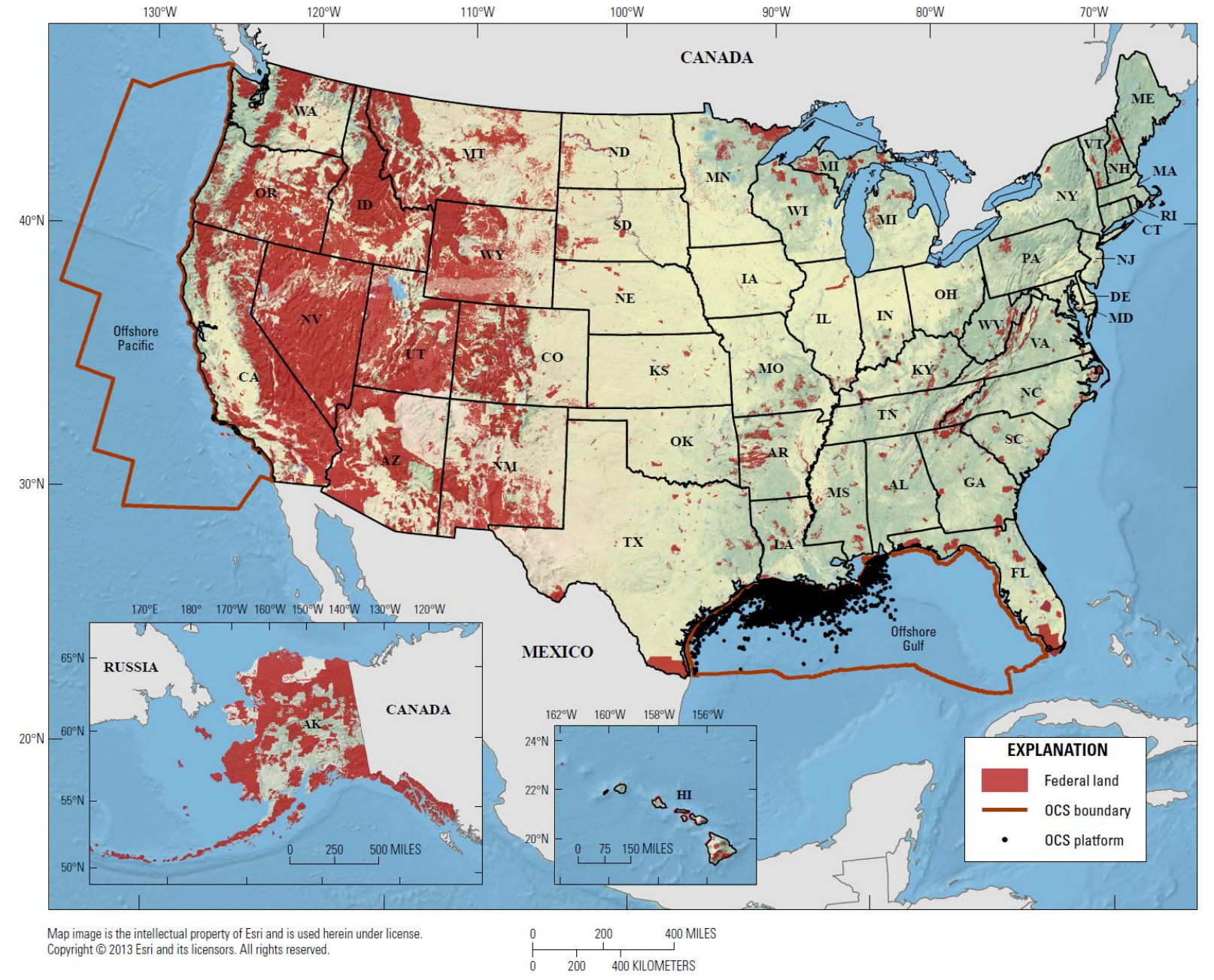
Comparing EPA GHG Inventory and USGS estimate

Fossil Fuel Associated Emissions Comparison	EPA GHG Inventory Energy Sect.	USGS Federal Lands Estimate
Established methodology	Yes	EPA's
Scope and complexity	Broad and evolving	Limited to task
Scale	National	Federal lands in States
Access to Federal lands fuels data	?	Yes
Exported fuels	Domestic side only	Yes

Comparing EPA and USGS: Who counts what?

 <p>EPA USGS</p>	<p>EPA: Emissions that occur in the USA regardless of fuel origin.</p>	<p>USGS: Emissions from fuels originating on US Federal lands regardless of destination.</p>
Oil from private land in Texas refined into gasoline for the US?	Yes	No
LNG from Trinidad & Tobago to fuel buses in Boston?	Yes	No
Coal from Federal lands in Utah that is shipped to Japan?	No	Yes
Coal from Federal lands in Wyoming for US electric power generation?	Yes	Yes

Onshore and offshore Federal lands in this estimate



Data requirements and sources

Fossil fuel production data

*Office of Natural Resources Revenues (ONRR)
and Bureau of Land Management (BLM)*

Fugitive emissions

EPA methodology and assistance

National and State energy
consumption by fuel type, use,
and economic sector

Energy Information Administration (EIA)

Process and sector-specific
emissions factors

EPA methodology and assistance

Report appendix - Example

Table 1–1. Inputs and sources for the stationary combustion greenhouse gas emissions estimate.

Input	Source
Coal, crude oil, and natural gas production volumes from Federal lands	Office of Natural Resources Revenue, data obtained via Memorandum of Agreement MOA16–5285
Coal: export data	U.S. Energy Information Administration, 2016a
Coal: sector use proportions	U.S. Energy Information Administration, 2016a
Coal: sector-specific emission factors	U.S. Environmental Protection Agency, 2014
Natural gas: export data	U.S. Energy Information Administration, 2016b, table 4.1
Natural gas: sector use proportions	U.S. Energy Information Administration, 2013
Natural gas: emission factors	U.S. Environmental Protection Agency, 2014
Natural gas: nonenergy storage factor	U.S. Environmental Protection Agency, 2016a, table A–62
Petroleum products: refining data	U.S. Energy Information Administration, 2015b
Petroleum products: export data	U.S. Energy Information Administration, 2015a
Petroleum products: sector use proportions	U.S. Energy Information Administration, 2016b, tables 3.5 and 3.7
Petroleum products: sector-specific emission factors	U.S. Environmental Protection Agency, 2014

Adapting the EPA Inventory methodology to the USGS task's scale and data availability realities

- Following the EPA Inventory Methodology exactly and generating a small EPA Inventory report clone for the Federal Lands in each State for 2005-2014 would be labor intensive, inefficient, and would not produce a more accurate result. Why?
- Some data are not available at our scale.
 - How much crude oil from Federal lands in Utah was used to make gasoline?
 - If 87% of coal in Colorado was used for electrical power generation, how much of that coal was from Federal lands?
 - Do gas wells on Federal lands have different fugitive emissions than wells on private lands?

Using National outputs from EPA and EIA

- Therefore, we use EPA's National level outputs to generate ratios of fugitive emissions per well, or platform, or volume of vehicle fuel combusted. These ratios are applied to Federal land well counts or refined fuel volumes.
- Some of EIA's National and State level sector ratios for fossil fuel usage are assumed to also be representative of fuels exclusively from Federal lands in those States.
- Ratios based on EIA's refined products per barrel of crude oil at the National level are assumed to be representative of ratios per barrel at State level.

Output types

	Fossil fuel associated	Ecosystems associated
Emissions (+)	End use combustion <ul style="list-style-type: none">• Power generation• Transportation/Mobile• Industrial/Commercial/Residential fugitive emissions• Extraction and distribution	Respiration Fire Harvest Land cover change Land use change
Sequestration (-)	CO ₂ sequestration not yet included	Net ecosystem productivity

Results – Summary

Averaged, 2005-2014 U.S. Federal lands emissions from production and use of fossil fuels represents the following **percentages of National emissions:**

- 23.7 % for carbon dioxide (CO₂),
- 7.3 % for methane (CH₄), and
- 1.5 % for nitrous oxide (N₂O).

Compared to 2005, the 2014 totals represent **decreases in emissions** of

- 6.1 % for CO₂,
- 10.5% for CH₄, and
- 20.3 % for N₂O.

2014 **total emissions** from production and use of fossil fuels originating on Federal lands were:

- 1,279.0 MMT CO₂ Eq. for CO₂,
- 47.6 MMT CO₂ Eq. for CH₄, and
- 5.5 MMT CO₂ Eq. for N₂O.

Terrestrial ecosystems on Federal lands sequestered an average of 194.8 MMT CO₂ Eq. per year (2005-2014), offsetting approximately 15 % of the fossil fuel associated CO₂ emissions on Federal lands.

Results

National totals and subtotals for several categories of the fossil fuel associated emissions estimate for Federal lands 2014.

Sector/fuel	CO ₂ emissions (MMT CO ₂ Eq.)	CH ₄ emissions (MMT CO ₂ Eq.)	N ₂ O emissions (MMT CO ₂ Eq.)
Combustion emissions from stationary sources			
Coal: electricity generation	725.36	2.09	3.68
Coal: industrial	9.3	0.0268	0.047
Coal: industrial coking	0.016	0.00005	0.00009
Coal: commercial	0.21	0.0006	0.001
Petroleum products	41.77	0.039	0.095
Natural gas	217	0.10	0.12
Stationary total	993.6	2.3	3.9
Combustion emissions from mobile sources			
Motor gasoline	110.892	0.143	1.239
Aviation gasoline	0.3	—	—
Jet kerosene	25.58	—	—
Diesel oil	58.25	—	0.06
Residual fuel oil	4.61	—	—
Liquefied petroleum gas	0.078	—	—
Mobile total	199.7	0.14	1.3
Extraction emissions from petroleum and natural gas systems			
Petroleum wells, equipment, and platforms	0.18	7.97	—
Natural gas wells, equipment, and platforms	5.3	25.31	—
Extraction emissions from coal mining			
Surface mines	—	4.34	—
Underground mines	—	6.20	—
Abandoned mines	—	1.22	—
Coal mining total	—	11.8	—
Total emissions from Federal lands			
Domestic	1,198.8	47.5	5.2
Exported	80.2	0.10	0.27
Total Federal lands	1,279.0	47.6	5.5

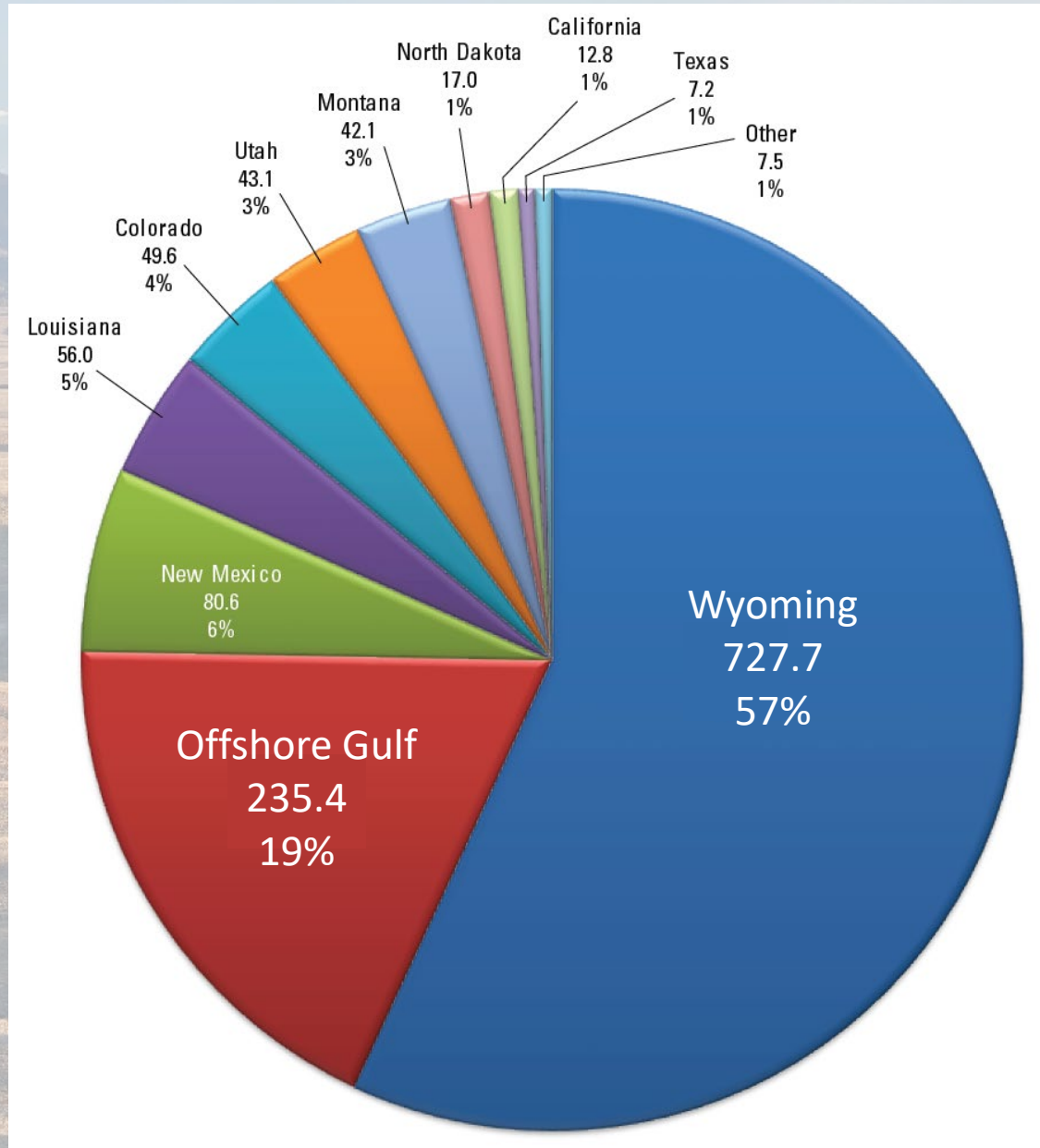
Comparison to EPA national GHG emissions

Year	CO ₂ emissions		CH ₄ emissions		N ₂ O emissions	
	Federal lands fossil fuels (MMT CO ₂ Eq.)	Percentage of U.S. total ¹	Federal lands fossil fuels (MMT CO ₂ Eq.)	Percentage of U.S. total ¹	Federal lands fossil fuels (MMT CO ₂ Eq.)	Percentage of U.S. total ¹
2005	1,361.9	22.2	53.2	7.4	6.9	1.7
2006	1,378.6	22.8	53.4	7.4	6.8	1.7
2007	1,398.3	22.8	53.8	7.4	6.4	1.5
2008	1,427.9	24.1	55.8	7.6	6.5	1.6
2009	1,422.5	25.9	53.4	7.3	6.7	1.7
2010	1,429.4	25.1	53.3	7.4	6.6	1.6
2011	1,362.4	24.5	55.7	7.8	6.2	1.5
2012	1,280.5	23.9	52.0	7.3	5.7	1.4
2013	1,210.5	22.0	48.8	6.8	5.4	1.3
2014	1,279.0	23.0	47.6	6.5	5.5	1.4

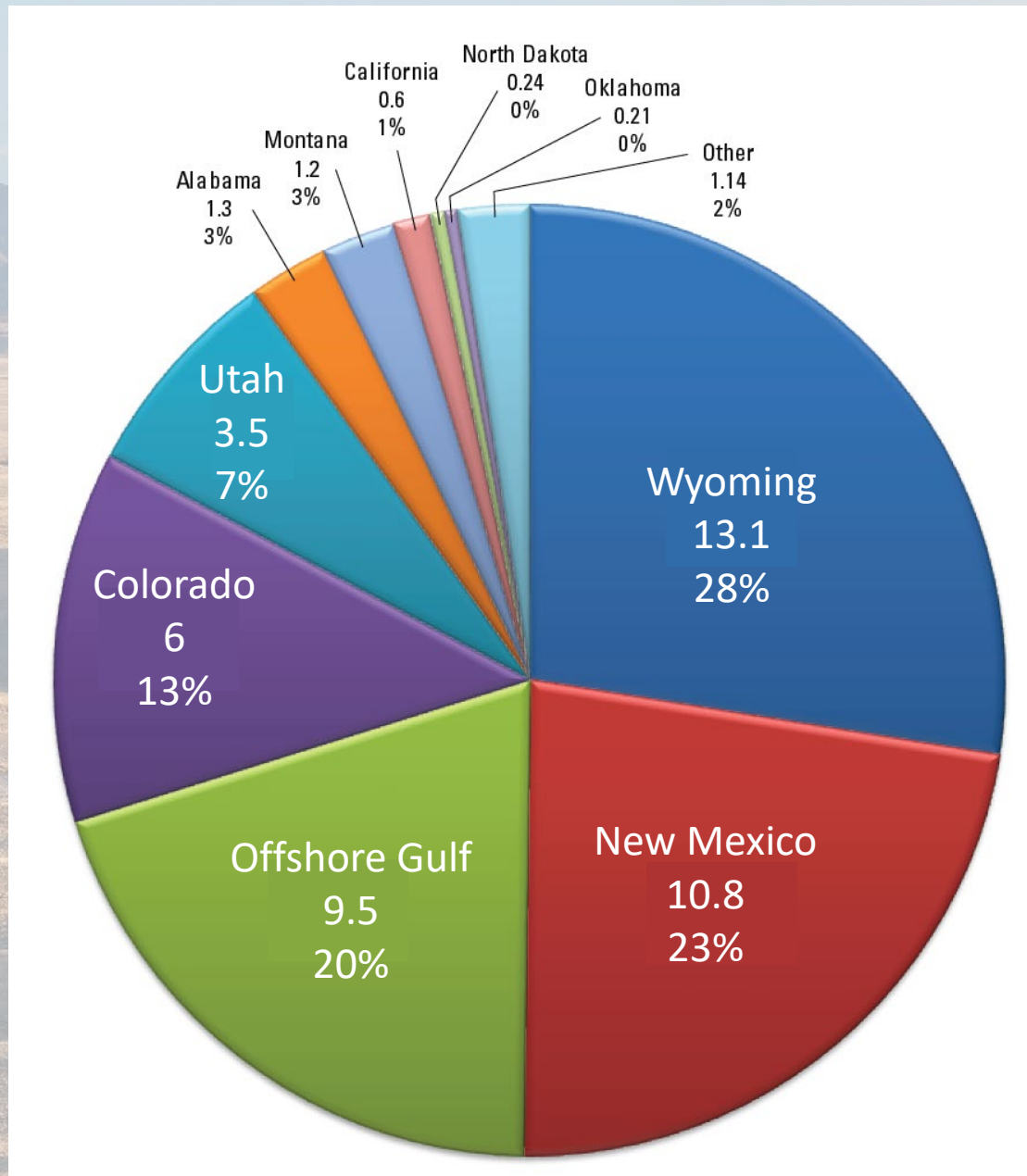
¹Percentages calculated from total U.S. emissions (U.S. Environmental Protection Agency, 2016b).

National totals for greenhouse gas emissions associated with the combustion and extraction of fossil fuels from U.S. Federal lands in 2005-14. And percentage compared to all National emissions.

CO₂ emissions associated with the extraction and combustion of fossil fuels on Federal lands, 2014. Emissions in MMT CO₂ equivalent.



CH₄ emissions associated with the extraction and combustion of fossil fuels on Federal lands, 2014. Emissions in MMT CO₂ equivalent.



Ecosystems estimates - Summary

Year	Carbon stocks				Carbon fluxes						
	TEC	Live	DOM	Soil	NPP	Rh	NEP	NBP	Fire	Harvest	Other
2005	-82,289	-21,270	-8,533	-52,486	-2,283	1,708	-575	-475	11	55	34
2006	-82,322	-21,090	-8,698	-52,534	-1,870	1,723	-147	-29	24	53	40
2007	-82,275	-20,889	-8,779	-52,607	-1,841	1,759	-83	51	34	53	46
2008	-82,353	-20,810	-8,870	-52,673	-1,854	1,661	-193	-75	24	56	38
2009	-82,605	-21,006	-8,875	-52,725	-2,038	1,687	-350	-249	9	59	34
2010	-82,951	-21,310	-8,871	-52,770	-2,174	1,734	-440	-342	9	55	34
2011	-83,170	-21,365	-8,982	-52,823	-1,986	1,686	-301	-219	19	25	38
2012	-83,139	-21,233	-9,033	-52,872	-1,875	1,786	-89	31	44	24	52
2013	-83,334	-21,392	-9,023	-52,919	-2,076	1,783	-293	-195	30	25	43
2014	-83,600	-21,670	-8,966	-52,964	-2,119	1,796	-323	-265	3	25	30
Average	-82,804	-21,204	-8,863	-52,737	-2,012	1,732	-279	-177	21	43	39

Table 4. Carbon stocks and fluxes for Federal lands in the conterminous United States, 2005–14.

[Units are in million metric tons of carbon dioxide equivalent for stocks and million metric tons of carbon dioxide equivalent per year for fluxes. Because of rounding, averages may not add to totals shown. Negative values indicate a net carbon sink or sequestration, and positive values indicate a net carbon source to the atmosphere or emissions. Total U.S. values can be approximated by adding the average stocks and fluxes in Alaska and Hawaii (table 5) to the values presented here. TEC, total ecosystem carbon; Live, storage in live vegetation; DOM, storage in dead organic matter; Soil, storage in soils; NPP, net primary productivity; Rh, heterotrophic respiration; NEP, net ecosystems productivity; NBP, net biome productivity; Fire, carbon emissions from wildfire; Harvest, carbon loss from forest harvest; Other, carbon loss from land-use and land-cover change and harvested agricultural products. See table 3 and the text for further explanation of carbon stocks and fluxes]

Net Emissions – Example

State	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Alabama	0.2	2.9	5.6	0.9	-0.7	2.7	2.7	2.6	-2.6	-2.5
Alaska	-14.1	-14.6	-15.0	-14.9	-15.7	-16.1	-16.6	-16.8	-16.7	-16.5
Arizona	-28.8	23.9	24.3	-8.6	0	-15.6	14.8	14.4	-13.2	7.5
Arkansas	1.6	1.2	-0.9	-5	-4.2	0.9	-1.2	-0.9	-3	-5.3
California	-82.8	22.9	55.4	34.9	-22.8	-69	-24	35.2	13.4	28.6
Colorado	29.3	34.4	32.8	52.8	37.1	52.1	43.2	68.7	30.7	12.1
Connecticut	0	0	0	0	0	0	0	0	0	0.0
Delaware	-0.1	-0.1	0	0	0	0	-0.1	-0.1	-0.1	0.0
District of Columbia	-0.1	0	0	0	-0.1	0	0	0	0	-0.1
Florida	-1.6	5.4	5.4	-2.6	1.9	-3.2	3.1	-1.6	-1.8	-6.0
Georgia	-2.5	-1.2	2.7	-2.7	-5.9	-2.3	-0.4	-2.5	-4	-3.6
Hawaii	—	—	—	—	—	—	—	—	—	—
Idaho	-44.2	-7.7	7.1	0	-33.3	-38.3	-14.3	13.3	-1.3	-21.2
Illinois	-0.1	-1.2	0.1	-1.7	-1.1	0.6	-2.5	0.5	-0.9	-0.8
Indiana	-0.3	-1.8	-0.3	-2	-1.1	0.4	-2.2	-0.9	-1.3	-1.4
Iowa	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0	0	-0.1
Kansas	0.4	0.9	0.4	0.3	0.2	0.5	0.8	0.5	0.2	0.4
Kentucky	-0.7	1	3.9	-0.7	-4.4	-0.5	-8	-5.4	-5.9	-4.3

See the report or associated data release for full results.

All three report products can be found at <https://doi.org/10.3133/sir20185131>

1. Report (SIR 2018-5131)
2. Data Release (38,000 outputs)
3. Interactive website (maps & graphs)

Project: Utilization of Carbon and other Energy Gases - Geologic Research and Assessments

Thanks to EPA for methodology assistance, and to EPA, ONRR, BLM, and EIA for input data.

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The collage features three overlapping images of USGS report products. The top image is a data table titled 'National greenhouse CO2 emissions and sequestration: 2005-14'. The middle image is a screenshot of the report's website, showing a title page with a landscape background and a 'Map' button. The bottom image is a screenshot of the 'Data Release' page, which includes a 'Summary' section, a 'Map' button, and a list of 'Attached Files' with their respective sizes.

Year	Total Greenhouse Gases	Sequestration	Net Emissions
2004	1,381.4	0.0	1,381.4
2005	1,375.4	0.0	1,375.4
2006	1,368.8	0.0	1,368.8
2007	1,362.9	0.0	1,362.9
2008	1,357.0	0.0	1,357.0
2009	1,351.1	0.0	1,351.1
2010	1,345.2	0.0	1,345.2
2011	1,339.3	0.0	1,339.3
2012	1,333.4	0.0	1,333.4
2013	1,327.5	0.0	1,327.5
2014	1,321.6	0.0	1,321.6
2015	1,315.7	0.0	1,315.7
2016	1,309.8	0.0	1,309.8
2017	1,303.9	0.0	1,303.9
2018	1,298.0	0.0	1,298.0
2019	1,292.1	0.0	1,292.1

Federal Lands Greenhouse Gas Emissions and Sequestration in the United States: Estimates 2005-14

Federal Lands Greenhouse Gas Emissions and Sequestration in the United States: Estimates 2005-14 - Data Release

Attached Files

File Name	Size
Product_10_000778982_DATA_DICTATORRY.CSV	26.25 KB
Product_10_000778982_ECOSYSTEMS_INGESTION_DATA.CSV	33.36 KB
Product_10_000778982_FOSSIL_EMISSIONS_DATA.CSV	722.8 KB
Original/USGS-Messages	59.41 KB