Colorado Plateau Greenhouse Gas Emissions Inventory and Forecast Report

July 2020

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Acronym List

AFOLU	Agriculture, Forestry and Other Land Use
AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
BOD	Biological Oxygen Demand
C&D	Construction and Demolition
CO_2	Carbon Dioxide
CO_2E	Carbon Dioxide Equivalent
CH_4	Methane
ECHO	Enforcement and Compliance History Online
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	Electric Vehicle
FHWA	Federal Highway Administration
FLIGHT	Facility Level Information for Greenhouse Gas Tool
GHGRP	Greenhouse Gas Reporting Program
GIS	Geographic Information System
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
Kg	Kilogram
kWh	Kilowatt Hour
LMOP	Landfill Methane Outreach Program
LNG	Liquified Natural Gas
MSHA	Mine Safety and Health Administration
MSW	Municipal Solid Waste
MWh	Megawatt Hour
N_2O	Nitrous Oxide
SEDS	State Energy Data System
SIT	State Inventory Tool
the Trust	Grand Canyon Trust
USDA	US Department of Agriculture
USCP	US Community Protocol
VMT	Vehicle Miles Traveled
WIP	Waste-in-Place

Executive Summary

The Intergovernmental Panel on Climate Change's (IPCC) recent report, *Global Warming of 1.5°C: Summary for Policymakers*, details the potential impacts to our planet should global temperatures continue to climb.[i] These changes and their impacts on our communities and livelihoods could be mitigated if humans reduce the amount of carbon being released into the atmosphere.

The Grand Canyon Trust (the Trust), a non-profit organization whose mission is to "safeguard the wonders of the Grand Canyon and the Colorado Plateau, while supporting the rights of its Native peoples", has recognized this challenge and has committed to reducing greenhouse gas emissions on the Colorado Plateau (the plateau). The region has already felt the impacts of a changing climate, including increased wildfire activity and water scarcity from prolonged droughts. Action is needed immediately to prevent the worst impacts of the climate crisis on the Colorado Plateau.

As an advocate for the Grand Canyon region and the plateau, the Trust understands that policy changes must be supported by sound science to gain widespread acceptance. As such, the first step of this process was to establish a baseline of greenhouse gas emissions.

The plateau includes land in four states—Arizona, Colorado, New Mexico, and Utah—and parts of 41 counties.[1] The inventory provides details on total emissions for each county that intersects the Colorado Plateau boundary, as well as the emissions specifically from activities occurring within the plateau. Because of its size and diverse character, a one-size-fits-all approach to accounting for emissions was not appropriate.

1 Gila County, Arizona, and Daggett and Summit counties, Utah were excluded from the inventory since they have less than 10 percent of their area on the Colorado Plateau, and the land that is within the Colorado Plateau is 90-100 percent national forest land. Therefore, it is very unlikely that there were any notable emissions coming from those areas.

An approach to greenhouse gas accounting specific to the Colorado Plateau was developed based on available emissions accounting protocols. Two separate, reputable greenhouse gas accounting protocols were used to complete the Colorado Plateau's emissions inventory: the IPCC Protocol and the U.S. Community Protocol. These protocols were selected based on the ability of the emissions inventory to inform future policymaking, the ease of both data collection and the calculation approach to improve replicability and transparency, and the alignment with available data and regional data variations. As discussed in the *Sectors, Sources, and Scopes* section, a consumption-based approach was used to calculate emissions from the electricity sector. The resulting greenhouse gas emissions inventory identifies significant emission sources on the Colorado Plateau for 2018 and serves as a foundation in prioritizing the Trust's response to the urgent need for emissions reductions throughout the Colorado Plateau area.

Supplemental to the calculated greenhouse gas emissions, the Trust sought to understand the current Colorado Plateau carbon stock. Carbon stock refers to the capacity of existing land cover and land use, such as forests and grasslands, to absorb carbon from the atmosphere. Increases in carbon stock mean a greater capacity for removal and storage of carbon from the atmosphere. Conversely, decreases in carbon stock, like a catastrophic forest fire, will not only decrease the capacity for carbon removal and storage but also adds carbon to the atmosphere as the previously captured carbon is released. These annual changes in carbon stocks are referred to as carbon sequestration. Current carbon stocks in five broad land cover types were assessed across the Colorado Plateau and serve as a baseline from which future changes in land cover and use can be compared.

Using 2018 as the baseline year, emissions were forecasted to 2050 in a business-as-usual scenario to help the Trust understand the trajectory of emissions on the Colorado Plateau without intervention. This report details the findings from the 2018 Plateau greenhouse gas emissions inventory, the carbon stock analysis, and the emissions forecast. Emissions are counted in carbon dioxide equivalent (CO_2e). Since different greenhouse gases have varying strengths with regard to their impact on climate change, CO_2e allows for comparing apples to apples to pull out the emitters with the most impact on climate change. For instance, methane is 25 times stronger than carbon dioxide at trapping heat in the atmosphere over a 100-year period.[ii] Therefore, the CO_2e of one pound of methane is greater than one pound of CO_2 meaning that a pound of methane emissions will have a greater climate impact than a pound of CO_2.

This analysis was performed before the global coronavirus pandemic; therefore, the pandemic was not factored into the greenhouse gas emissions forecast. However, the pandemic and the actions taken to mitigate it will undoubtedly have an impact on near-term and long-term emissions. For example, over the next few years it is expected that oil demand will remain low, which will drastically decrease the amount of fugitive emissions within the plateau.

KEY FINDINGS FROM THE 2018 INVENTORY AND FORECAST

In 2018, the 41 counties across the Colorado Plateau produced more than 124 million metric tons of carbon dioxide equivalent (mt CO_2e) emissions. That amounts to approximately 2.1 percent of the total 2018 greenhouse gas emissions for the United States.[2] Sixty-four percent, about 79 million mt CO_2e, of that total are estimated to have occurred on the Colorado Plateau.[3] This is about 1.3 percent of the total 2018 greenhouse gas emissions for the United States. The 20 counties in Utah included in the inventory contributed the largest proportion of emissions, while counties from Arizona contributed the least (see Figure ES-1).

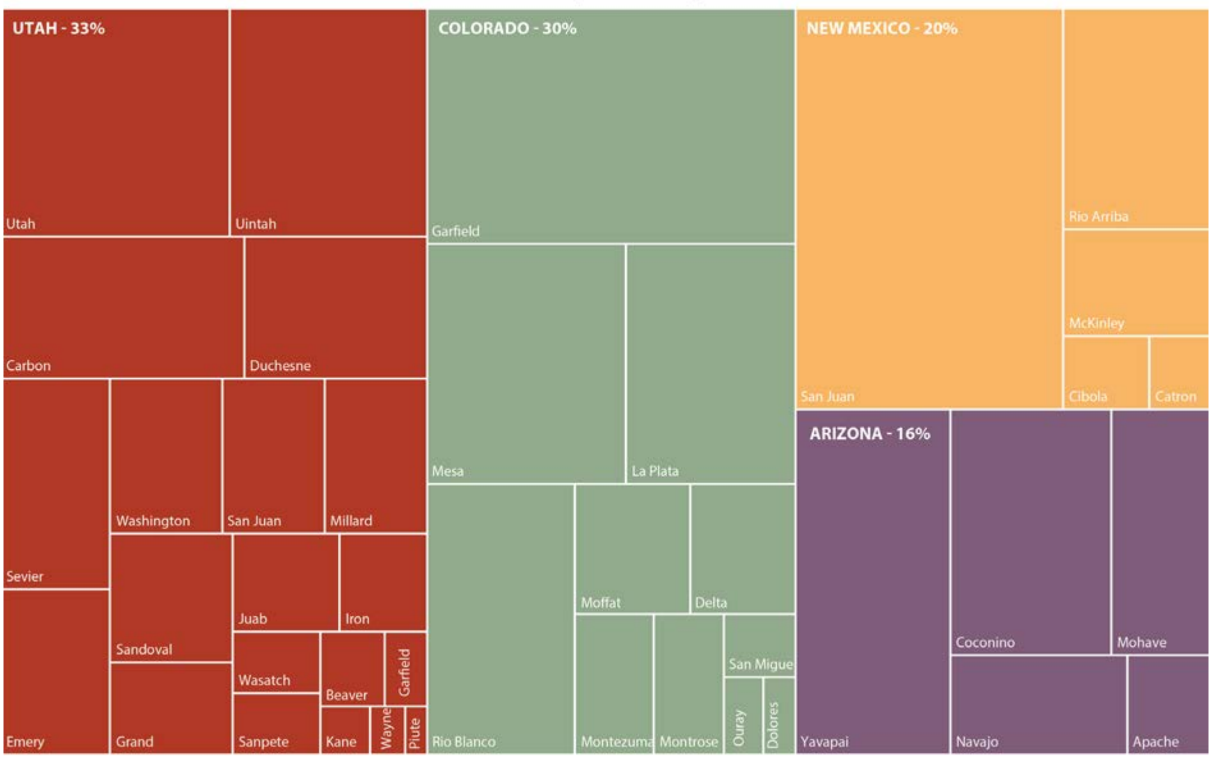

Figure ES-1. Colorado Plateau 2018 emissions by state and county (mt CO_2e).

2 According to the EPA, after accounting for sequestration from the land sector, 2018 U.S. greenhouse gas emissions totaled 5,903 million mt CO_2e.

3 Emissions are measured in metric tons of carbon dioxide equivalent (mt CO_2e). Greenhouse gases considered in the inventory include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and hydrofluorocarbons (HFCs).

Emissions were broken down by sectors, subsectors, and sources. Emission sectors refer to the overarching activity type from which emissions are generated, like the transportation sector. Subsectors are the specific subtype of activity. For example, transportation is further subdivided into subsectors like on-road transportation. The source of emissions refers to the actual "source" of generated greenhouse gases, such as the fuel burned or emitted from a material's decomposition (e.g., oil and gas wells or wastewater treatment).

The fugitive emissions sector, which includes the subsectors of oil and gas systems and coal mining, produced the most emissions on the plateau; this was followed by the stationary energy and transportation sectors. The waste sector produced the least emissions on the plateau. Figure ES-2 shows the breakout of greenhouse gases by subsectors and sources.

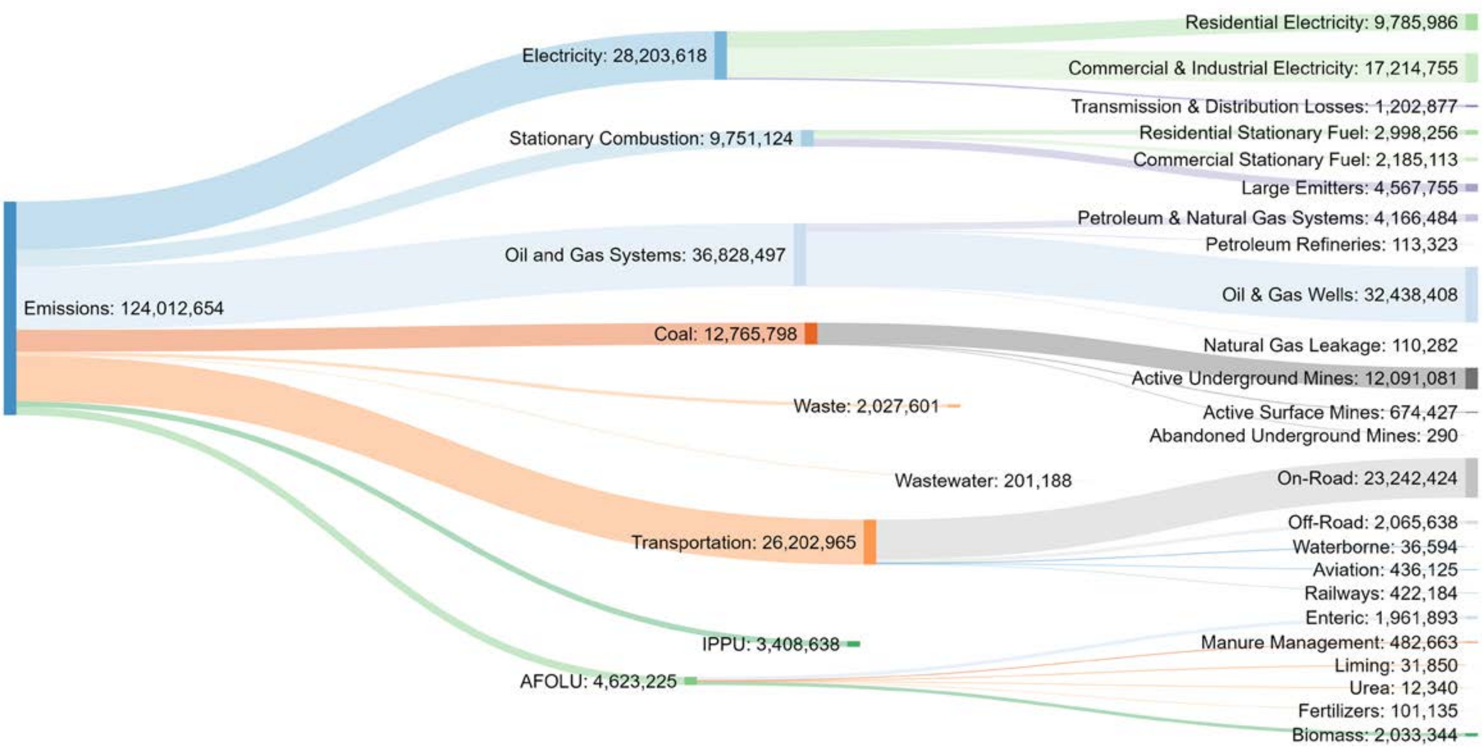

Figure ES-2. Colorado Plateau emissions by subsector and source (mt CO_2e).

The inventory evaluated emissions generated from carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and hydrofluorocarbons (HFCs). The majority of analyzed emissions were in the form of CO_2, followed by CH_4 and N_2O. Each gas is normalized to CO_2e using a specific global warming potential (GWP) that measures the gas's impact relative to one ton of CO_2. Methane emissions are generated primarily from oil and gas activity, coal mining, agricultural activities, and waste, while nitrous oxide is emitted from fertilization of agricultural lands and wastewater activities and in the electricity, stationary combustion, and oil and gas sectors. Figure ES-3 illustrates a breakdown of sector emissions by the three major gases in 2018.

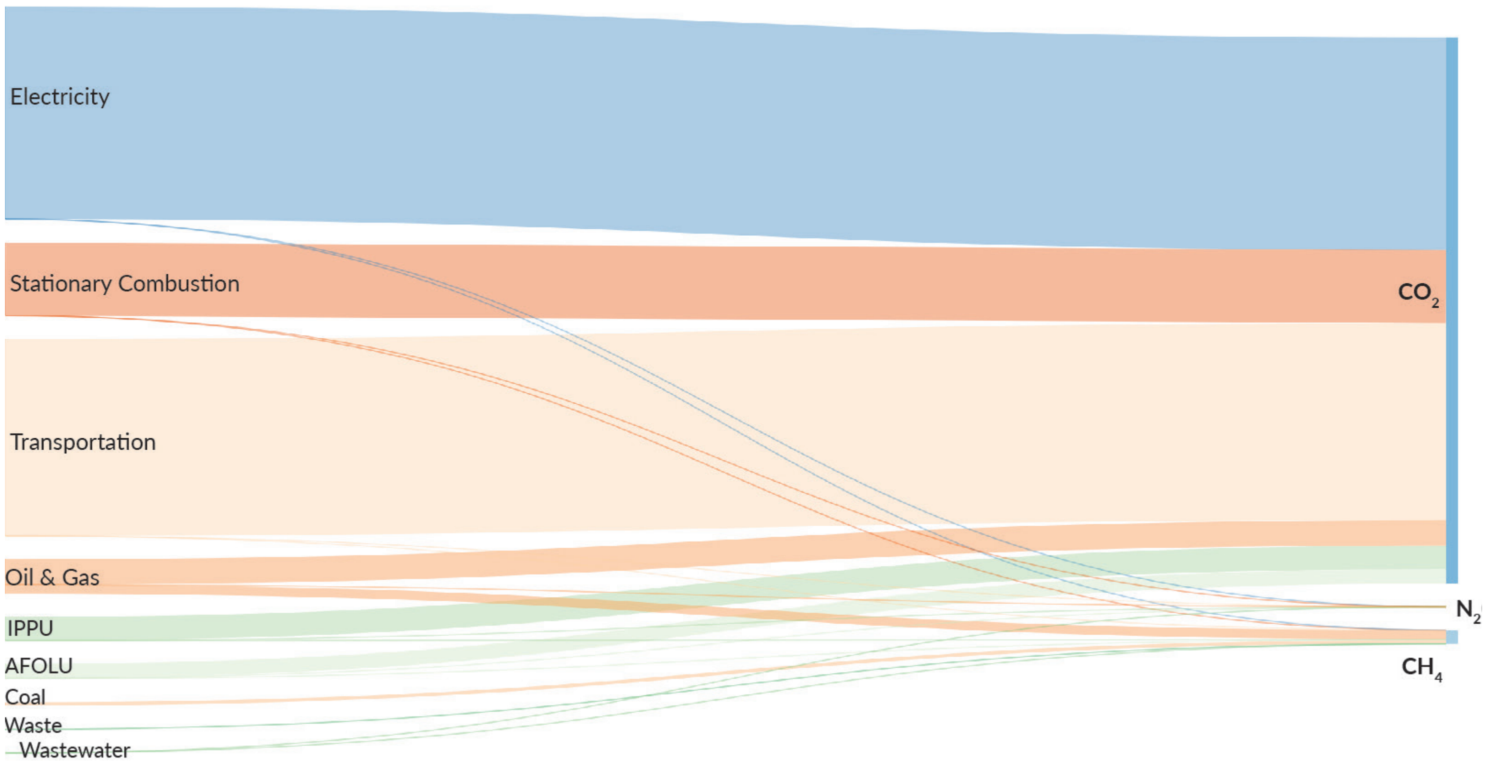

Figure ES-3. Colorado Plateau emissions by sector and greenhouse gas.

Carbon stock occurring from the sequestration of carbon by varying land types was calculated at the county level. Five land cover and use types were analyzed: forests, croplands, grasslands/shrublands, wetlands, and other lands. The total carbon stock is estimated to be just under 2.5 billion metric tons of carbon (mt C) (Figure ES-4). This is carbon that is already stored and does not represent available storage capacity. It does represent potential added emissions if the land cover providing the carbon storage is destroyed. Colorado Plateau counties in Utah had the largest carbon stock followed by the Arizona counties. The forest land cover type was the largest carbon stock across the region, followed by grasslands and shrublands (Figure ES-5).

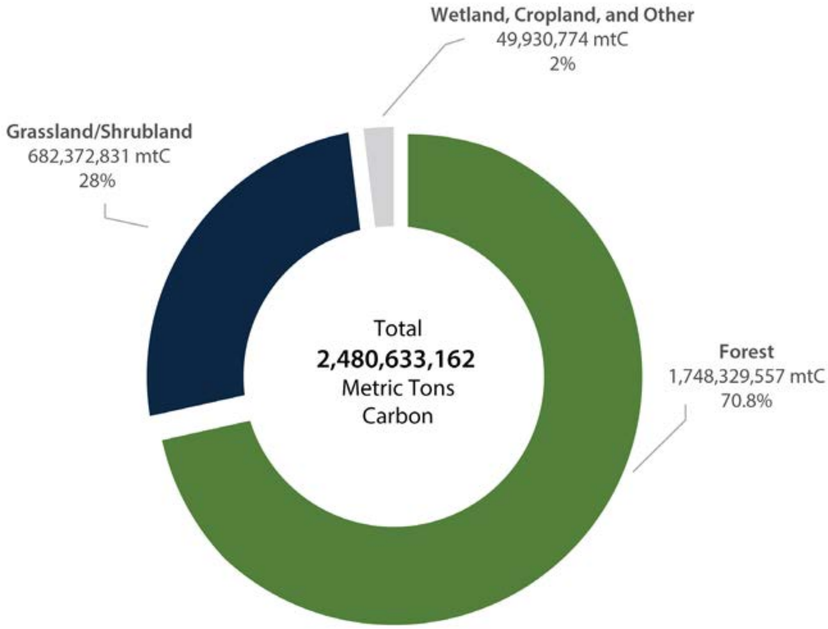

Figure ES-4. Colorado Plateau 2018 carbon stocks (mt C).

FORECASTED EMISSIONS

Greenhouse gas emissions were forecasted out to 2050 in a business-as-usual scenario using 2018 as the baseline year. The cumulative reduction across the plateau was responsible for overall emission reductions of

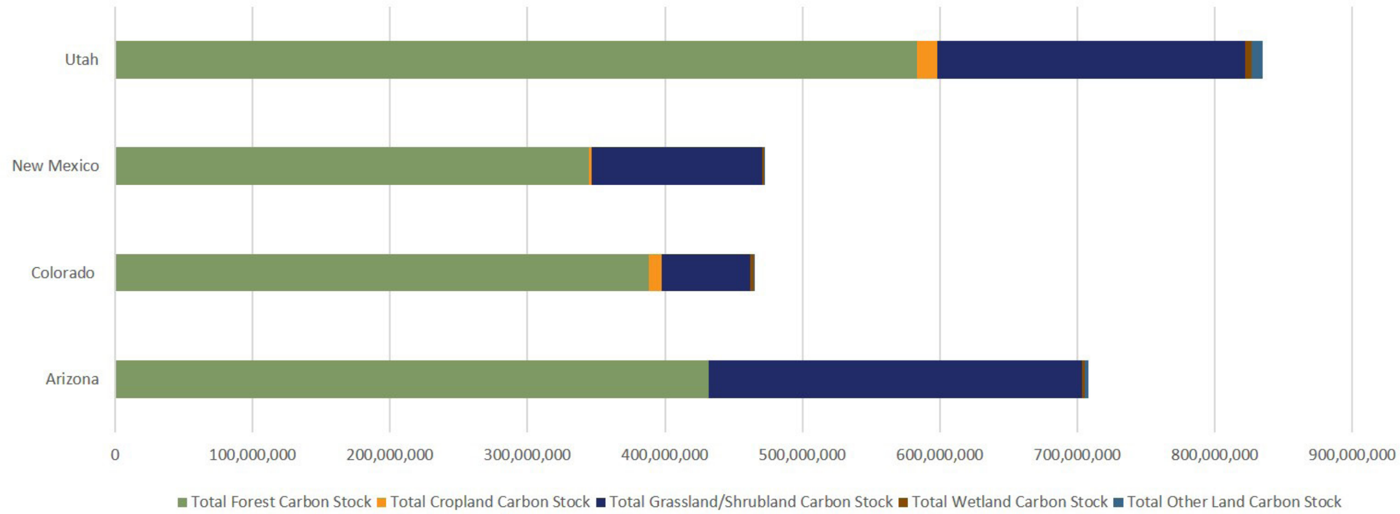

Figure ES-5. Colorado Plateau 2018 carbon stocks by state (mt C).

approximately 14 percent (Figure ES-6). Emission-generating activities[4] for most sectors were projected to grow at the same rate as the population. All sectors decreased emissions through 2050 with the exception of waste/wastewater, which saw an increase, and industrial processes and product use, which saw no change. The largest decrease in emissions by 2050 came from stationary energy and electricity sectors, where emissions were expected to reduce by 28 percent. While oil and gas systems emissions were expected to decrease by 2050, for Utah, Colorado, and New Mexico, they are expected to see an exponential 14 percent increase until peak oil in 2035.[iii] For Colorado, New Mexico, and Arizona counties, all three states saw the largest emissions reduction in the stationary energy sector.[5]

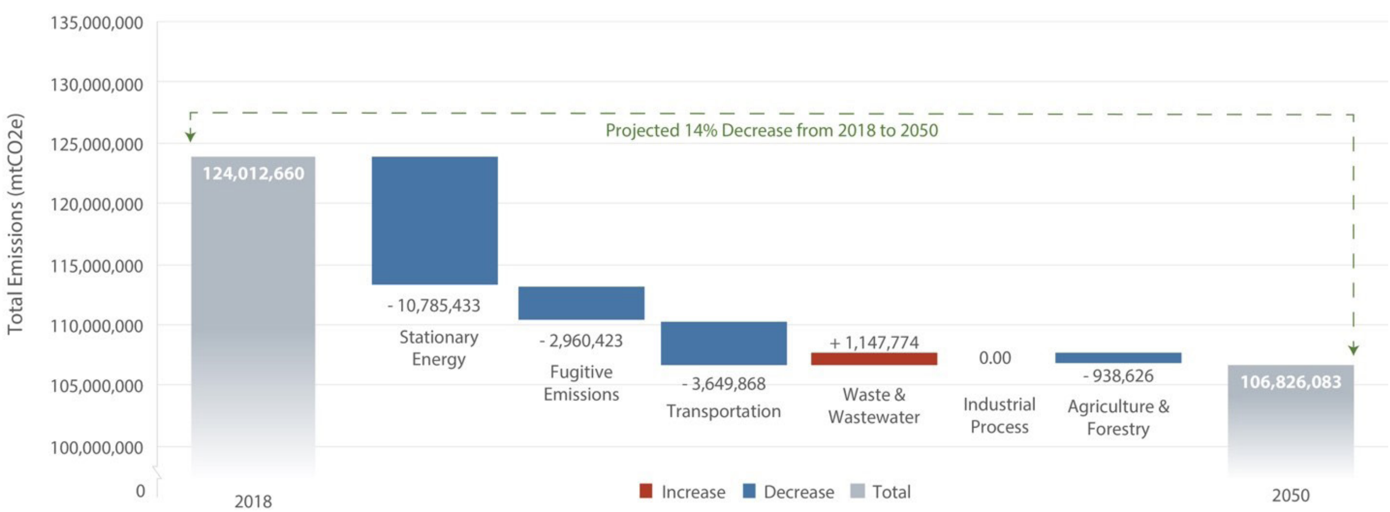

Figure ES-6. Colorado Plateau emission change by sector from 2018 to 2050 (mt CO_2e).

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4 'Emissions-generating activities' include items such as landfilling of waste, use of natural gas in buildings, etc.

5 This is primarily driven by the closures of major energy facilities, like coal-fired power plants, and state and utility carbon reduction policies and goals for electricity generation.

The projected rate of emissions change was not equal across the counties that intersect the plateau boundary. Counties in Arizona are expected to see the largest decrease in emissions at 52 percent. This was closely associated with the closure of the Navajo Generating Station and the commitment by Arizona's largest retail and wholesale electricity provider to be a carbon-free electrical utility by 2050 and to source two-thirds of electricity from carbon-free sources by 2030.[iv]

Emissions from Colorado counties were expected to decrease by 31 percent mostly due to statewide air quality and vehicle emissions goals and a commitment to 100 percent renewable electricity by 2040.[v] New Mexico also has a statewide goal for New Mexico investor-owned utilities and rural electric cooperatives to increase electricity sourced from renewables to 50 percent by 2030 and 80 percent by 2045.[vi] Therefore, counties in New Mexico were expected to see a 14 percent reduction in emissions by 2050. However, coal emissions are expected to stay relatively flat and oil and gas well emissions are expected to rise until 2035 and drop to 10 million mt CO_2e in 2050. This was only slightly below 2018 emissions (11 million mt CO_2e). Further, emissions from large emitters and oil and gas systems were expected to be about the same in 2050 as in 2018.

Colorado Plateau counties in Utah, as a whole, are anticipated to increase emissions by 20 percent. This was partially due to a 91 percent projected population increase which contributes to increased activity in stationary energy, transportation, and waste/wastewater sectors. The fastest rate of population growth is projected in counties adjacent to Salt Lake City and Saint George, Utah.[vii] And similar to New Mexico counties, emissions from oil and gas were expected to continue increasing at a steady rate until 2035 (over 12 million mt CO_2e) and then decrease to 9.8 million mt CO_2e. This was just below the 2018 emissions, over 10 million mt CO_2e, by 2050. In addition, Utah does not currently have any statewide carbon reduction policies for electricity generation.

Introduction

The Colorado Plateau region has already felt the impacts of a changing climate, including increased wildfire activity, air quality issues, and water scarcity from prolonged droughts. As an advocate for the Grand Canyon region and the Colorado Plateau, the Trust understands that policy changes must be supported by sound science to gain widespread acceptance and implementation. The first step of this process was to establish a baseline of greenhouse gas emissions. The Trust engaged Lotus Engineering and Sustainability, LLC (Lotus) to complete a 2018 emissions inventory and related work.

In addition to the 2018 inventory Lotus forecasted emissions to 2050 in a business-as-usual scenario to help the Trust understand the trajectory of emissions across the plateau without intervention and with no change to policy or carbon reduction programs. The Trust also sought to understand the current plateau-wide carbon stock and how future changes in land cover might impact greenhouse gas emissions. Current carbon stocks were assessed on a county-by-county basis across the 41 plateau counties in five broad land cover types. This report details the findings from the 2018 Plateau Greenhouse Gas Emissions Inventory, including the carbon stock analysis, and the emissions forecast.

Background

INVENTORY DEVELOPMENT AND METHODOLOGY

Two greenhouse gas accounting protocols (IPCC and USCP), one accounting calculator (SIT), and one reporting platform (FLIGHT) were utilized to calculate greenhouse gas emissions. These resources are:

1. 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC);[viii]
2. U.S. Community Protocol (USCP);[ix]
3. U.S. Environmental Protection Agency's (EPA) State Inventory Tool (SIT);[x] and
4. EPA's Facility Level Information on Greenhouses Gases Tool (FLIGHT).[xi]

Protocols vary in their application. Some are better suited for local government inventories, while others are better suited for regional inventories. Further, some require extensive data collection, while others require simple data entries. Some inform future policymaking better than others. The available protocols were reviewed and the most appropriate protocol for each emission source was chosen based on the following:

- Ability to inform future policymaking.
- Ability to enable the simplest data collection and calculation approach to improve replicability and transparency.
- Ability to align well with available data.
- Ability to enable regional inventorying considerations.

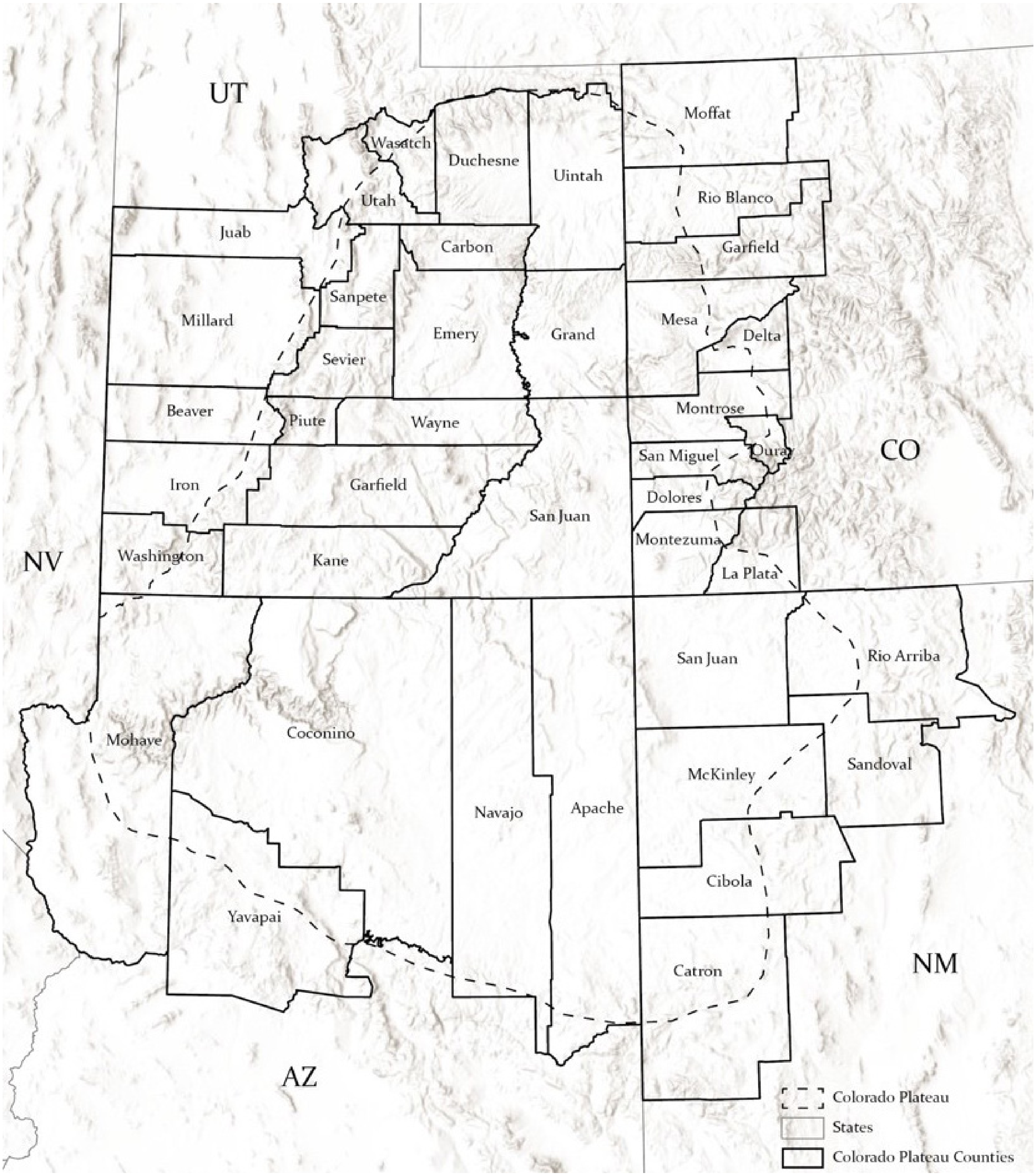

Figure 1. Map of the Colorado Plateau.

The EPA's State Inventory Tool is a greenhouse gas emission calculator used by states to calculate greenhouse gas emissions. The EPA's Greenhouse Gas Reporting Program (GHGRP) requires facilities that emit over 25,000 metric tons of carbon dioxide equivalents (mt CO_2e) to report their emissions.[xii] These emissions are reported in the FLIGHT database.

The inventory evaluated emissions that are generated from carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and hydrofluorocarbons (HFCs).

INVENTORY BOUNDARY

The plateau includes land in four states—Arizona, Colorado, New Mexico, and Utah[6]—and portions of 41 counties (Figure 1). The Colorado Plateau inventory is unique; unlike a standard community or state-wide inventory, where the boundaries are easily discernible by the city or state limits, the plateau boundary is established by geography. The Trust's Geographic Information Systems (GIS) team established the inventory boundary in GIS software and used the boundary to estimate activity on the plateau versus off the plateau.

The emissions inventory provides details on total emissions for the entire county that intersects the plateau boundary, as well as estimated emissions for only the land area of the county within the Colorado Plateau. For example, for Catron County, New Mexico, 45 percent of land area falls within the plateau boundary (Figure 2). The "plateau emissions" for Catron were estimated within that 45 percent land mass, while the "county emissions" accounted for all emissions within the entire county. This gives a frame of reference to compare total county emissions to specific actives that are occurring on the Colorado Plateau.

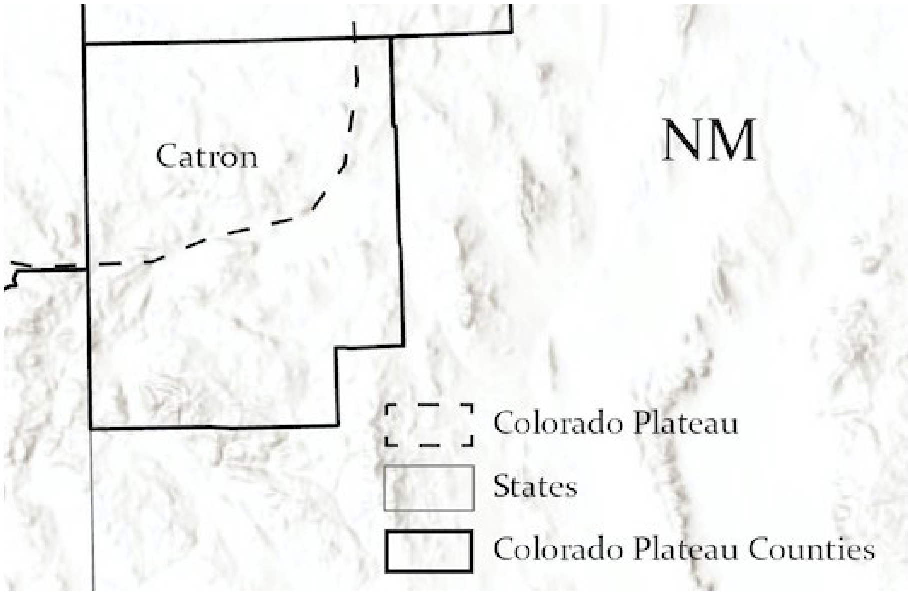

Figure 2. Detailed map of Catron County, New Mexico.

6 Gila County, Arizona, and Daggett and Summit counties, Utah were excluded from the inventory since they have less than 10 percent of their area on the Colorado Plateau, and the land that is within the Colorado Plateau is 90-100 percent national forest land. Therefore, it is very unlikely that there were any notable emissions coming from those areas.

SECTORS, SOURCES, AND SCOPES

The 2018 greenhouse gas emissions inventory categorized emissions by scopes, sectors, and sources. Scopes are defined by globally recognized protocols and provide a very high-level view of emissions with combined sectors and sources within each scope. Per the Global Protocol for Community-Scale Greenhouse Gas Emissions[xiii] (GPC), the following definitions apply to emission scopes:

- Scope 1: Direct greenhouse gas emissions from sources within the 41 counties or on the Colorado Plateau.
- Scope 2: Indirect greenhouse gas emissions occurring as a result of the use of grid-supplied electricity, heat, steam, and/or cooling within the 41 counties or on the Colorado Plateau.
- Scope 3: All other indirect greenhouse gas emissions that occur outside the study area as a result of activities taking place within the 41 counties or on the Colorado Plateau.

The main sectors included in the emissions inventory were fugitive emissions; stationary energy; transportation; waste; industrial processes and product use (industrial processes); and agriculture, forestry, and other land use. Sectors were divided into subsectors, for instance fugitive emissions include the subsectors of coal and oil and gas systems. Most subsectors were further divided into emission sources like gasoline, diesel, and propane use in the transportation subsectors. Table 1 and Figure 3 below detail the sectors, subsectors, sources, and scopes applied to the Colorado Plateau.

It is important to understand that the emissions estimates for the electricity sector were made using a consumption-based approach to emissions accounting, and thus reflect the greenhouse gas emissions created in each county based on the amount of resources used in that county. This means that direct emissions from the Colorado Plateau's large power plants were not included in the inventory except to the extent that the power they generate is used on the Colorado Plateau. This approach was used so that the impact of consumption-based local policies, programs, and energy efficiency measures can be reflected in an updated inventory. Additionally, as the Colorado Plateau's era of coal-fired power winds down, a consumption-based approach more accurately conveys the region's likely energy future.

However, the Colorado Plateau is an energy exporter – meaning that a significant portion of electricity generated on the Colorado Plateau, predominately by coal-fired power plants, is consumed off the Colorado Plateau. Appendix A of this report utilizes generation-based accounting to calculate the greehouse gas emissions produced by electricity generation facilities on the Colorado Plateau. To protect the integrity of the analysis, the generation-based emissions total cannot be simply added into the main overall inventory. It must be considered separately.

Table 1. Sectors, Subsectors, Sources, and Scopes.

Emission Scope	Sector	Subsector
Stationary Energy Emissions		
Scope 2	Electricity	Residential, Commercial, Industrial, Transportation
Scope 3		Transmission and Distribution
Scope 1	Stationary Combustion (Propane, Natural Gas, and Wood)	Residential
		Commercial
		Subpart C- Industrial
Oil & Gas Systems		
Scope 1	Oil & Gas Systems	Subpart W – Petroleum and Natural Gas Systems
		Subpart Y – Petroleum Refineries
		Oil and Gas Wells
	Natural Gas Leakage	Natural Gas Leakage
Coal		
Scope 1	Coal	Active Underground Mines
		Active Surface Coal Mines
		Abandoned Underground Mines
Transportation		
Scope 1	Aviation	Local Travel
Scope 3		Transboundary Travel
Scope 1	On-road Transportation	Gasoline, Diesel, and Ethanol
Scope 2		Electricity
Scope 1	Off-road Transportation	Agriculture, Construction, Lawn & Garden, Recreation, Military, Miscellaneous, Other Off-Highway
Scope 1	Railways	Railways
Scope 1	Waterborne	Domestic Waterborne
Waste		
Scopes 1, 3	Waste	Community-generated Waste
Scopes 1, 3	Wastewater	Wastewater Treatment
Scope 1		Lagoons, Septic Tanks
Industrial Processes and Product Use		
Scope 1	Industrial Processes	Subpart H: Cement Production
		Subpart I: Electronics Manufacturing
		Subpart S: Lime Production
Agriculture, Forestry, and Other Land Use (AFOLU)		
Scope 1	Enteric Emissions	Enteric Emissions
Scope 1	Manure Management	Manure Management
Scope 1	Liming Emissions	Liming Emissions
Scope 1	Urea Emissions	Urea Emissions
Scope 1	Direct and Indirect N_2O Emissions	Direct and Indirect N_2O Emissions
Scope 1	Biomass Burning	Biomass Burning
Carbon Sequestration		
N/A	Sequestration	Sequestration

SECTORS EXPLAINED

Emission Sector	Emission Subsector	Emission Source	Notes
Energy Emissions	Residential, commercial, industrial, transportation, transmission and distribution	Electricity	Includes emissions from electricity generation counted from the user end. Generation emissions are accounted for here by way of an energy mix based emissions factor.
		Stationary combustion	The non-transport combustion of propane, natural gas, and wood. Includes use of boilers, furnaces, and ovens. Does not include coal fired power plants (counted in electricity use).
Fugitive Emissions	Oil and gas systems	Petroleum and natural gas systems, petroleum refineries, oil and gas wells	Emissions from the oil and gas industry, and the processes related to oil and gas extraction, production, transport, storage, and end use at refineries (fugitive emissions).
		Natural gas leakage	Leakage from natural gas distribution systems (fugitive emissions).
	Coal	Active underground coal mines, active surface coal mines, abandoned underground mines	Also includes emissions from post closure activities, and fugitive emissions from mines (fugitive emissions).
Transportation	Aviation (local and transboundary)	Jet fuel and aviation gas	Includes freight and passenger rail, aviation, waterborne, off-road, and on-road transport by passenger vehicles, light duty trucks, motorcycles, and heavy-duty trucks and buses.
	On road transportation	Gasoline, diesel, ethanol, electricity	
	Off road transportation	Gasoline and diesel used for agriculture, construction, lawn and garden, recreation, miscellaneous, military, other off-highway	
	Railways	Diesel	
	Waterborne	Diesel, gasoline, propane	

Figure 3. Details on emissions sectors and sources.

SECTORS EXPLAINED continued

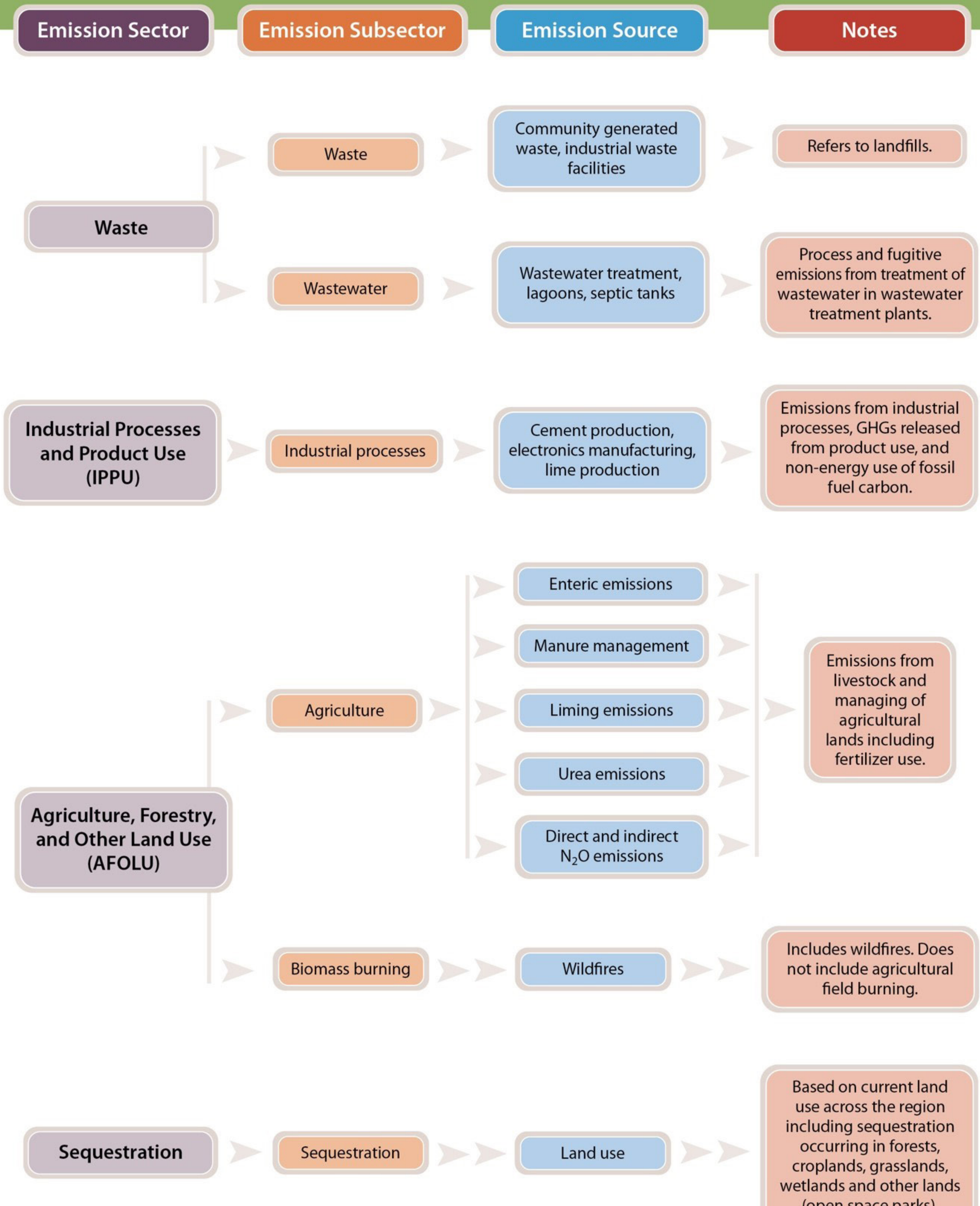

Figure 3. Details on emissions sectors and sources.

Plateau Emissions Overview

KEY EMISSIONS INVENTORY FINDINGS

In 2018, activities across the Colorado Plateau counties emitted over 124 million mt CO_2e, or 2.1 percent of the total 2018 greenhouse gas emissions for the United States.[7] Sixty-four percent of that total, 79,258,435 mt CO_2e, are estimated to have occurred on the Colorado Plateau, or about 1.3 percent of the total 2018 greenhouse gas emissions for the United States.

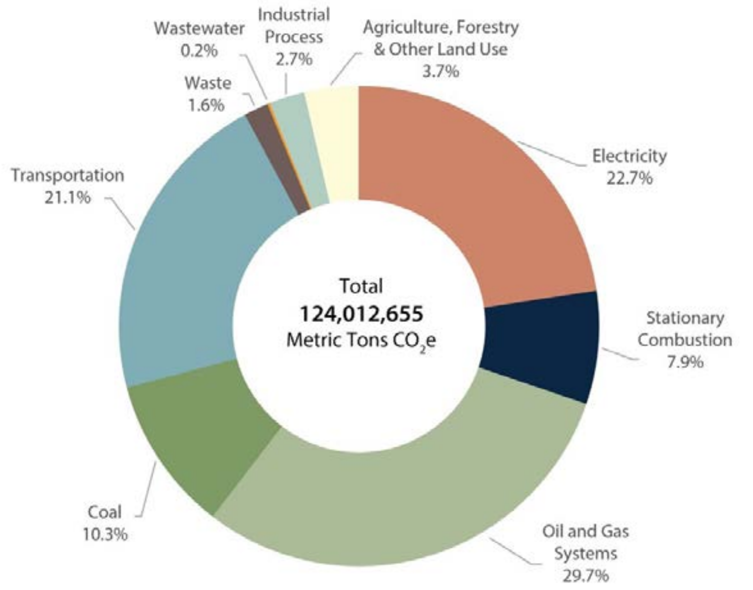

Figure 4. Colorado Plateau counties summary emissions (mt CO_2e).

The majority of emissions across Colorado Plateau counties occur from activities associated with energy production and fugitive emissions. Fugitive emissions from oil and gas systems and coal mining contribute nearly 40 percent of total county emissions, and energy emissions from electricity generation and stationary combustion account for nearly 31 percent of total county emissions (Figure 4). Further, most of the activities associated with those

7 According to the EPA, after accounting for sequestration from the land sector, 2018 U.S. greenhouse gas emissions totaled 5,903 million mt CO_2e.

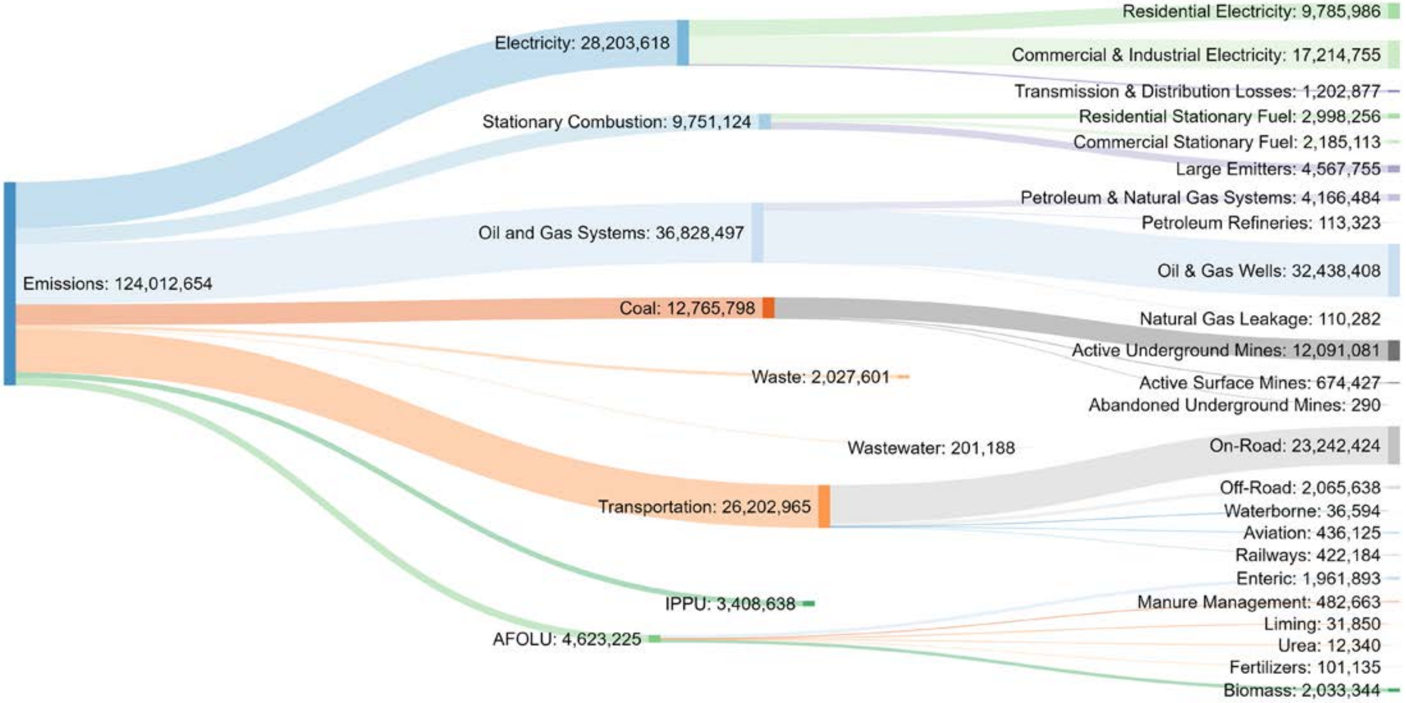

Figure 5. Colorado Plateau emissions by subsector and source (mt CO_2e).

emissions are occurring on the plateau. Figure 5 illustrates emissions from the sectors, subsectors, and sources across the entire Colorado Plateau.

When comparing the emissions for each county on the Colorado Plateau by state, counties in Utah contributed the most emissions at 33 percent of the total for all 41 counties, while Arizona had the smallest contribution at only 16 percent (Figure 6). Utah's high contribution is likely due to the state's larger proportion of land area on the plateau and emissions-heavy industries, like oil and gas, which are a large part of the state's economy.

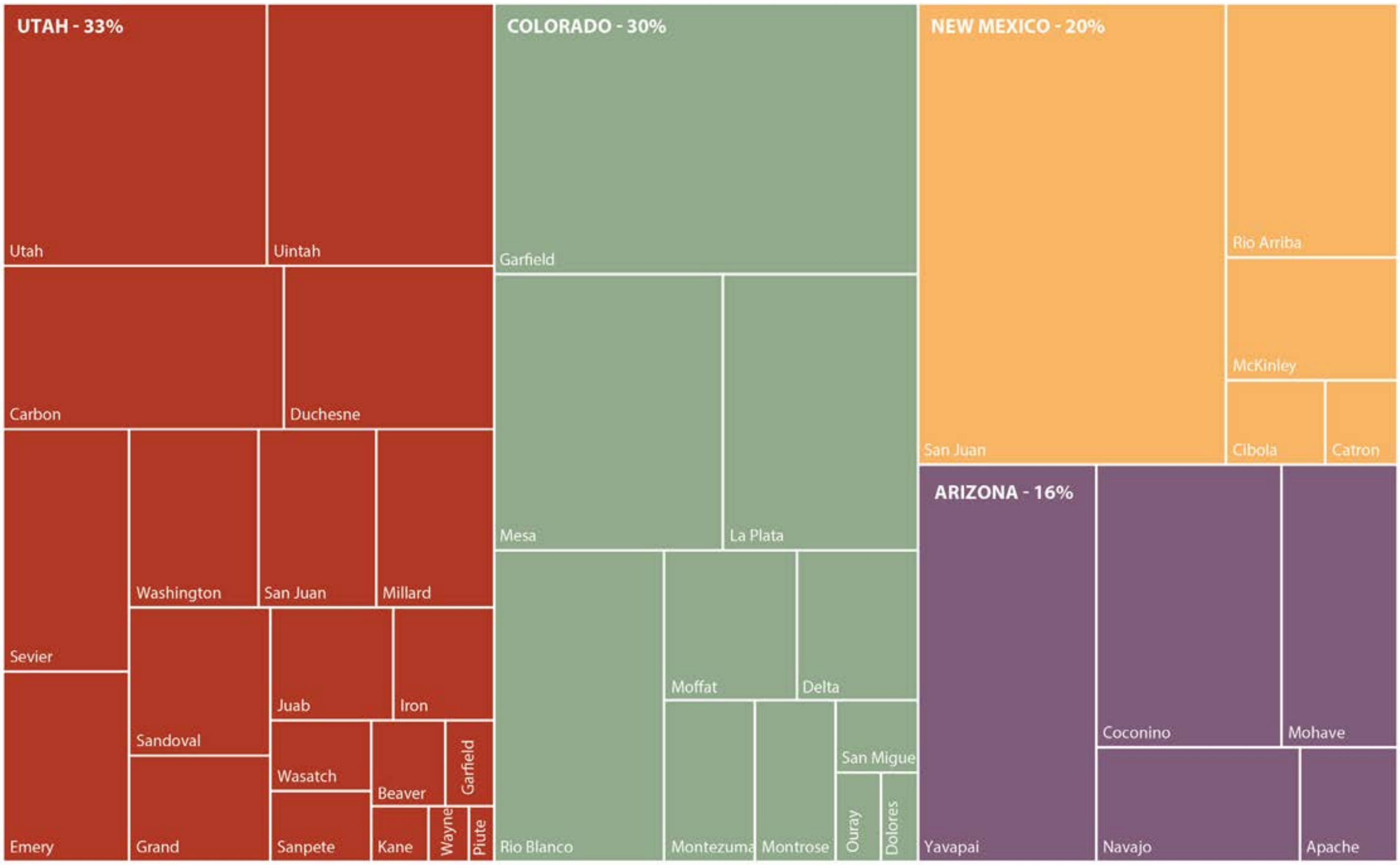

Figure 6. Colorado Plateau 2018 emissions by state and county (mt CO_2e).

Across the various sectors, oil and gas systems were the largest source of emissions for Utah, Colorado, and New Mexico counties. Transportation and electricity emissions are primarily associated with higher population areas. Since the population is the greatest for the plateau region in Arizona counties, electricity and transportation accounted for 76 percent of the state's county totals. Collectively, transportation and electricity also account for 51 percent of Colorado counties' other high-emission activities. In New Mexico, fugitive emissions from coal accounted for 18 percent of the state's county totals—the highest for coal emissions across the region. Utah counties had the second-highest coal emissions across the region, and they comprised 23 percent of the state's total (Figure 7).

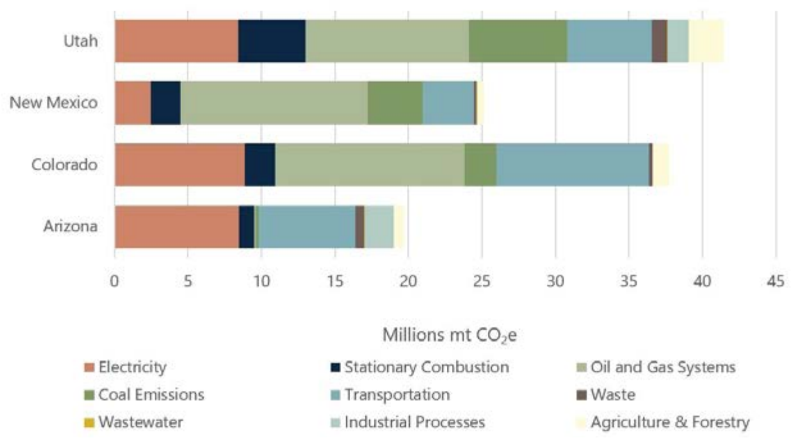

Figure 7. Colorado Plateau county emissions by state (mt CO_2e).

Emissions by county ranged from just under 137,000 mt CO_2e in Piute County, Utah to just under 15 million mt CO_2e in San Juan County, New Mexico. The map in Figure 8 displays the intensity of total emissions for each county. San Juan County, New Mexico alone accounts for 12 percent of aggregate county emissions (Figure 8). This is primarily attributed to the fugitive emissions from the oil and gas subsector (see the *Fugitive Emissions* section).

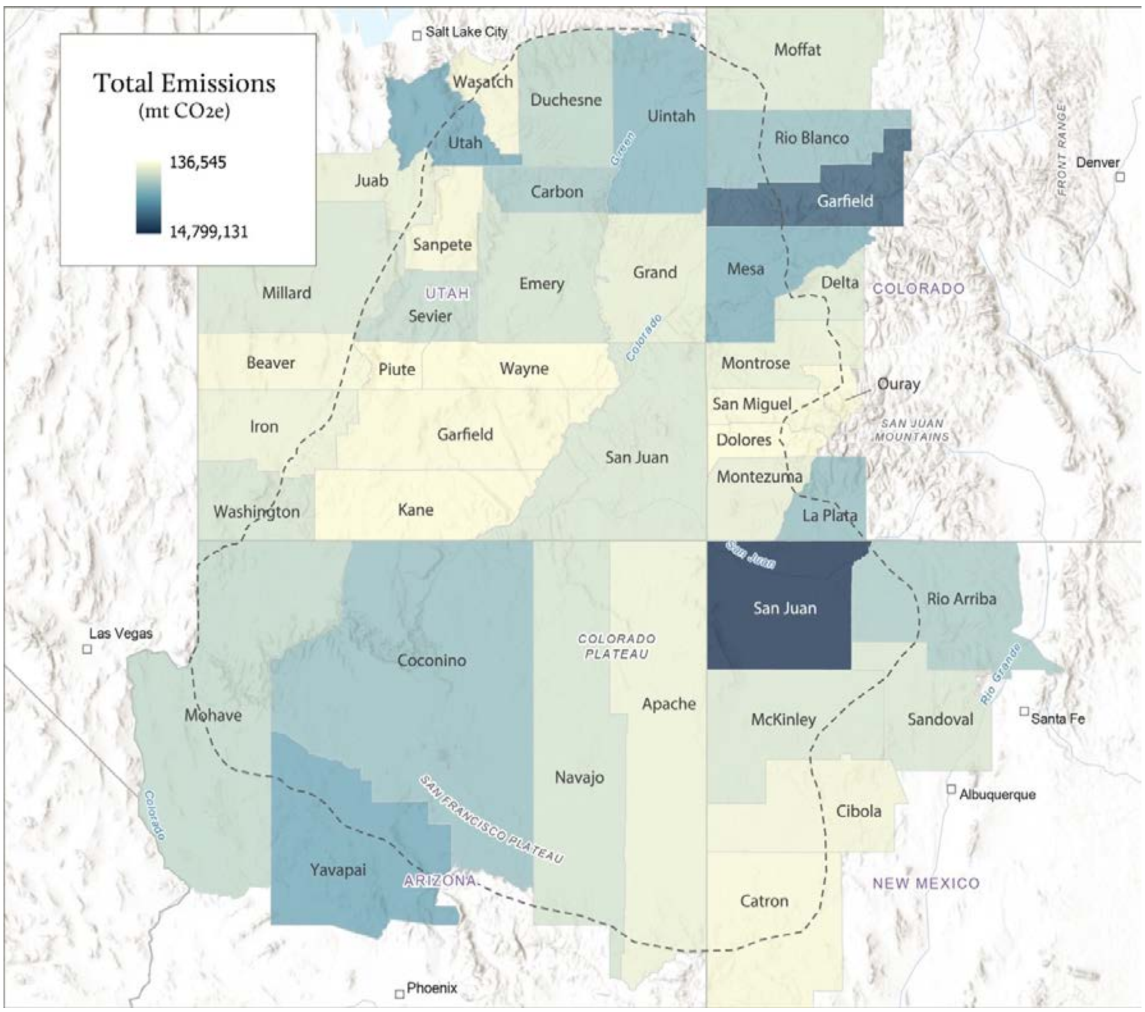

Figure 8. Colorado Plateau 2018 total emissions (mt CO_2e).

Another area of higher emissions due to the oil and gas subsector occurs in La Plata and Garfield counties in Colorado, and Uintah County in Utah. Garfield County alone accounts for 10 percent of aggregate county emissions across the Colorado Plateau. Further, La Plata County, Colorado accounts for nearly 5 percent, and Uintah County, Utah another 5 percent. The higher emissions values in Mesa County, Colorado; Utah County, Utah; and Yavapai and Coconino counties, Arizona are likely related to higher population density and are mostly attributed to emissions from stationary combustion and transportation.

KEY FINDINGS FROM EMISSIONS FORECAST

Emissions were forecasted from the 2018 baseline year to 2050 in a business-as-usual scenario to help demonstrate the trajectory of emissions for the plateau without intervention. The forecast considered current legislation in Colorado and New Mexico requiring utilities to generate 100 percent of electricity from renewable sources by 2050. Additionally, the recently announced goal from Arizona Public Service, Arizona's largest electric utility, to be a carbon-free utility by 2050 and reduce emissions from its power supply by two-thirds by 2030, was also included in the forecast. The activity data for most sectors (i.e., electricity consumed, or waste produced) were projected to increase at the same rate as a county's population change.

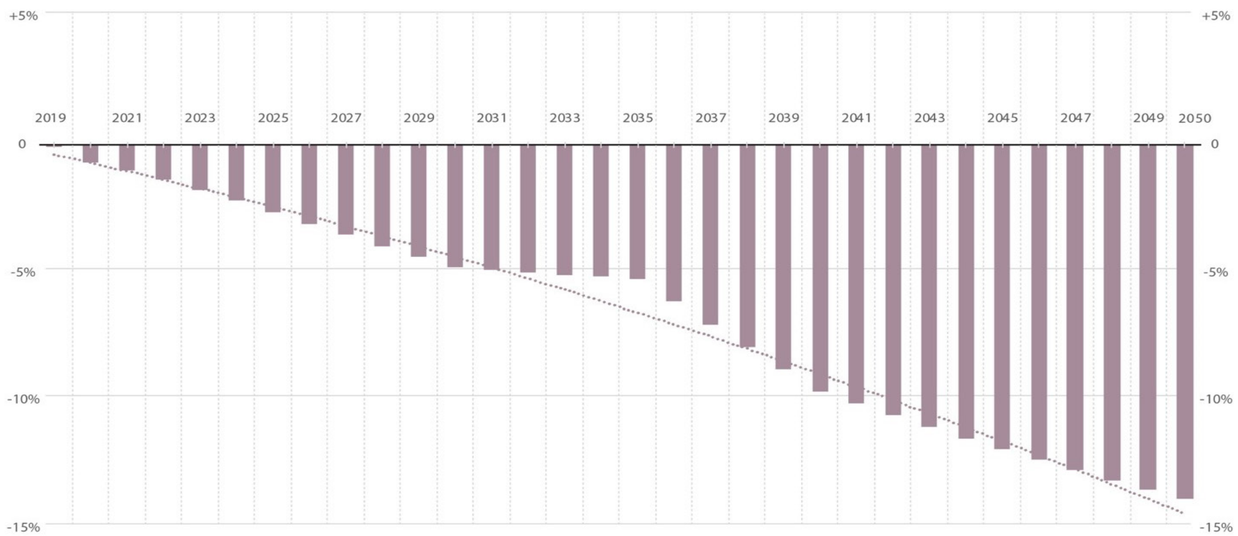

Figure 9. Forecasted total business-as-usual emissions for the Colorado Plateau 2018-2050 (mt CO_2e).

In the business-as-usual scenario, as of 2018, emissions are projected to decrease by 14 percent, or slightly more than 17 million mt CO_2e (Figure 9). All sectors saw decreases through 2050 except for waste/wastewater and industrial process, which saw no change (Figures 10, 11). The stationary energy sector saw the largest decrease in emissions by 2050 with a 28 percent reduction, primarily due to reductions in the carbon intensity of electricity supplied on the plateau. All states saw decreases in emissions through 2050 except Utah, which saw an increase in emissions due to a lack of state or utility policies on renewable energy or carbon reduction, and population

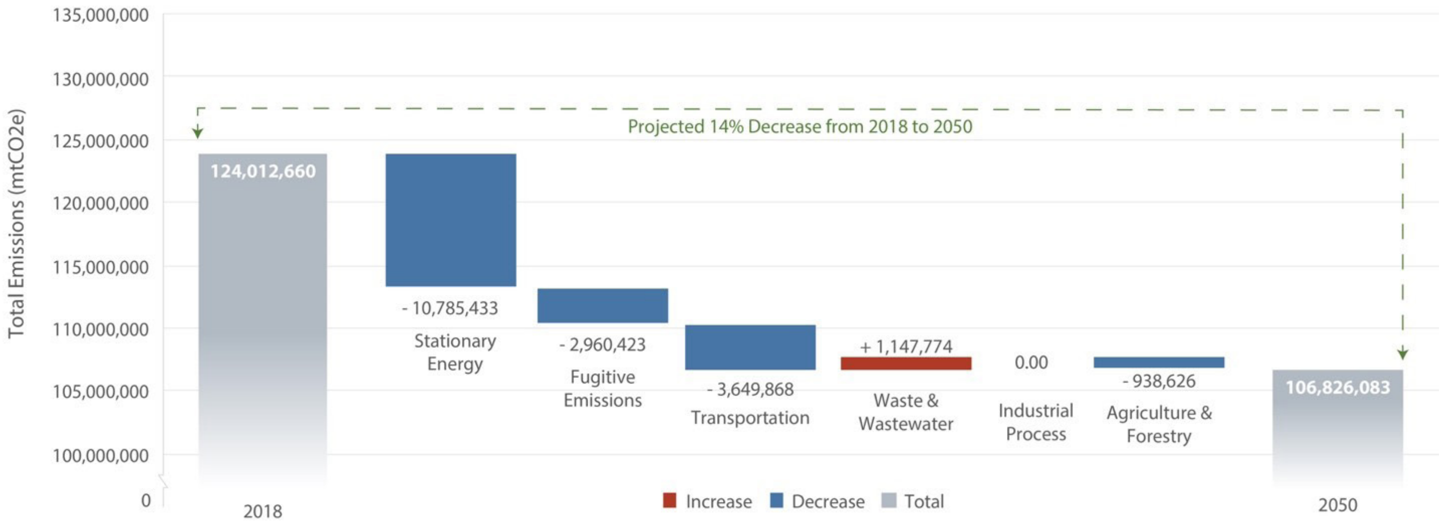

Figure 10. Colorado Plateau forecasted emissions change by sector from 2018-2050 (mt CO_2e).

increases. Arizona saw the largest decrease in emissions at 52 percent, of which the majority was from a decrease in fugitive emissions due to population decreases and utility carbon reduction goals.[8]

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8 The portion of the Colorado Plateau and Colorado Plateau counties that fall within Arizona are comprised of mostly rural populations, which are projected to decline. Because of this, Arizona Colorado Plateau populations are generally forecasted to decrease by 2050, despite the state's population as a whole increasing.

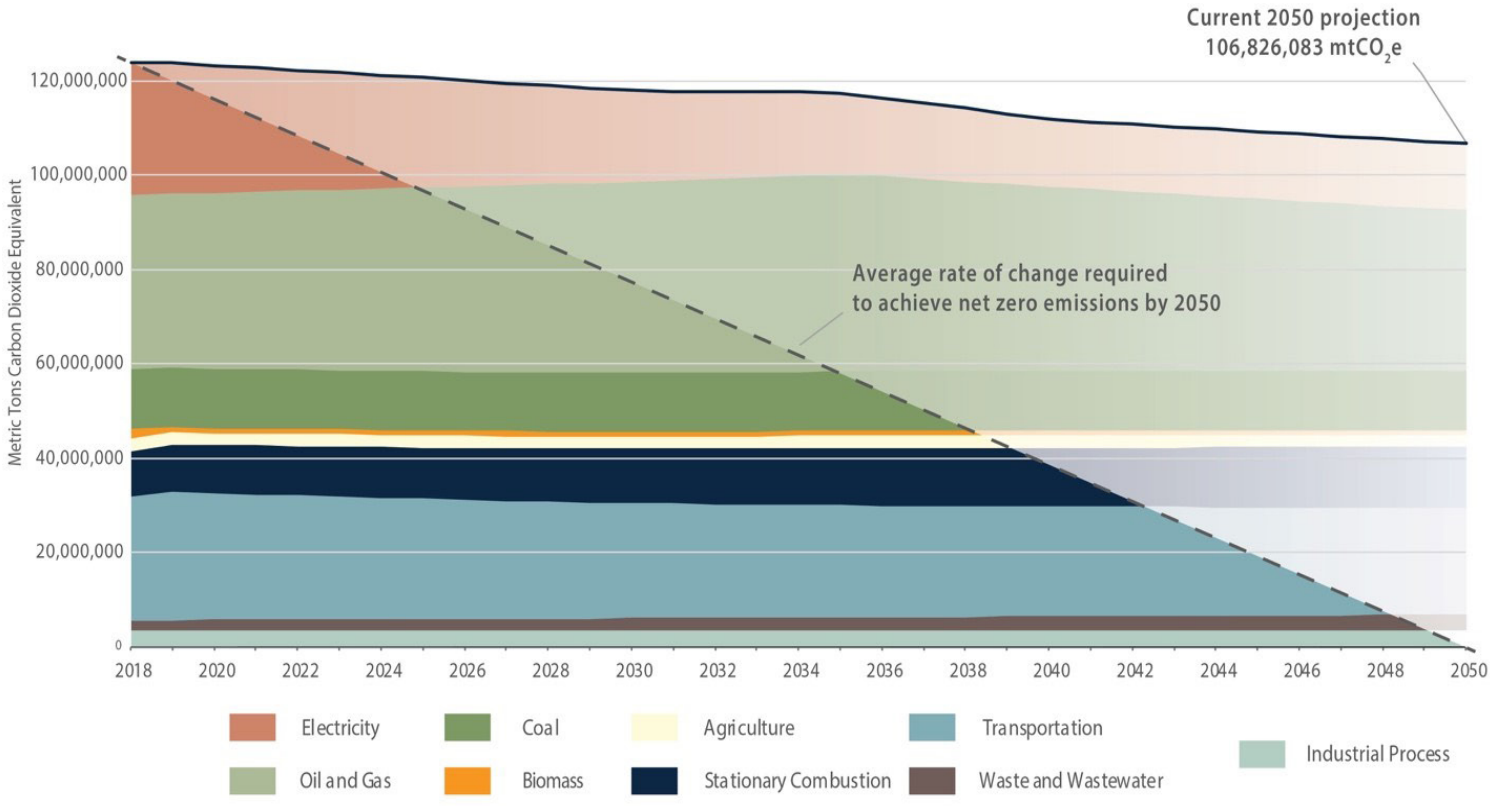

Figure 11. Forecasted emissions for Colorado Plateau counties through 2050 (mt CO_2e).

While oil and gas systems emissions are expected to decrease by 2050, for Utah, Colorado, and New Mexico, they are expected to see an exponential 14 percent increase until peak oil.[xiv] Peak oil—the point at which oil production hits its maximum rate, after which it will begin to decline—is reached in 2035[xv] (Figure 12[9]). As previously stated, the emissions forecast did not take into account the impacts of the response to the global coronavirus pandemic. It is unclear whether the pandemic will affect peak oil. However, it is likely that oil demand will likely be lower over the next few years.[xvi]

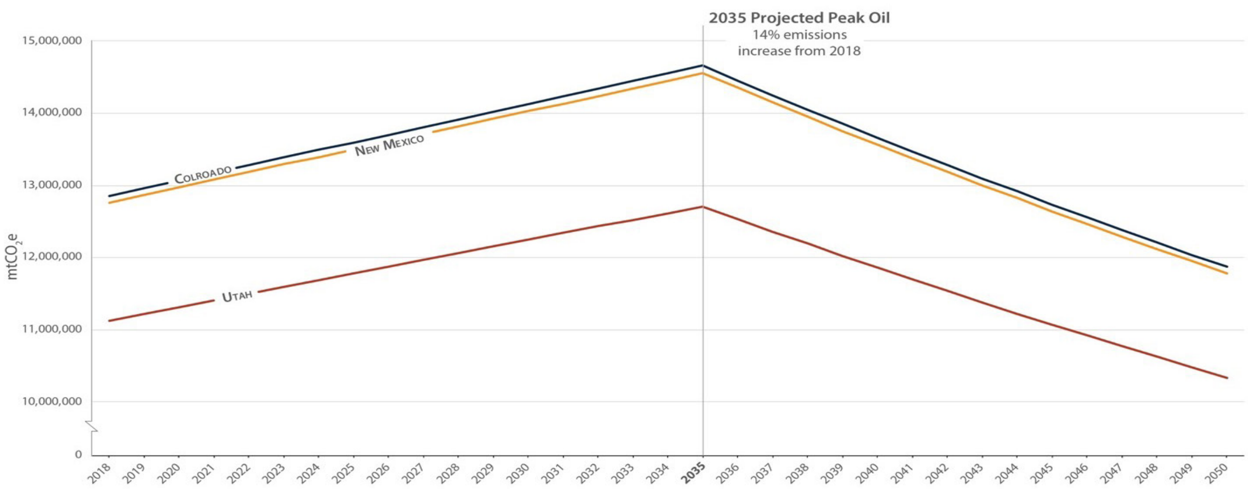

Figure 12. Projected oil and gas systems emissions from 2018-2050 (mt CO_2e).[8]

KEY FINDINGS FROM CARBON SEQUESTRATION ANALYSIS

Carbon stocks were estimated from four main land-cover types—forests, croplands, grasslands/shrublands, and wetlands. All other land cover types were classified as "other."

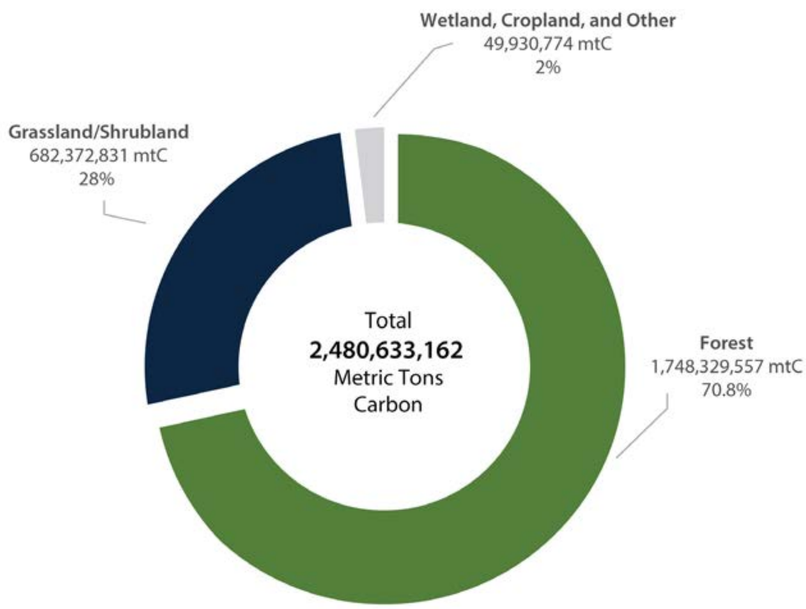

Figure 13. Carbon stocks across the Colorado Plateau.

There are currently nearly 2.5 billion mt of carbon stored in these land types. Forest cover and grasslands/shrublands account for the largest carbon stock across the plateau. Forests hold around 71 percent and the grassland/shrubland cover type holds 27 percent. By estimating the land-cover change in future years, one can estimate year-over-year changes in carbon sequestration using the estimated carbon stock in 2018 as the baseline.

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9 This graph is scaled for readability, thus excluding Arizona. Arizona's values increase from 61,093 mt CO_2e in 2018 to 69,646 mt CO_2e in 2035 and decrease to 56,370 mt CO_2e in 2050.

STATIONARY ENERGY SECTOR

Combustion of fuels in stationary non-transported sources results in carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) greenhouse gases. Sources of emissions from stationary combustion may include boilers, heaters, furnaces, kilns, ovens, flares, thermal oxidizers, dryers, and any other equipment or machinery that combusts carbon-bearing fuels. The stationary energy sector was broken down into two broad emission sources: electricity and stationary combustion.[xvii]

Electricity emissions account for electricity generated and consumed by residential, commercial and industrial users, and any losses in the transmission and distribution of electricity. Electricity emissions are calculated based on total electricity used combined with the EPA Emissions Generation Resource Integrated Database average emissions factors for carbon, methane, and nitrous oxide. This calculation accounts for electricity generation from a mix of sources such as coal-fired power plants, natural gas, etc. Electricity emissions in the inventory also consider electricity that is generated but lost in the transmission and distribution process from the utility to the end user.

Stationary combustion sector emissions are generated from the on-site combustion of propane, natural gas, and wood from residential and commercial sources as well as from the use of large industrial boilers. Emissions generated from on-site fuel combustion of various fuels used by power plants, other than burning coal, were also included in stationary combustion. However, the emissions from the coal itself to generate electricity at power plants were included in the emissions generated from electricity production.

TOTAL STATIONARY ENERGY EMISSIONS

Total stationary energy accounted for about 31 percent, and nearly 38 million mt CO_2e, of county emissions across the Colorado Plateau (Figure 14). Fifty-six percent (21.1 million mt CO_2e) of these emissions occur from activities within the Colorado Plateau boundary.

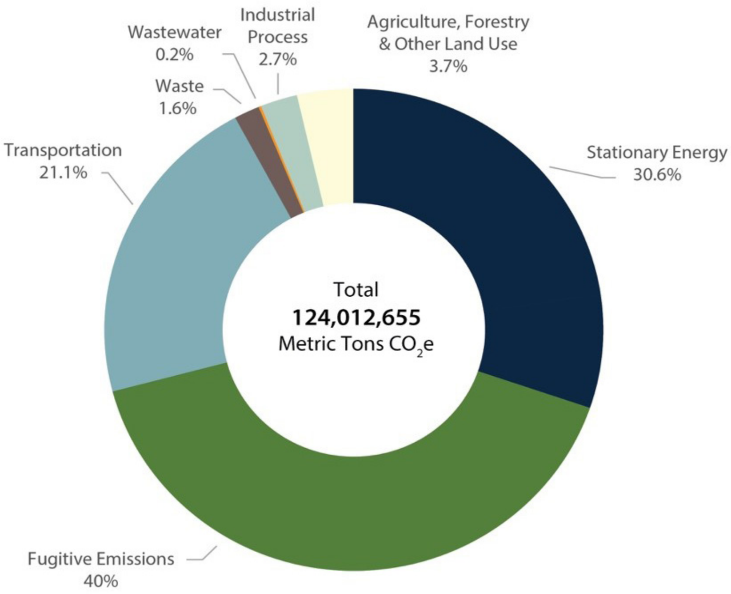

Figure 14. Colorado Plateau counties total emissions by sector.

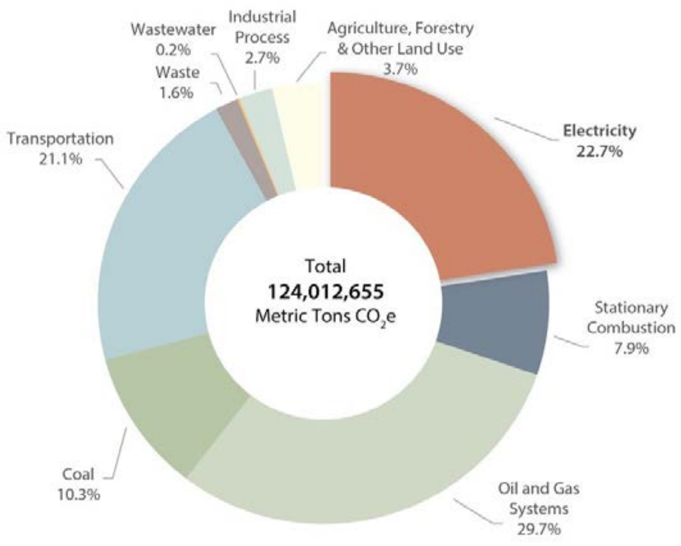

Figure 15. Proportion of total emissions from electricity.

ELECTRICITY EMISSIONS

The generation and use of electricity accounted for 23 percent of the total county emissions across the Colorado Plateau and 28.2 million mt CO_2e (Figure 15). Around 55 percent—over 15 million mt CO_2e—of those emissions were estimated to have originated directly from within the Colorado Plateau boundary. The commercial electricity use subsector generated the largest amount of emissions at over 10 million mt CO_2e followed by the residential use subsector with over 9 million mt CO_2e. The losses occurring from the transmission and distribution of electricity to end users were the smallest contributing subsector accounting for less than 5 percent of total electricity emissions (Figure 16).

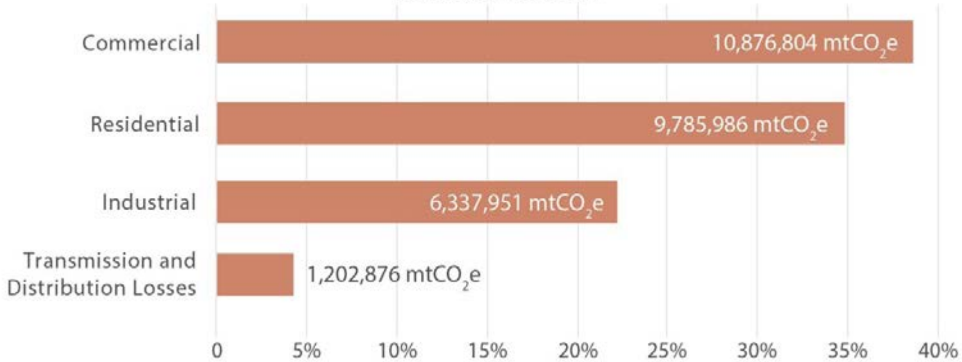

Figure 16. Total county emissions from electricity subsectors (mt CO_2e).

Electricity emissions were not evenly distributed across all counties. Clear emissions hot spots emerge in northern Arizona and the western slope counties in Colorado where the population is higher (Figure 17). The highest emissions from electricity use included Garfield and Mesa counties in Colorado, and Yavapai and Coconino counties in Arizona.

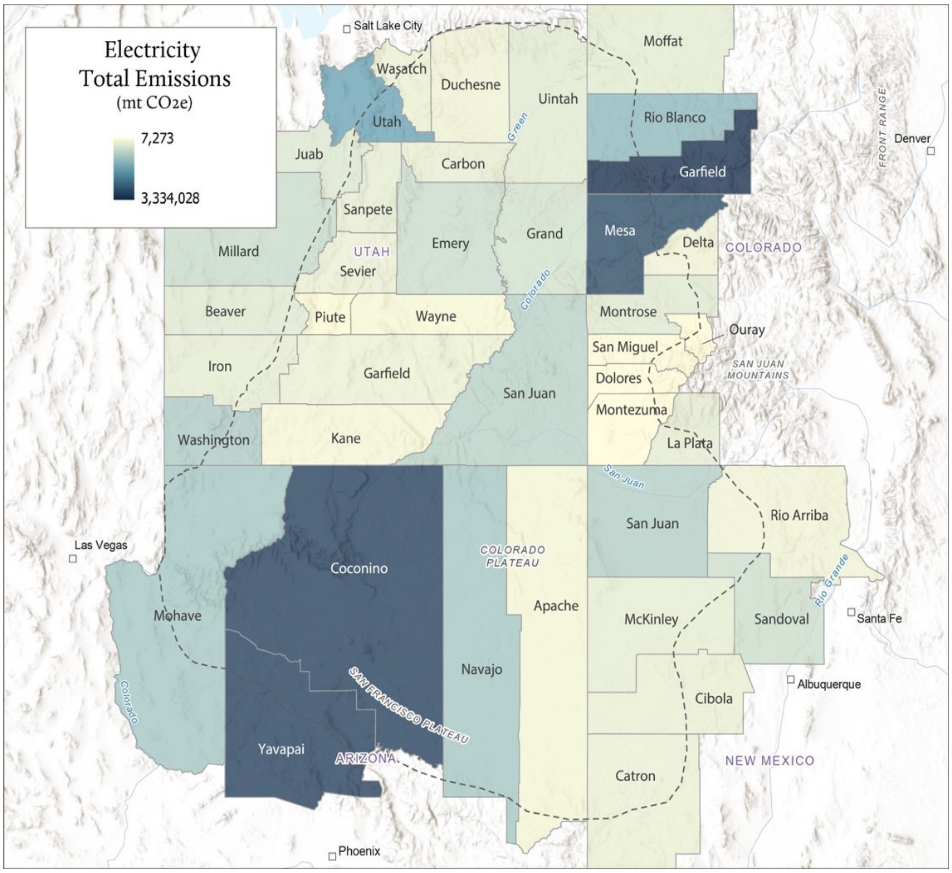

Figure 17. Map of total electricity emissions across the Colorado Plateau.

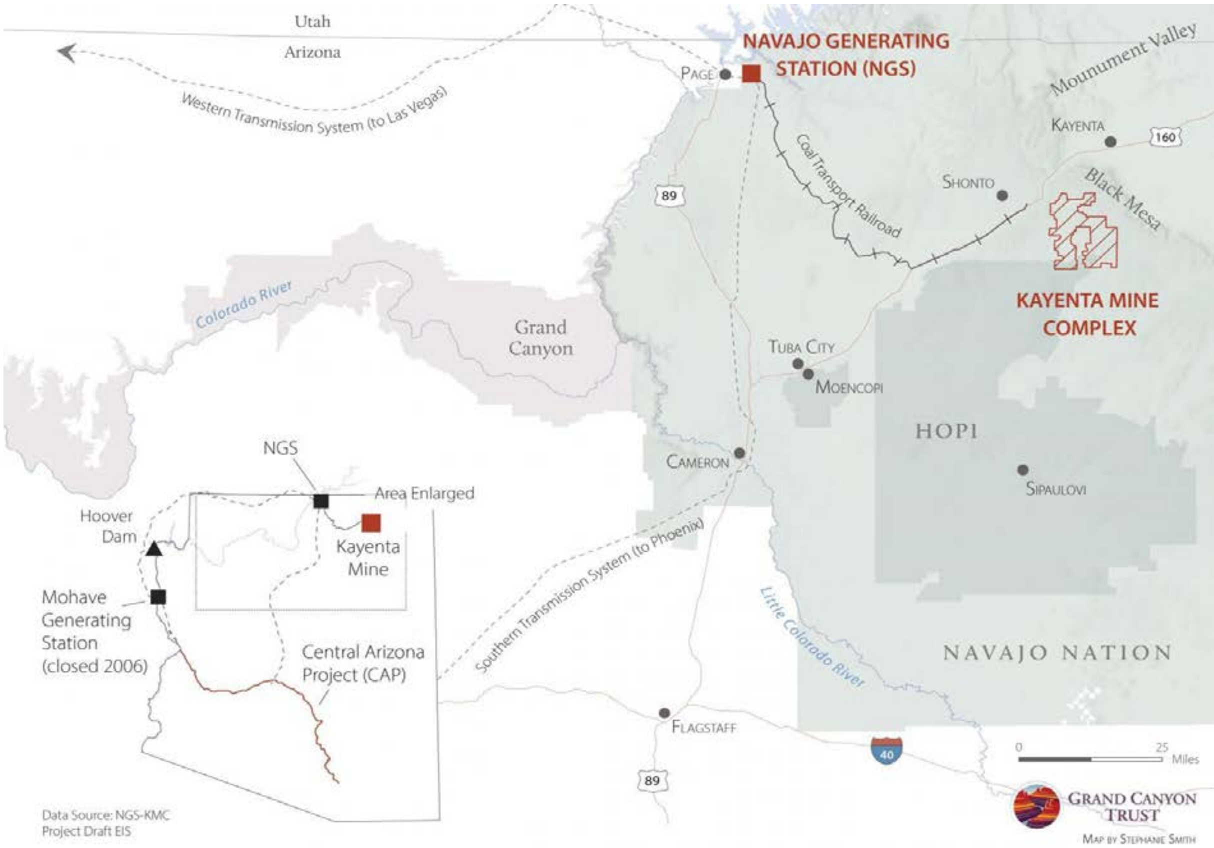

Figure 18. Map of Navajo Generating Station and Kayenta Coal Mine Complex.

NAVAJO GENERATING STATION

Navajo Generating Station (NGS) near Page, Arizona came online in the mid-1970s to supply power to one of Arizona's largest utilities, the Salt River Project (Figure 18). The decision was made in 2017 to close the coal-fired power plant after pressure from the energy industry due to renewables rapidly becoming cheaper than their fossil fuel counterparts. It officially ceased operations on November 18, 2019.

In addition to NGS closing, the nearby Kayenta Coal Mine, the supplier of coal burned at NGS, closed its operations in August 2019 after delivering the last load of coal. The closing of these two facilities will help decrease the amount of future emissions across the Colorado Plateau region. Since NGS was still operating in 2018, this inventory includes emissions from the last full year of operation reported to the EPA. However, the forecasted emissions accounted for the closure of these facilities.

STATIONARY COMBUSTION EMISSIONS

Stationary combustion accounted for nearly 8 percent of total county emissions, and over 9.7 million mt CO_2e, across the Colorado Plateau counties (Figure 19 and 20). Fifty-seven percent of those emissions—over 5.5 million mt CO_2e—were estimated to be attributed to activities directly on the plateau.

Large emitters[10] represented the largest share of stationary combustion emissions, totaling 47 percent of emissions. The emissions from the Sunnyside Power Plant in

10 Large emitters include facilities that report to the GHGRP under "subpart C," which includes emissions from devices that combust any solid, liquid, or gaseous fuel to produce electricity, steam, useful heat, or energy for industrial, commercial, or institutional use. These devices include but are not limited to: boilers, combustion turbines, engines, incinerators, and process heaters.

Carbon, Utah accounted for 10 percent of total emissions from all large emitters.[11]

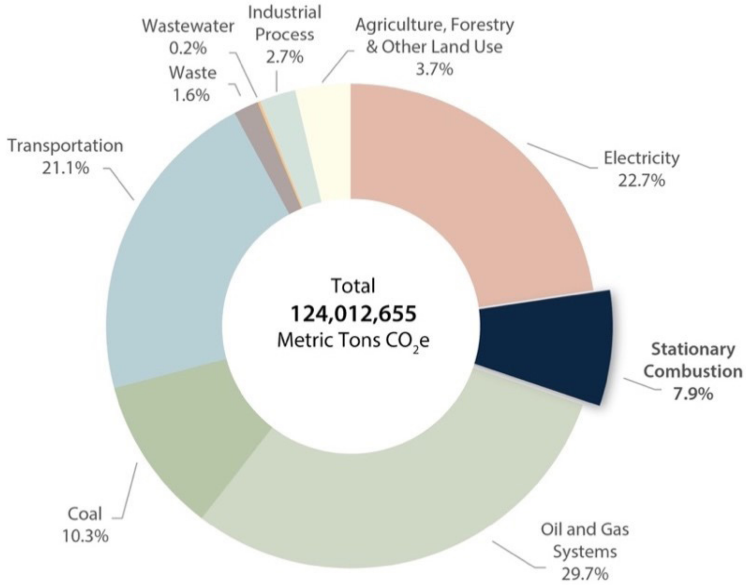

Figure 19. Proportion of total emissions from stationary combustion.

The highest emissions, over 1.8 million mt CO_2e, occurred in Utah County, Utah from activities that mostly fall outside the Colorado Plateau boundary (Figure 21). Taking this into consideration, across the plateau, San Juan County, New Mexico contributes the most stationary combustion emissions (1,404,019 mt CO_2e). Over 1.2 million mt CO_2e of those emissions result from activities from large emitting facilities from the petroleum and natural gas sector. Similar to San Juan County, Garfield County in Colorado and Carbon County in Utah also contribute a significant amount of emissions from the combustion of fuels at large emitting facilities from petroleum and natural gas.

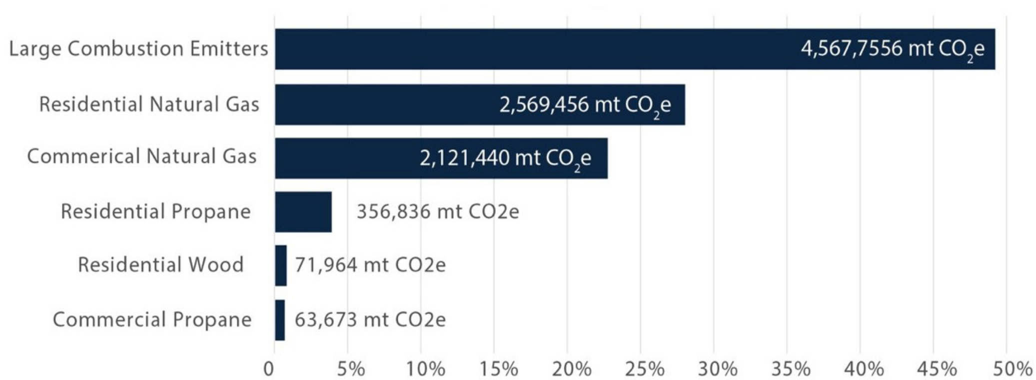

Figure 20. Total county emissions from stationary combustion subsectors (mt CO_2e).

FORECASTED STATIONARY ENERGY EMISSIONS

Emissions from electricity consumption and stationary combustion across the plateau are forecasted to decrease by 28 percent by 2050 (Figure 22). Lower electricity emission factors contribute the most to the forecasted decrease in emissions, largely due to policies recently enacted by utilities in Arizona and state legislatures in Colorado and New Mexico.

Policies in Colorado and New Mexico require utilities to increase the proportion of electricity sourced from renewable energy, with a goal of reaching 100 percent

11 Direct emissions from the Colorado Plateau's large power plants are not included in the inventory except to the extent the power that they generate is used on the Colorado Plateau. This category of emissions, largely from coal-fired power plants, are discussed at length in Appendix A. Sunnyside Power Plant is the only coal-fired power plant on the Colorado Plateau whose emissions are reported under GHG Reporting Rule C.F.R. 98, Subpart C (General Stationary Fuel Combustion Sources) rather than Subpart D (Electricity Generation). As such, the direct emissions from Sunnyside Power Plant are included in the inventory and it is the largest producer of emissions in the stationary combustion sector.

renewable electricity in Colorado by 2040 and 80 percent renewable electricity in New Mexico by 2045. Arizona's largest utility recently announced a goal to achieve 100 percent carbon-free electricity by 2050 and reduce emissions of its resource mix by two-thirds by 2030. Collectively, these goals and policies will result in lower emissions factors for electricity in the future. If similar policies were enacted in Utah and by other utilities in Arizona, it might be possible for electricity emissions to decrease to near zero by 2050.

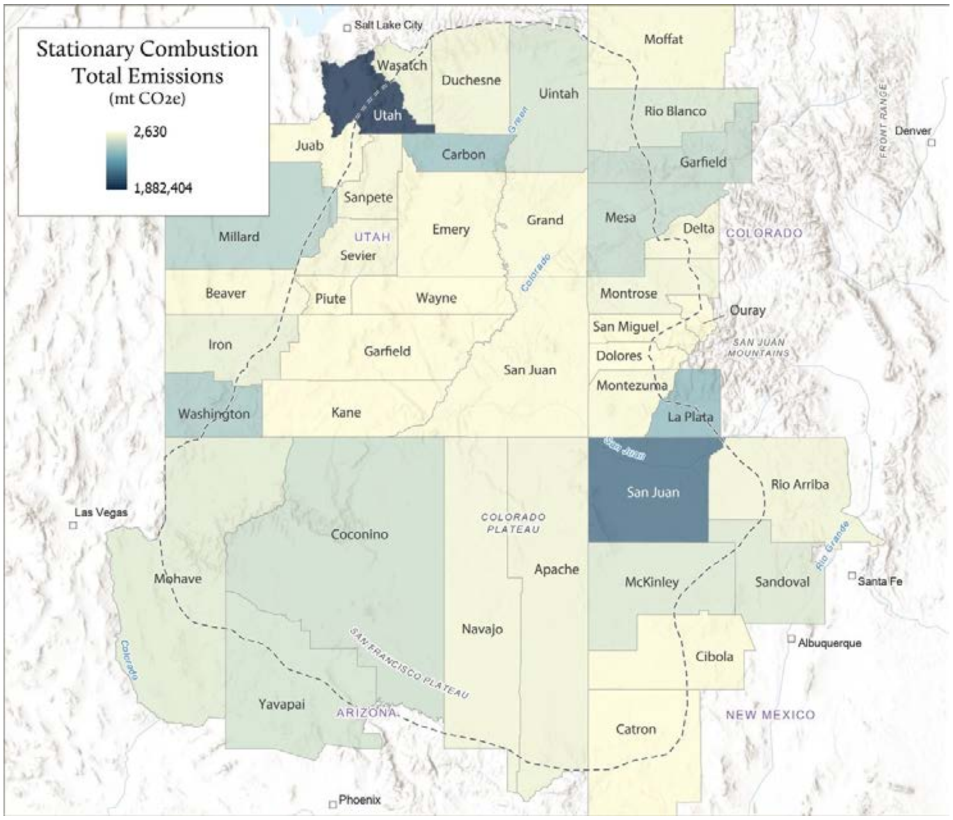

Figure 21. Map of total stationary combustion emissions across the Colorado Plateau.

Emissions from natural gas, propane, and wood use were projected to change in relation to population increases (or decreases) through 2050. Emissions from large emitting facilities were projected to change based on the facility type, whereas power plant and chemical manufacturing plant emissions were forecasted to stay constant. Constant emissions were based on a 2010-2018 average emissions value. Stationary combustion emissions were expected to change at the rate of population and (based on national studies[xviii]) emissions from natural gas facilities and supplies are anticipated to increase until 2035 and then slowly decrease until 2050.

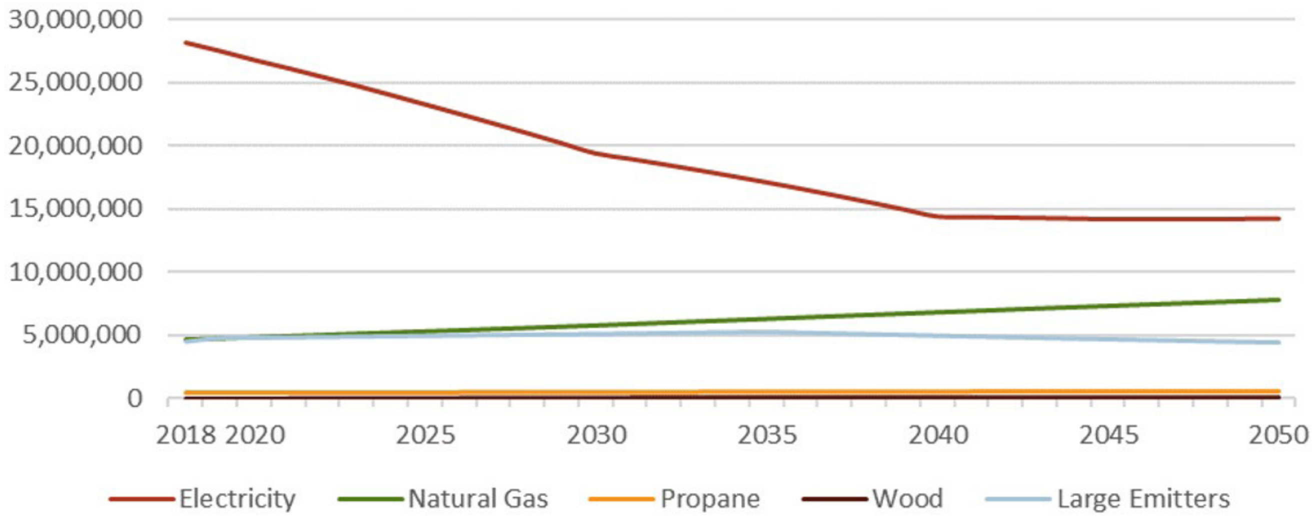

Figure 22. Forecasted emissions for electricity and stationary combustion, 2018-2050 (mt CO_2e).

FUGITIVE EMISSIONS

The fugitive emissions sector accounts for intentional and unintentional emissions from the release of greenhouse gases during the extraction, processing, and delivery of fossil fuels from oil and gas systems and activities associated with coal mining. Intentional emissions can occur from intended and designed venting from things like tanks, controllers, compressor seals, or stacks. Unintentional emissions can occur from things like normal wear and tear, improper assembly of components, damage during installation or use, or corrosion.

Emissions from oil and gas systems include leaked and vented[xix] emissions from:

- the processes of oil and natural gas extraction, production, transport, storage, and end use at petroleum refineries;[xx] and
- the refining in facilities that produce gasoline, gasoline blending stocks, naphtha, kerosene, distillate fuel oils, residual fuel oils, lubricants, or asphalt (bitumen) by the distillation of petroleum or the re-distillation, cracking, or reforming of unfinished petroleum derivatives. This also includes leakage during the production, processing, and transport of natural gas.[xxi]

Fugitive emissions (methane (CH_4), and carbon dioxide (CO_2)) associated with coal mining include emissions from the coal mining process and do not include emissions from burning coal. Emissions from burning coal were included in stationary energy. Fugitive emissions remain trapped in coal seams until coal is exposed and broken down during mining activities and after mines are abandoned. The emissions from post-closure activities and fugitive emissions from mines are included. Coal mining emissions include three sources: active aboveground mining, active belowground mining, and abandoned belowground mines.

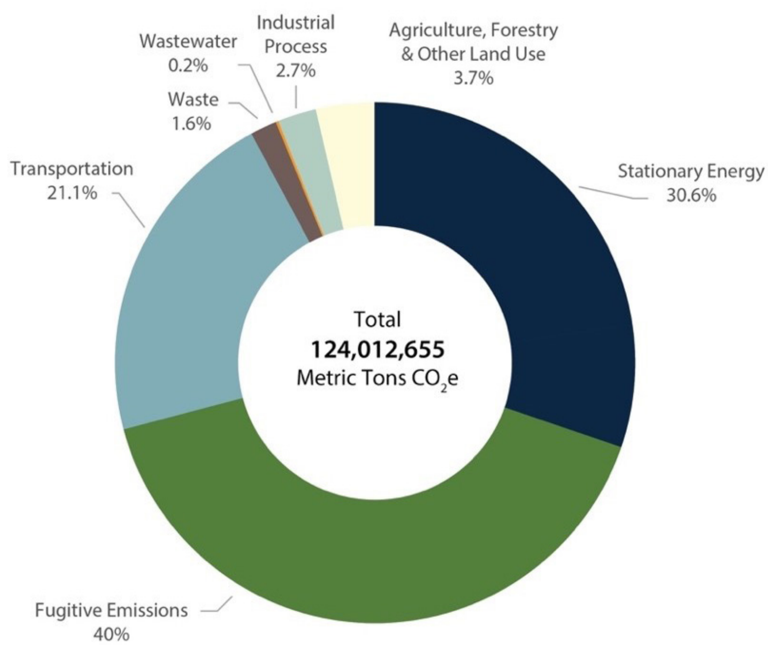

Figure 23. Proportion of total emissions from Fugitive Emissions.

TOTAL FUGITIVE EMISSIONS

Total fugitive emissions accounted for 40 percent—over 49 million mt CO_2e—of all emissions for plateau counties (Figure 23). Seventy-nine percent of those emissions were estimated to result from activities on the Colorado Plateau.

OIL AND GAS SYSTEMS EMISSIONS

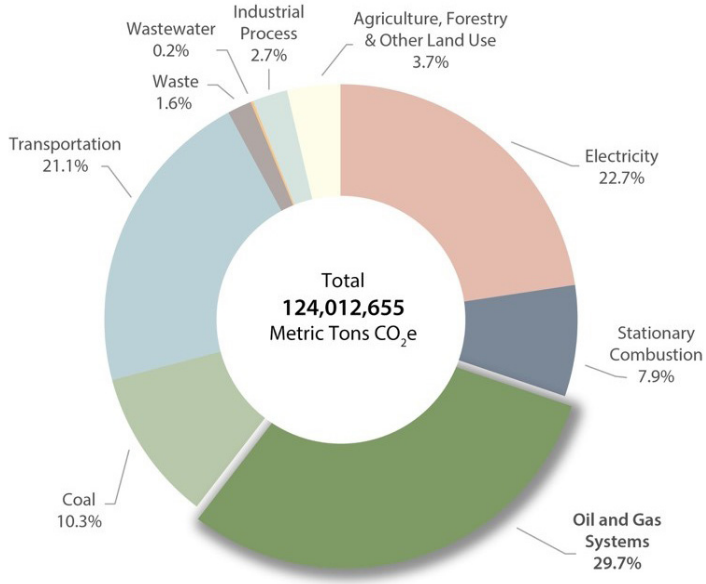

Figure 24. Proportion of total emissions from oil and gas systems.

Emissions from oil and gas systems totaled nearly 30 percent, 36,828,497 mt CO_2e, of total county emissions across the Colorado Plateau (Figure 24). Of those emissions, 75 percent (27,641,413 mt CO_2e) were estimated to have occurred directly on the Colorado Plateau.

Of the sources within the oil and gas systems subsector, oil and gas wells account for most of the emissions followed by petroleum and natural gas systems (Figure 25).Oil and gas emissions were not evenly distributed across the plateau. Clear emissions hot spots of oil and gas development emerge in northwestern New Mexico, northern Utah, and western Colorado (Figure 26). San Juan County, New Mexico accounted for 23 percent—nearly 8 million mt CO_2e—of total oil and gas emissions for the entire region, and 99.9 percent of those emissions occurred within the portion of San Juan County that lies on the Colorado Plateau. The majority of the emissions for San Juan County occurred from oil and gas well sites (6,566,601 mt CO_2e) but a notable amount also originated from subpart W leaked or vented petroleum and natural gas systems (1,371,634 mt CO_2e).[12]

12 Coalbed methane (CBM) is a significant source of emissions on the Colorado Plateau, specifically in the San Juan Basin in southern Colorado and northern New Mexico. It is accounted for in the Oil and Gas Systems sector, under Subpart W- Petroleum and natural Gas Systems, and Subpart Y- Petroleum Refineries. Due to reporting protocols, coalbed methane emissions are included within the larger category of Subpart W rather than parsed out as a separate category.

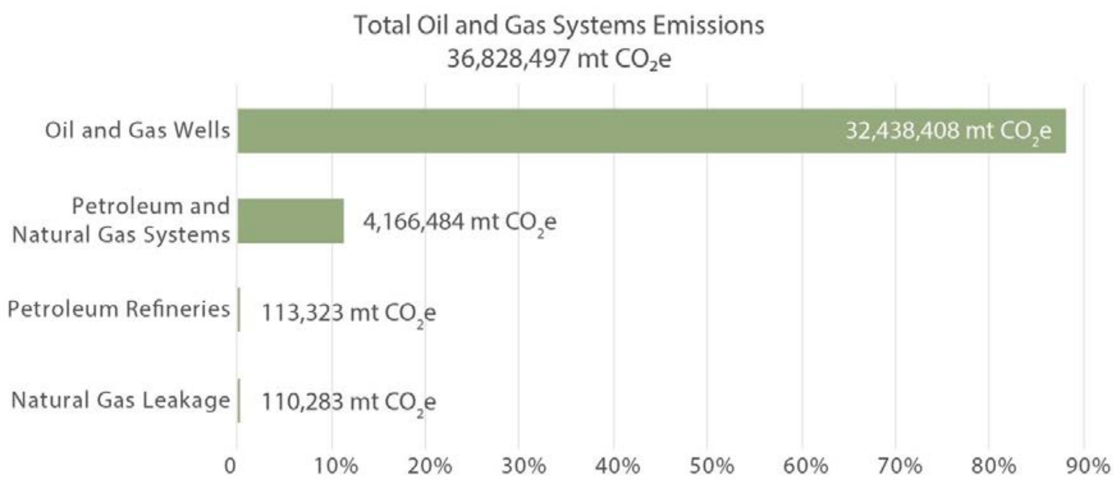

Figure 25. Total emissions sources for oil and gas systems (mt CO_2e).

COAL MINING EMISSIONS

Coal mining emissions across all counties accounted for 10 percent and over 12 million mt CO_2e of total emissions (Figure 27 and 28). Ninety-two percent (over 11 million mt CO_2e) of those emissions were associated with activities that occur on the Colorado Plateau.

Active underground coal mining contributed the greatest amount of coal emissions and accounted for 95 percent (over 12 million mt CO_2e) of total coal mining emissions across the Colorado Plateau counties (Figure 29). Overall, the highest concentration of coal mining emissions occurred in Carbon, Sevier, and Emery counties in Utah and San Juan County, New Mexico. Underground mines located in San Juan County, New Mexico and Carbon County, Utah make up 52 percent of total underground mine emissions. San Juan Mine 1 in San Juan County, New Mexico alone accounted for over 3.3 million mt CO_2e (28 percent), and the four mines in Carbon County, Utah accounted for nearly 3 million mt CO_2e (24 percent) of total underground mine emissions.

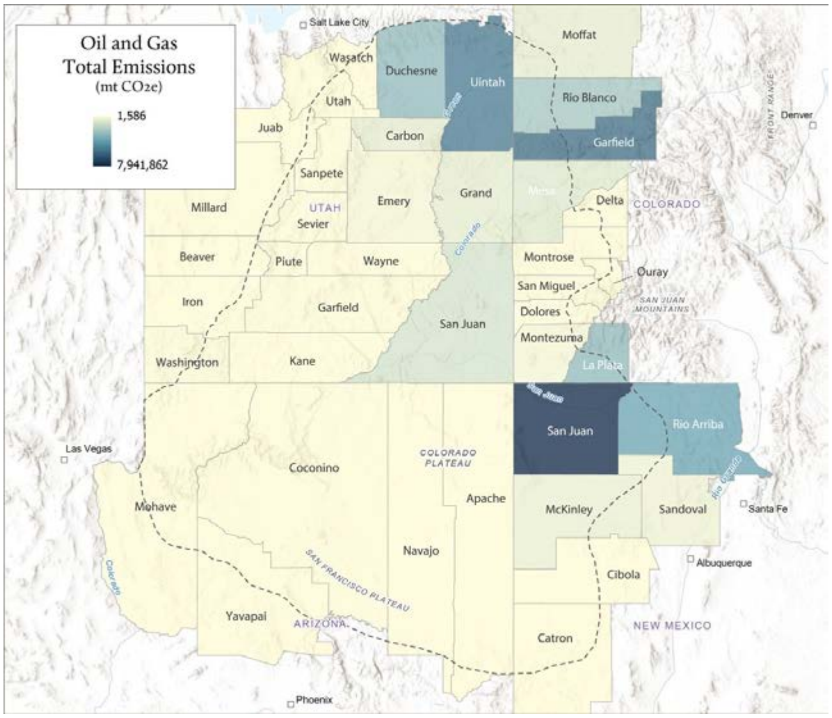

Figure 26. Map of total oil and gas systems emissions across the Colorado Plateau.

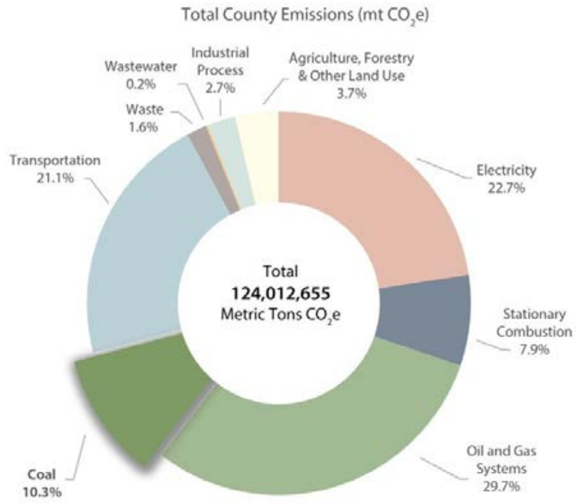

Figure 27. Proportion of total emissions from coal mining.

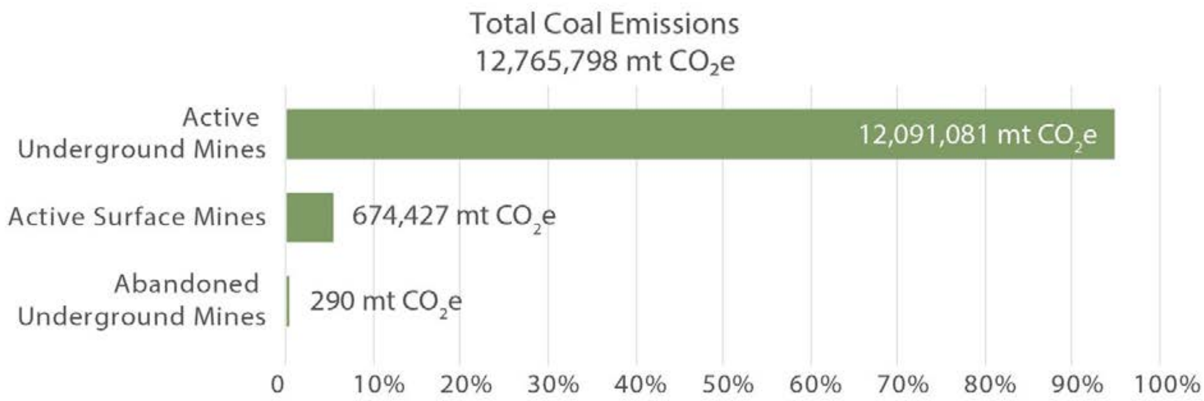

Figure 28. Total emissions sources for coal mining (mt CO_2e).

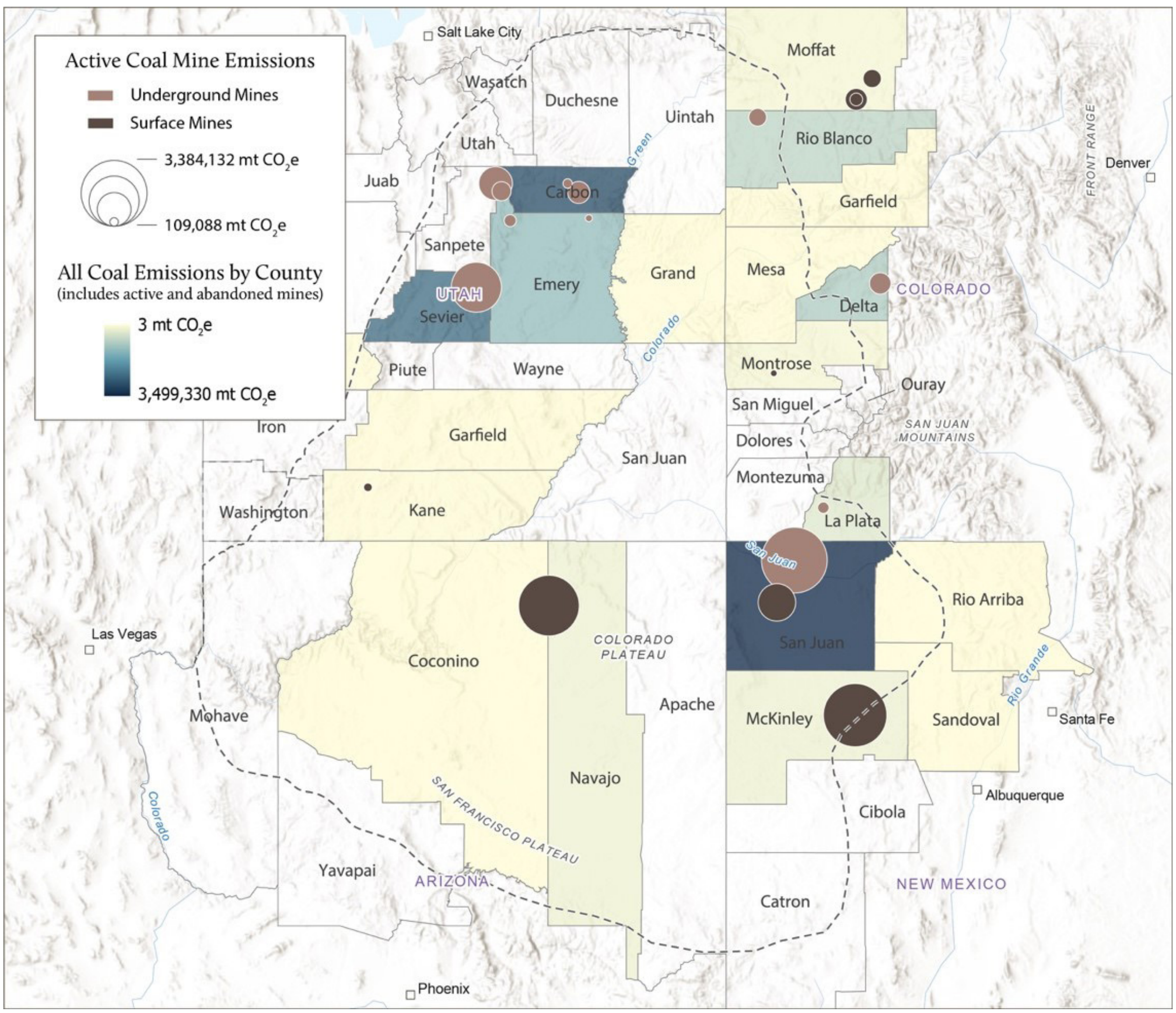

Figure 29. Map of total coal emissions and active coal mine emissions across the Colorado Plateau.

FORECASTED FUGITIVE EMISSIONS

Fugitive emissions were estimated to decrease by 6 percent (2,960,424 mt CO_2e) between 2018-2050 across counties on the plateau (Figure 10). However, emissions were projected to increase through 2035 when the sector is estimated to reach its peak and then steadily decrease through 2050. With the 2035 peak, demand for natural gas is estimated to be nearly 14 percent higher than it is today[xxii] (Figure 30).

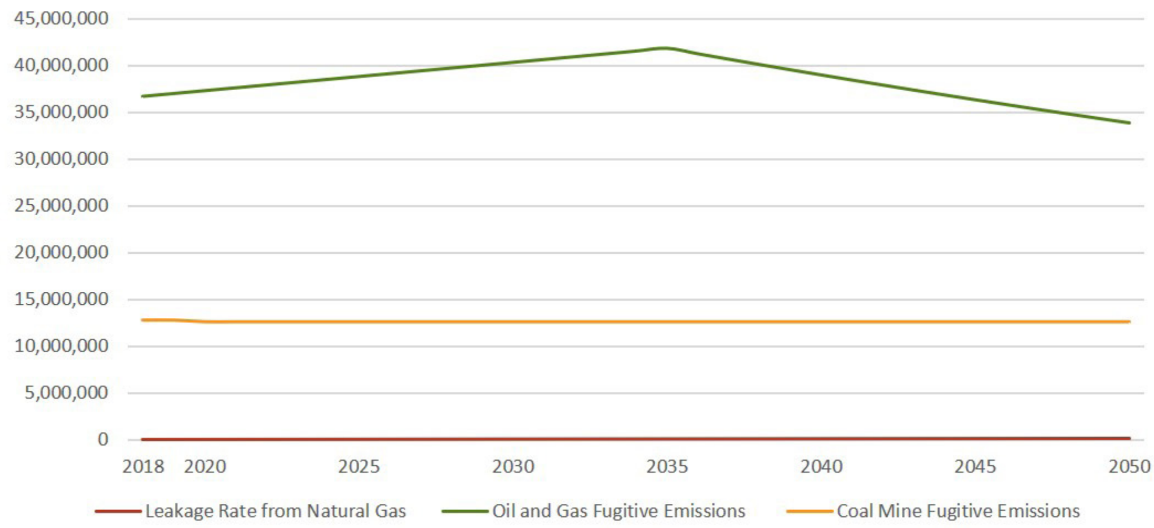

Figure 30. Forecasted emissions for fugitive emissions sector, 2018-2050 (mt CO_2e).

After 2035, demand is expected to decline until 2050; the rates of decline were not found, but data on decreased production of conventional onshore oil, where production is anticipated to decrease by 1.4 percent per year, were used as a proxy.[xxiii] Therefore, the number of oil and gas wells and oil and gas systems in each county were estimated to increase linearly to 14 percent higher than 2018 levels from 2019-2035 and then decrease annually by 1.4 percent through 2050 (Figure 31[13]).

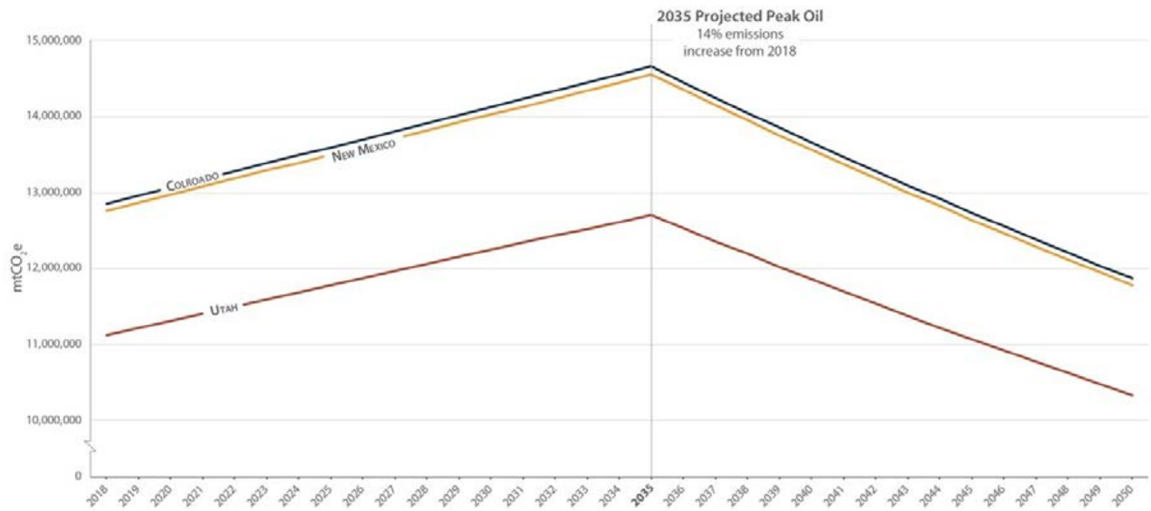

Figure 31. Projected oil and gas systems from 2018-2050 (mt CO_2e).[10]

13 This graph is scaled for readability, thus excluding Arizona. Arizona's values increase from 61,093 mt CO_2e in 2018 to 69,646 mt CO_2e in 2035 and decrease to 56,370 mt CO_2e in 2050.

Transportation Sector

The transportation sector consists of the following five subsectors:

1. on-road transportation: emissions produced by the burning of gasoline, diesel, and ethanol in on-road vehicles including passenger vehicles and large transport trucks, as well as the emissions produced from electric vehicles.
2. off-road transportation: emissions from vehicular activity that does not occur on a highway or regular paved road, includes fuel (i.e., gasoline and diesel) used in agriculture, construction, lawn and garden, recreation, military, and other miscellaneous activities.
3. waterborne transportation: emissions from gasoline fuel used in boats.[14]
4. aviation: emissions produced by the burning of aviation gasoline and jet fuel in airplanes, helicopters, and other aircrafts.
5. railways: emissions from diesel/electric engines that produce emissions when in operation; these engines have their own on-board generators that burn diesel fuel to generate electricity that powers the trains.

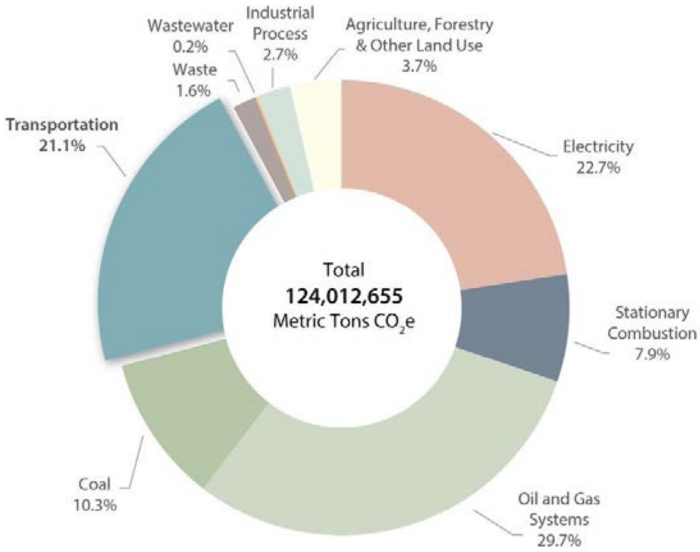

Figure 32. Proportion of total emissions from transportation.

Emissions from the transportation sector accounted for over 21 percent of the total emissions for counties across the plateau, 26.2 million mt CO_2e (Figure 32). Fifty percent of those emissions were estimated to have occurred from activities on the Colorado Plateau.

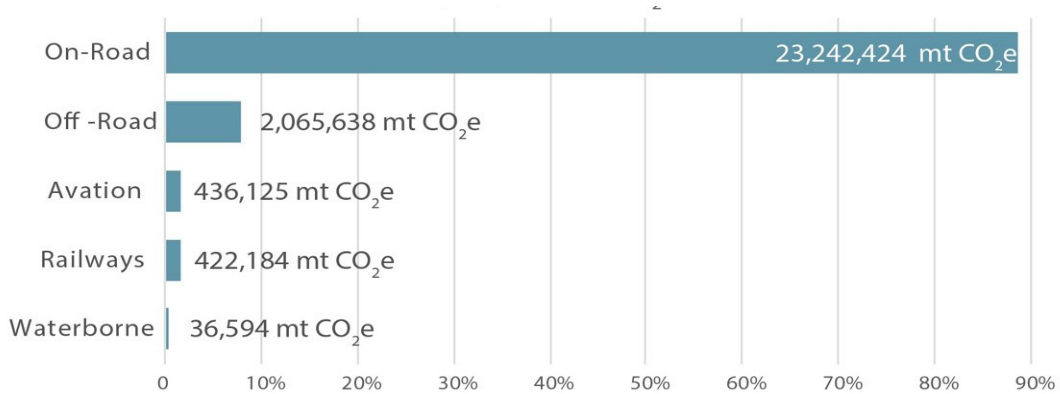

Figure 33. Total emissions from sources in the transportation sector (mt CO_2e).

On-road and off-road transportation made up 97 percent of all transportation emissions for plateau counties, 25.3 million mt CO_2e (Figure 33). However, only 50 percent of the on-road activity was estimated to originate in areas on the plateau,

14 Waterborne transportation emissions on the plateau occur solely on Lake Powell on the Utah/Arizona border.

while 76 percent of off-road emissions were estimated to occur from activities on the Colorado Plateau. For both on-road and off-road vehicles, emissions were the greatest from gasoline, followed by diesel use. Ethanol accounted for less than 1 percent of those emissions.

Total emissions from aviation fuel usage on the plateau made up 2 percent, 436,184 mt CO_2e, of total transportation emissions with 65 percent of those occurring on the plateau (283,048 mt CO_2e). Emissions from railways on the plateau totaled nearly 2 percent (422,184 mt CO_2e) of total transportation emissions and 53 percent, 224,934 mt CO_2e, were estimated to originate on the plateau. Waterborne fuel usage created less than 0.5 percent of total transportation emissions (36,594 mt CO_2e). The Colorado Plateau is a largely desert area with very few navigable waterways. Lake Powell, on the border of Utah and Arizona, is a large, navigable lake on the Colorado River. It was the only waterborne activity source included in the inventory, and therefore only Garfield, Kane, and San Juan counties in Utah and Coconino counties in Arizona, reported emissions from waterborne fuel usage.

Emissions from transportation across the plateau were not equally distributed. Some of the highest emissions occurred in counties that are only partially on the Colorado Plateau. This is likely due to higher population densities in those counties and commuting distance to larger cities and towns outside the Colorado Plateau (Figure 34).

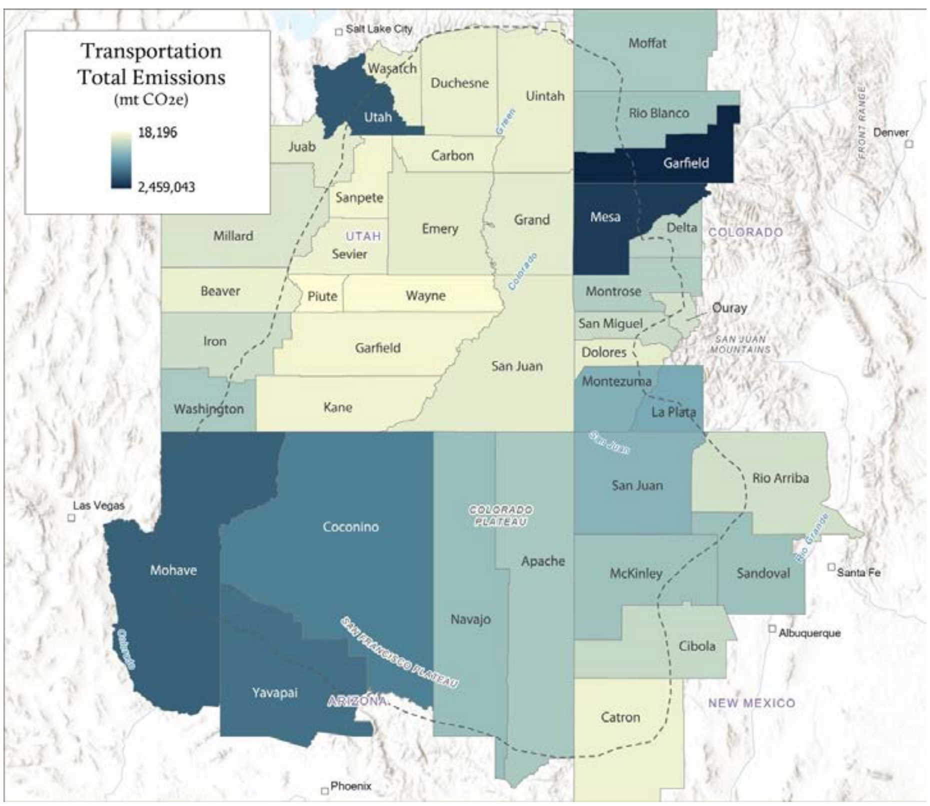

Figure 34. Map of total transportation emissions across the Colorado Plateau.

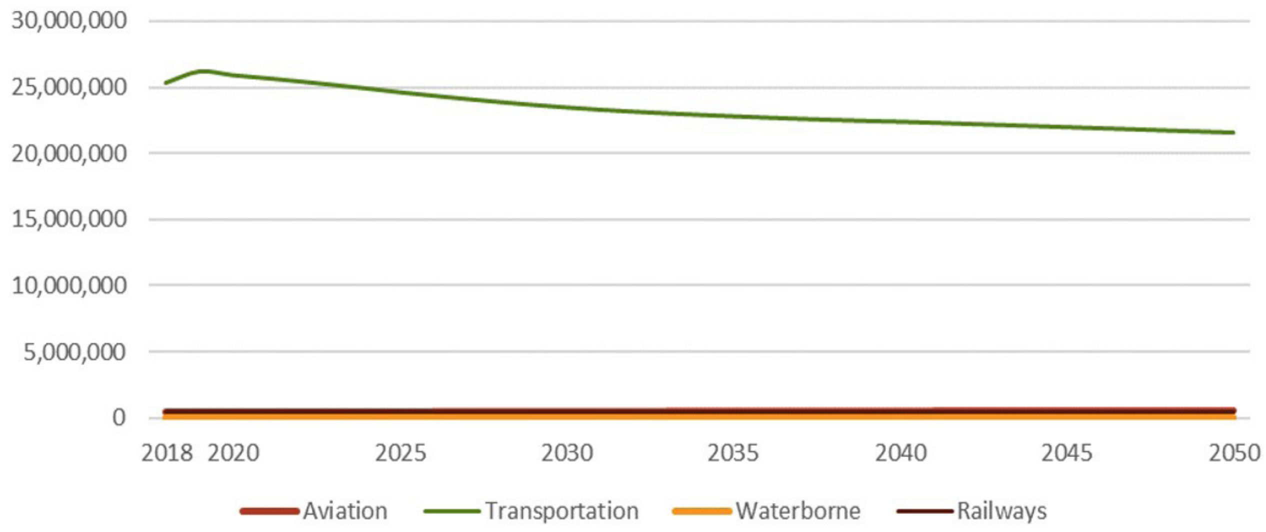

Figure 35. Forecasted emissions for the transportation sector, 2018-2050.

FORECASTED TRANSPORTATION EMISSIONS

Emissions from transportation were forecasted to decrease through 2050 by 14 percent, 3,649,868 mt CO_2e (Figure 35). Emissions from railways and waterborne activity were assumed to remain constant through 2050, and aviation emissions are expected to increase with population through that same time period. The decrease in emissions stems from a presumed increase in fuel efficiency for standard gasoline-powered vehicles over the coming years. Additionally, the replacement of conventional gasoline-powered vehicles with electric vehicles was included in the forecast for Colorado based on the state's current goals and projections of the electric vehicle market growth through 2030.

WASTE SECTOR

The waste sector includes emissions from the generation and disposal of community-generated solid waste, residential and commercial waste, construction and demolition waste, and industrial waste landfills subsectors reporting to the GHGRP. It also includes emissions from wastewater processes and fugitive emissions from the treatment of wastewater in wastewater treatment plants, wastewater treatment lagoons, and septic systems.

SOLID WASTE AND WASTEWATER EMISSIONS

Emissions from the waste sector contributed the lowest amount of emissions for the plateau region, making up 2 percent, 2,228,789 mt CO_2e, of all plateau county emissions (Figure 36). One million mt CO_2e were estimated to come directly from the Colorado Plateau.

Solid waste generated over 90 percent, 1.8 million mt CO_2e, of all emissions from the solid waste sector (Figure 36). Wastewater treatment contributed 0.2 percent of emissions (201,188 mt CO_2e emissions) and the majority of these emissions were from septic systems.

Waste emissions were in large part driven by population. And the highest waste and wastewater emissions occur in Utah County, Utah where the population density is greatest amongst plateau counties (Figure 37). However, the majority of that population is estimated to live off the Colorado Plateau.

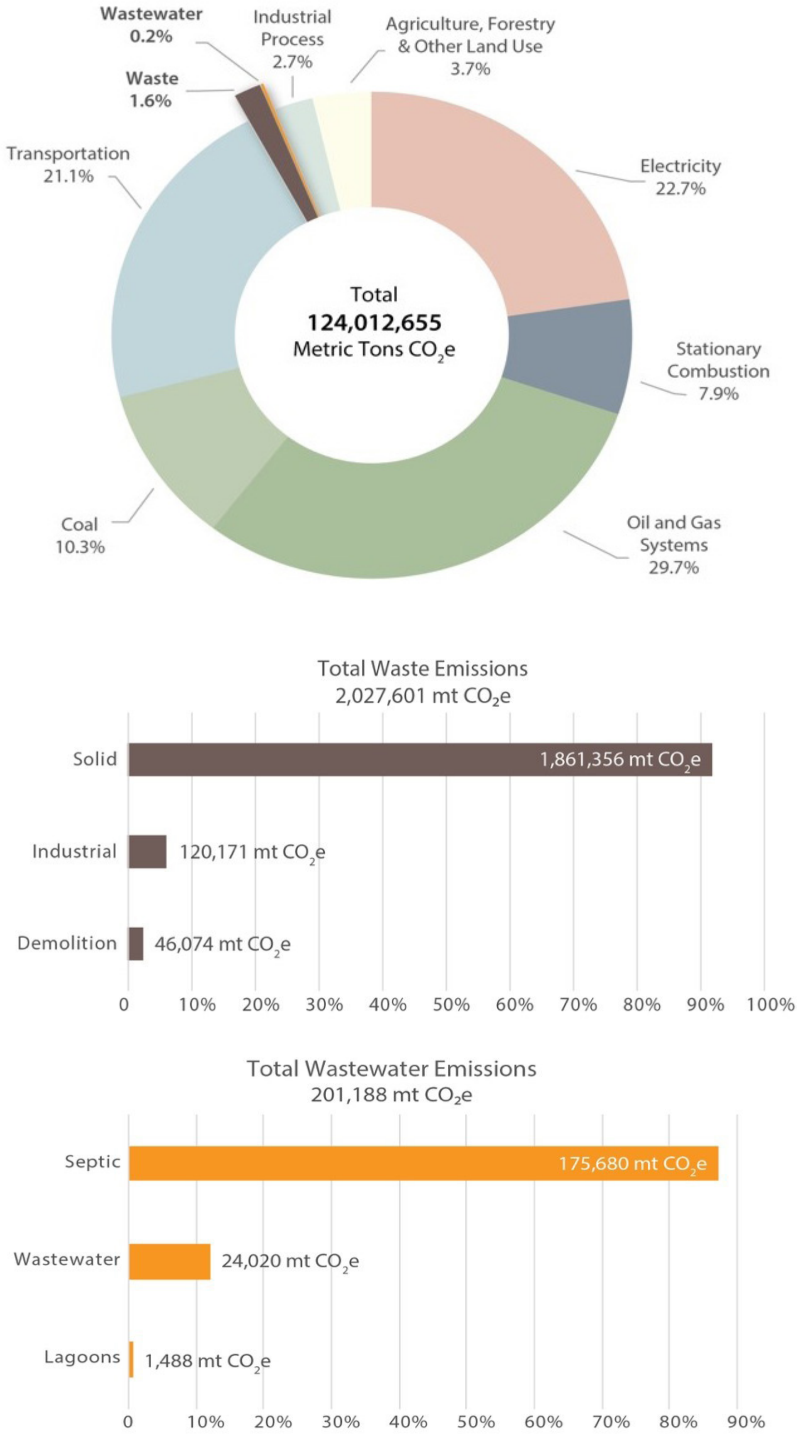

Figure 36. Total emissions and sources for waste and wastewater (mt CO_2e).

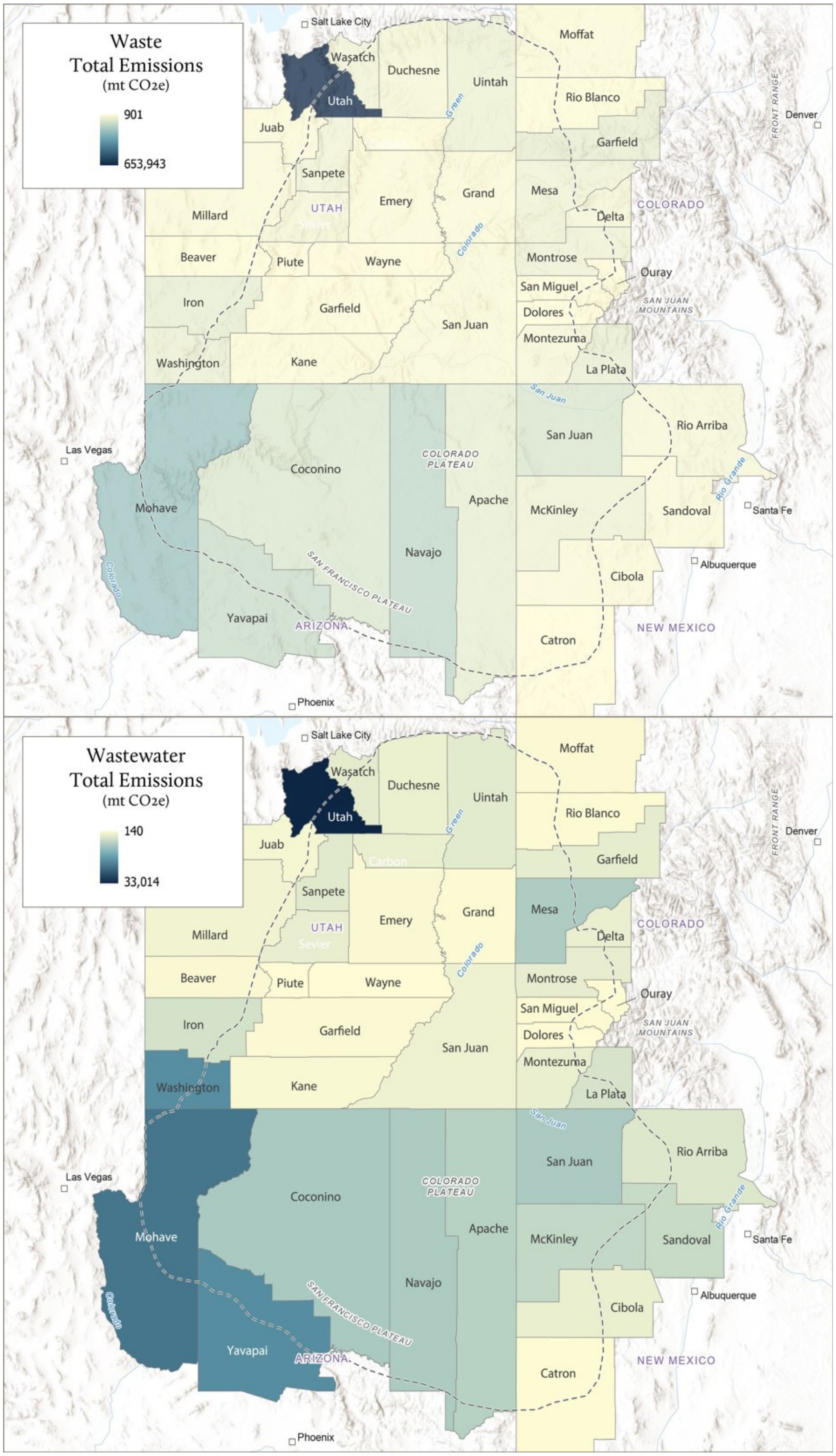

Figure 37. Map of total waste and wastewater emissions across the Colorado Plateau.

Excluding Utah County, Utah, the highest collective population density for the Colorado Plateau occurs in northern Arizona, so concentrations of waste and wastewater emissions were higher in these counties.

FORECASTED WASTE EMISSIONS

Emissions in the waste sector were forecasted to increase at the same rate as population. This results in an emission increase of approximately 51 percent (Figure 38) between 2018 and 2050.

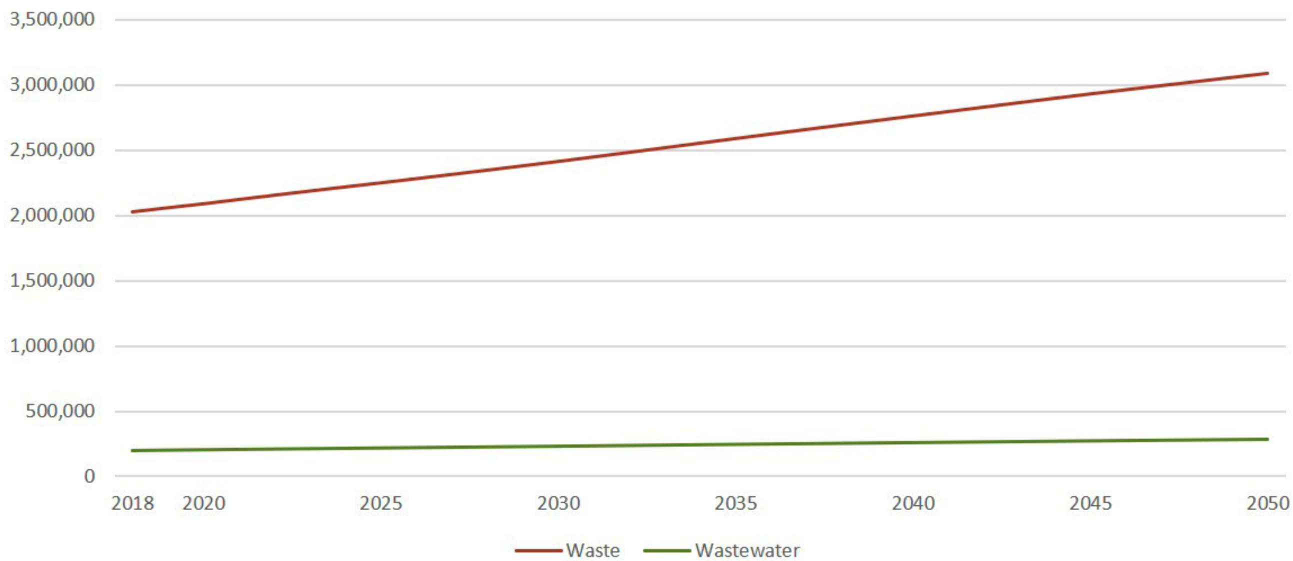

Figure 38. Forecasted emissions from the waste sector, 2018-2050 (mt CO_2e).


VOLVO

INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR

The industrial processes and product use (IPPU) sector includes emissions from industrial processes such as cement production, electronics manufacturing, and lime production. Greenhouse gas emissions from industrial processes can be emitted from product end use or manufacturing use and as non-energy related industrial activities. The emissions in this sector differ from the large emitters in the stationary energy sector because industrial process facilities are involved in the production of a material, whereas large stationary emitters are facilities involved directly in the production of energy.

INDUSTRIAL PROCESSES EMISSIONS

Industrial processes did not play a large role in the emissions for the Colorado Plateau region. There were only seven facilities that produce emissions in this sector:

1. Drake Cement, Arizona
2. Lhoist North America, Arizona
3. Phoenix Cement Company, Arizona
4. Ash Grove Cement Company, Utah
5. IM Flash Technologies, Utah
6. Intel Corporation, New Mexico
7. Graymont Western U.S. INC. Cricket Mountain, Utah

Together, these seven facilities produced nearly 3 percent of the total plateau emissions and 3,408,638 mt CO_2e. Only 1,605,356 mt CO_2e (47 percent) of those emissions were estimated to originate from activities on the Colorado Plateau (Figure 39).

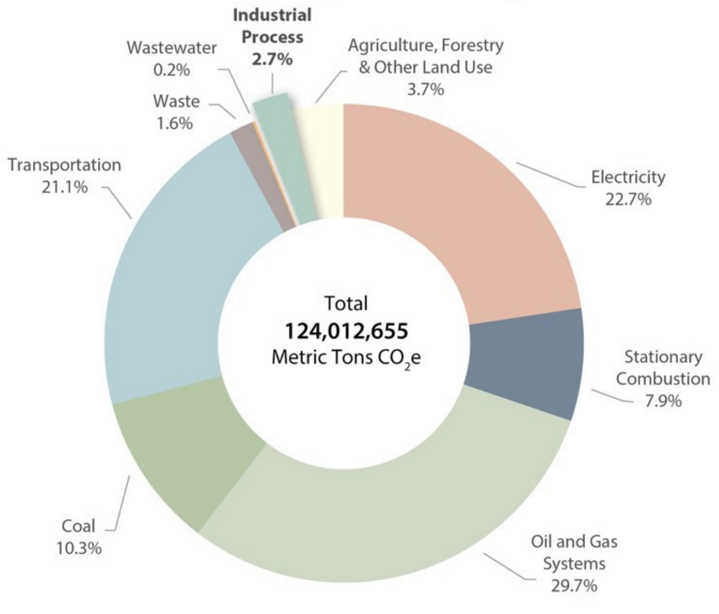

Figure 39. Proportion of total emissions from industrial processes.

FORECASTED EMISSIONS

Without better data and assumptions from the IPPU industries, it is difficult to project potential changes in this sector. Emissions from the IPPU sector were assumed to remain constant through 2050.

AGRICULTURE, FORESTRY, AND OTHER LAND USE SECTOR

The agriculture, forestry, and other land use sector (agriculture and forestry sector) includes emissions from livestock, managing of agricultural lands, and biomass burning. Sources of emissions include the following:

1. enteric emissions from livestock: methane produced from the digestive process in animals,
2. emissions from manure management: methane and nitrous oxide emissions from manure created by animals,
3. liming and urea applications: application of crop or soil amendments during the agricultural process,
4. direct and indirect nitrous oxide from managed soils: nitrogen release from fertilizers that converts to nitrous oxide in the atmosphere,
5. biomass burning: combustion of organic matter from wildfires.[15]

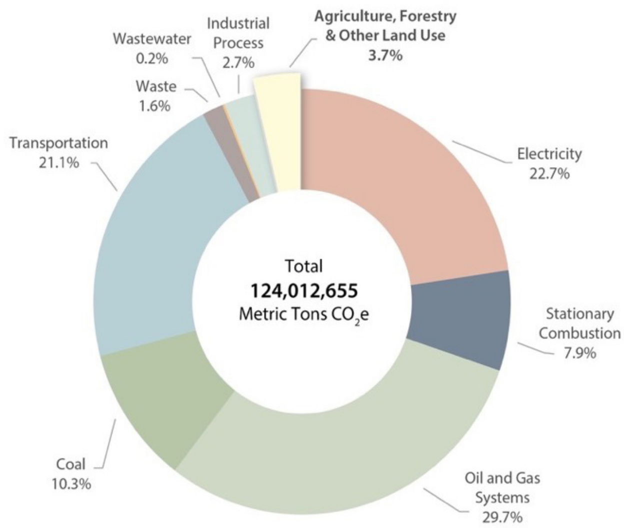

Figure 40. Proportion of total emissions from agriculture, forestry, and other land use.

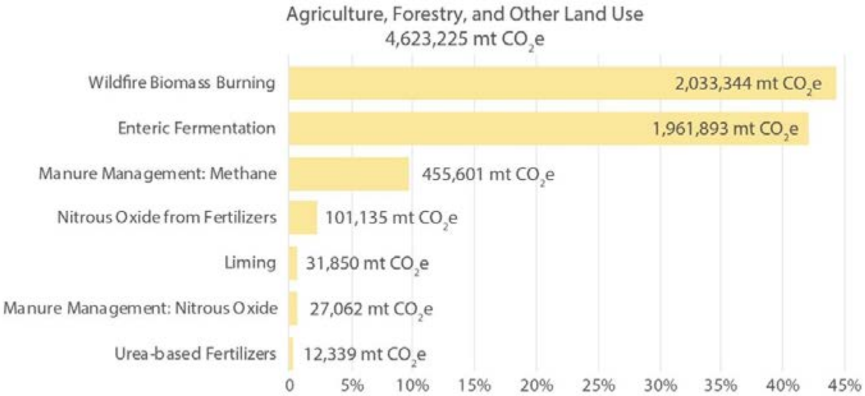

Figure 41. Total emissions sources for agriculture, forestry, and other land use (mt CO_2e).

AGRICULTURE AND FORESTRY EMISSIONS

The agriculture and forestry sector produced nearly 4 percent, 4,623,225 mt CO_2e, of total county emissions. Sixty-one percent, 2,893,003 mt CO_2e, were estimated to have occurred from activities located on the Colorado Plateau (Figure 40).

Naturally occurring wildfires play a major role in ecosystem health across the Colorado Plateau. Wildfires of various sizes are not uncommon and can vary from year to year depending on many variables. For 2018 greenhouse gas emissions, biomass burning was the top emitter for agriculture and forestry emissions. Fires accounted for 44

15 Agricultural burning was assumed to not occur in significant amounts across the plateau.

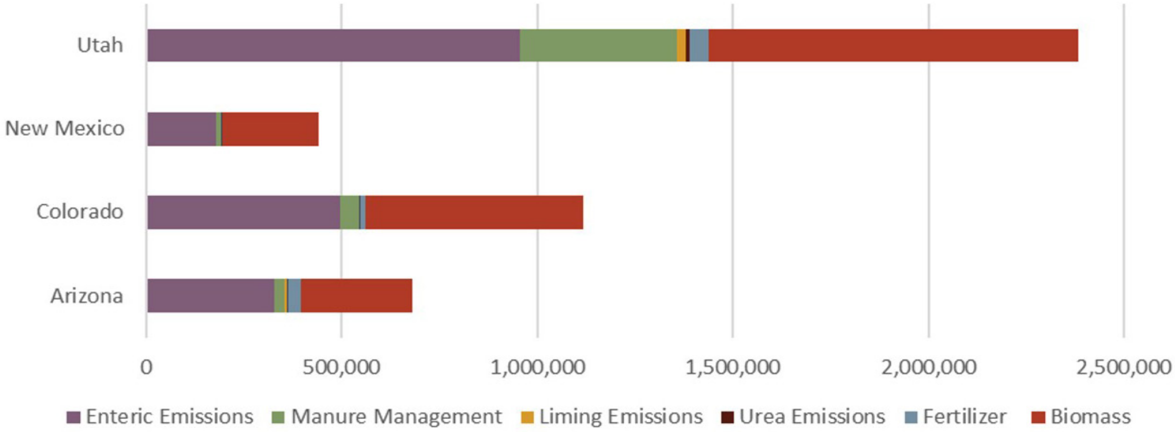

Figure 42. County summary by state for agriculture, forestry, and other land use sources.

percent, and over 2 million mt CO_2e, of total agriculture and forestry emissions (Figure 41). Of those emissions, 68 percent were directly attributed to fires on the Colorado Plateau with the majority occurring in counties in the state of Utah (Figure 43). Enteric emissions comprised over 45 percent, nearly 2 million mt CO_2e of total agriculture and forestry emissions, and all other sources accounted for the remaining 14 percent of total agriculture and forestry emissions (Figure 41). However, less than 50 percent of livestock-generated enteric emissions occurred on the Colorado Plateau. Utah County, Utah was the top emitter for enteric emissions, but only 7 percent of those emissions were estimated to be within the Colorado Plateau.

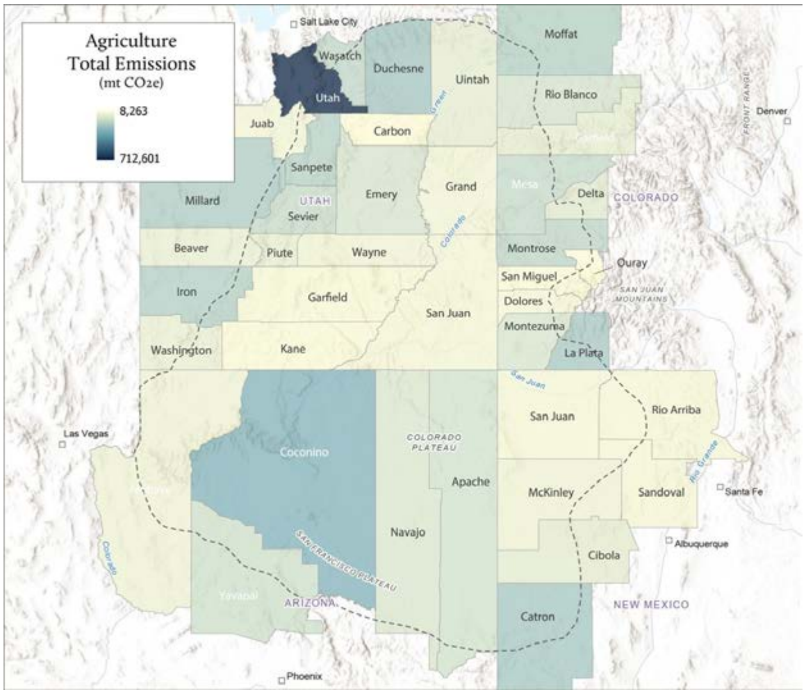

Figure 43. Map of total agriculture, forestry, and other land use emissions across the Colorado Plateau.

Utah County, Utah was the highest emitter across plateau counties for agriculture and forestry (Figure 42). This was attributed to two factors: the proportion of wildfires occurring within the county, and enteric emissions from livestock mentioned above. Twenty-four percent of wildfire emissions in 2018 occurred in Utah County, Utah, and 99 percent of those fires occurred on the Colorado Plateau. Coconino County, Arizona was the second highest emitter for agriculture and forestry, and this too was mostly attributed to wildfire activity, which comprised nearly 10 percent of all biomass emissions (Figure 43).

FORECASTED EMISSIONS

Emissions from agriculture and forestry are forecasted to decrease by 20 percent, 0.94 million mt CO_2e, by 2050 (Figure 44). It was assumed that agricultural operations will remain constant from 2018 moving forward. Therefore, emissions from enteric sources and manure management, liming, urea, and fertilizer use are all forecasted to remain constant. However, large changes in biomass burned between 2018 and 2050 result in an overall decrease in emissions from this sector.

Future burned biomass was based on an average between 2000-2019. In 2018, wildfires were higher than average for most counties across the plateau. This resulted in a large drop in projected emissions between 2018 and 2019 (Figure 44). It was assumed that biomass-burning emissions from wildfires will increase by 5 percent between 2019-2050. However, many variables such as annual weather patterns, land management actions, and long-term climate fluctuations can drastically impact this actual rate from year to year.

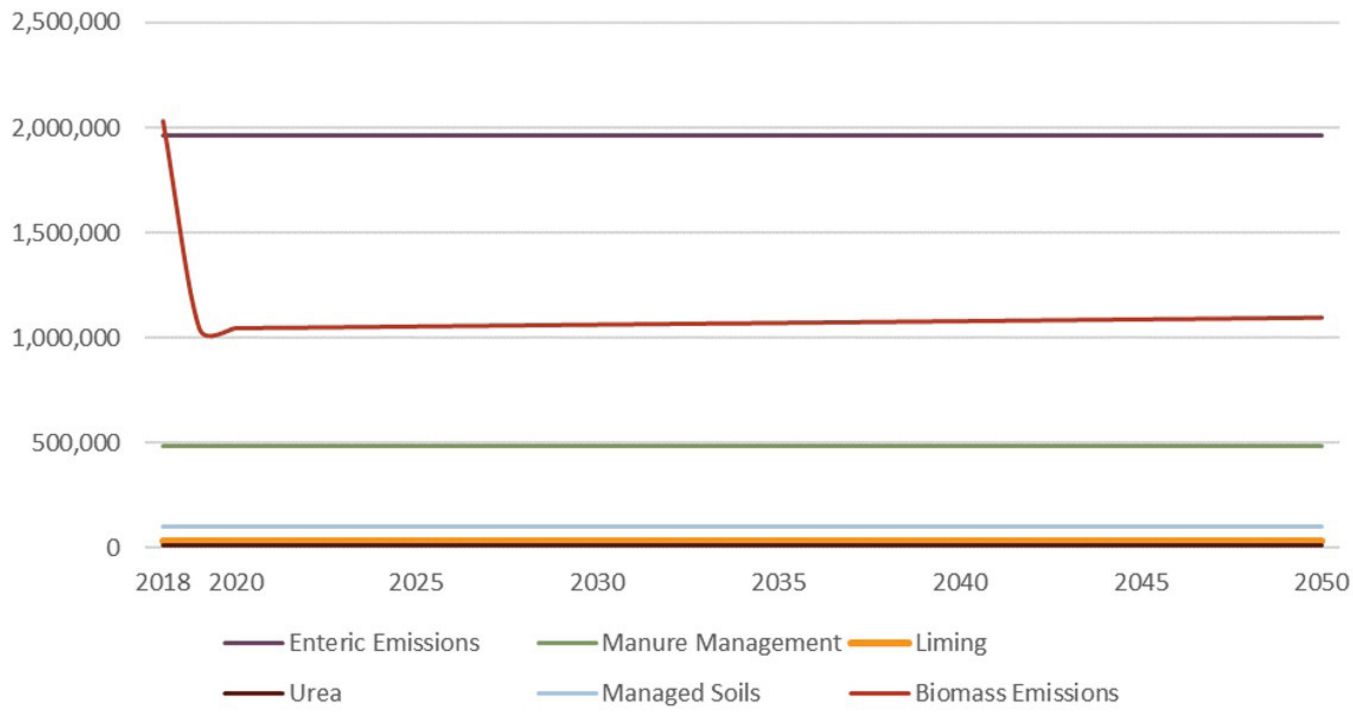

Figure 44. Forecasted emissions from the agriculture, forestry, and other land use sector, 2018-2050 (mt CO_2e).

CARBON SEQUESTRATION

OVERVIEW OF CARBON STOCKS IN 2018

Carbon stock values were estimated at the county level only (i.e., values were not estimated for only the land area within the Colorado Plateau boundary). Five broad land-cover type categories were estimated to calculate the total potential for carbon sequestration on the plateau including:

1. forests
2. croplands
3. grasslands/shrublands
4. wetlands
5. other lands

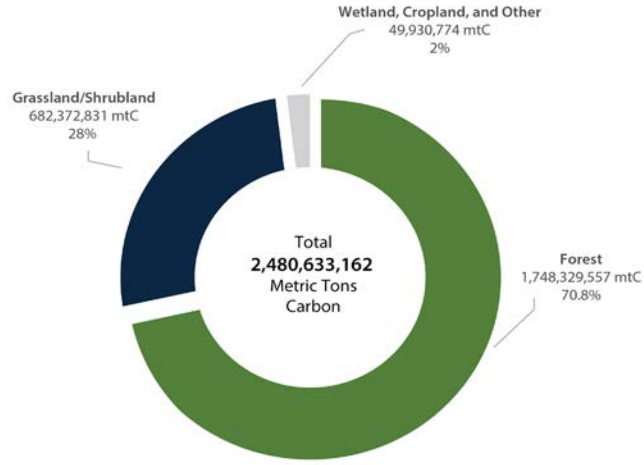

Figure 45. Carbon stocks across the Colorado Plateau.

These 2018 values provide a baseline for the amount of carbon (metric tons of carbon) that is currently stored in the landscape so that, in future emissions inventories, additional carbon sequestered or lost due to annual land-cover type changes can be estimated. It is important to note that carbon stock measures carbon that is already stored and does not represent available storage capacity for additional storage. It does represent potential added emissions if the land-cover providing the storage is destroyed.

There was an estimated total of 2.5 billion mt carbon currently stored for the entire region and the majority was stored in forests and grasslands/shrublands (Figure 45). The forest land-cover type was the largest carbon stock in all four states, followed by grasslands/shrublands (Figure 46). Forests have the largest carbon sequestration factor (52.5 mt carbon per acre), nearly double that of grasslands and shrublands (25.6 mt carbon per acre).

The total land area of the plateau is 122,938 square miles, with Arizona accounting for 40 percent, Colorado 10 percent, New Mexico 14 percent, and Utah 37 percent. The amount of land and the proportion of land cover types will directly affect each state's carbon sequestration total. Thus, because a large portion of the plateau is in Utah and the land cover type with the most land area in Utah was forests, Utah had the largest total for carbon sequestration potential on the plateau.

Carbon stocks across the counties ranged from 14 million mt carbon in Piute County, Utah to 241 million mt carbon in Coconino County, Arizona. Other counties with higher carbon stocks included Apache, Mojave, and Navajo counties in Arizona and Catron County in New Mexico.

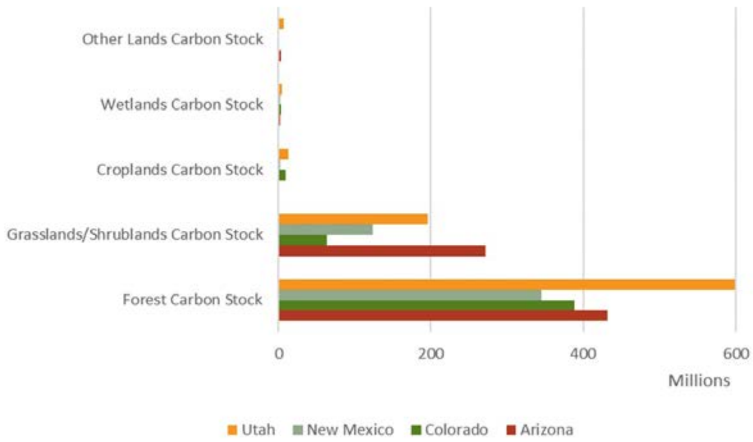

Figure 46. Carbon stocks by land cover type in 2018 (mt C).

CONCLUSION

The science is clear: the climate is changing, and the world is just beginning to feel the impacts.[xxiv] On the Colorado Plateau, this could mean increased and more intense wildfires, water shortages, extreme heat, and more infrequent or intense precipitation. According to the Fourth National Climate Assessment, heat-associated deaths and illnesses across the Southwest are expected to rise,[xxv] and the cultural, traditional foods, and natural resource-based livelihoods of Indigenous communities will be increasingly affected by drought and wildfire.[xxvi] In order to lessen the impacts of climate change, it is imperative to take actions to significantly reduce greenhouse gas emissions in every way possible.

In 2018, the counties across the Colorado Plateau emitted an estimated 124,012,655 mt CO_2e emissions, and an estimated 79,258,435, or 64 percent of those mt CO_2e were produced from activities occurring directly on the plateau (i.e., within the plateau boundary). When forecasted in a business-as-usual scenario, emissions on the plateau are projected to decrease by 14 percent, or 17,186,577 mt CO_2e by 2050. In light of warnings from the IPCC that the global community must reduce emissions by 45 percent from 2010 levels by 2030 and reach net zero by 2050, the business-as-usual scenario for the Colorado Plateau is not aggressive enough. Actions must be taken to more significantly reduce emissions going forward if the American Southwest is to do its part to avoid the catastrophic effects within the region from further global climate change.

This greenhouse gas emissions inventory can help inform the process of identifying the next steps communities throughout the plateau can take in the fight against climate change.

ENDNOTES

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[xix.] Per the U.S. EPA, "Subpart W requires petroleum and natural gas facilities to report annual methane (CH_4) and carbon dioxide (CO_2) emissions from equipment leaks and venting, and emissions of CO_2, CH_4, and nitrous oxide (N_2O) from flaring, onshore production stationary and portable combustion emissions, and combustion emissions from stationary equipment involved in natural gas distribution." United States Environmental Protection Agency. "Frequently Asked Questions: Q436: What GHG emissions at oil and natural gas facilities are covered under the rule?" 28 October 2019. https://ccdsupport.com/confluence/pages/viewpage.action?pageId=98009236. Accessed 23 June 2020.

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Appendix A

In this inventory, estimates for the electricity sector were made using a consumption-based approach to emissions accounting. This means that direct emissions from the Colorado Plateau's large electricity-generating power plants were not included in the inventory except to the extent that the power they generate was used on the Colorado Plateau. There are several reasons for this choice. First, as the era of coal comes to a close, many of the region's largest coal-fired power plants are actively being phased out across the plateau. Given this, using a consumption-based approach ensures that the inventory was reflective of the region's likely energy future. Additionally, a consumption-based approach also allows the ability to measure the ongoing impacts of consumption-based local policies, programs, and energy efficiency measures in future updated inventories.

At the same time, the Colorado Plateau is an energy exporting region. There are twenty coal-fired power plants within the counties that make up the plateau and thirteen of these are within the plateau boundary. Rather than being used on the plateau, most of the energy produced by these power plants is exported off of the plateau to major urban areas such as Phoenix, Albuquerque, Las Vegas, and Los Angeles. The Colorado Plateau itself is rural, and as a consequence of its paucity of residents, does not have the same levels of electricity use within its boundaries as other large metropolitan regions, resulting in lower emissions for the counties included in this inventory. While many coal-fired power plants are being phased out, not every coal-fired power plant is scheduled to shut down in the near-term. Generation-end emissions are still an undeniable part of the greenhouse gas emission problem on the Colorado Plateau.

In 2018, direct power plant emissions within Colorado Plateau counties contributed 75,424,796 mt CO_2e; of this total, 63,736,880 mt CO_2e of those emissions originated on the Colorado Plateau. This number is striking given that the total estimated greenhouse gas emissions across all emission sectors for plateau counties was 124,012,655 mt CO_2e, with 79,249,431 mt CO_2e originating within the plateau boundary. However, to protect the integrity of the inventory, these generation-based emissions cannot be added to the total emissions or emissions by sector. Rather, these generation-based emissions were partially included in the 28,203,618 mt CO_2e emissions captured in the electricity sector of the main inventory because some electricity produced by these power plants was consumed by plateau residents and businesses. Nonetheless, it is important to note that generation-based power plant emissions are the single largest contributor to greenhouse gases occurring in this region.

The table and map below outline the details of generation-end emissions for 2018 based on sources that report electricity emissions under subpart D.[1] The total metric tons of CO_2e recorded at each power plant from electricity generation is listed in the table A-1. This includes the region's largest power plants such as coal-fired and natural gas power plants. On the map, the shaded areas represent the total consumption-based electricity emissions within each county as they were calculated in the inventory (Figure A-1). The graduated circles show the locations of the power plants and reflect the direct emissions from each power plant for electricity generation.

1 Emissions from stationary fuel-combustion sources reporting under sub-part C, such as the Sunnyside and Animas power plants, are included in the main inventory.

It is important to note that the current operational statuses of the power plants are changing in real time as many plants shutter in response to market forces and climate policy. For instance, Navajo Generating Station and units of the San Juan Generating Station have closed since these report data were compiled.

The Colorado Plateau is at a fascinating moment in its energy history – transitioning away from the era of coal-fired power. As such, consumption-based accounting allows for a more accurate portrayal of the region's likely energy future and the emissions most likely to be affected by the change in state-based energy efficiency policies. However, the region's history and present reality as an energy exporting region renders it essential to also consider the significant generation-based emissions from electricity generated on, but used off, the Colorado Plateau. Together, these two accounting methods paint the clearest picture of the region's greenhouse gas emissions.

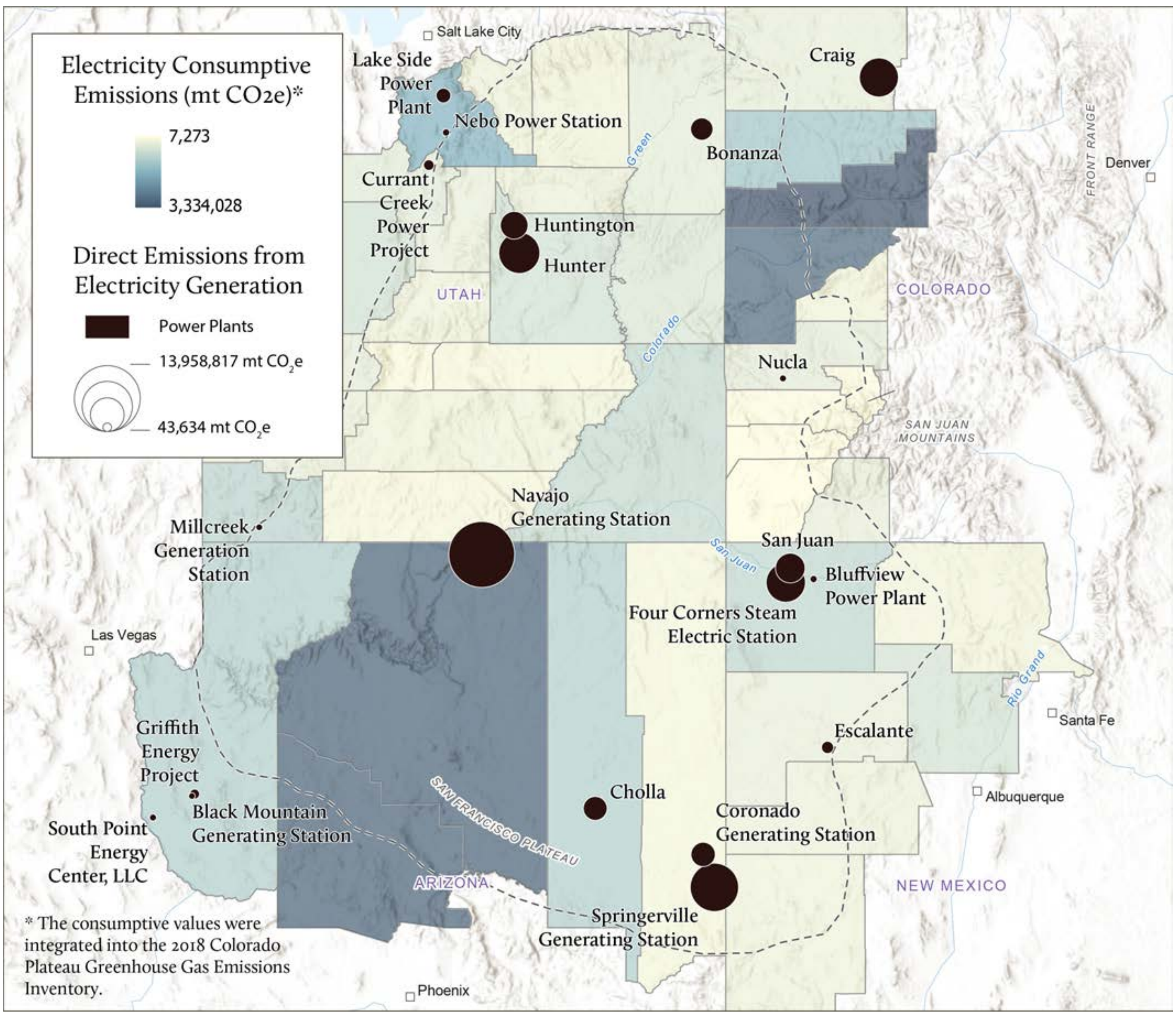
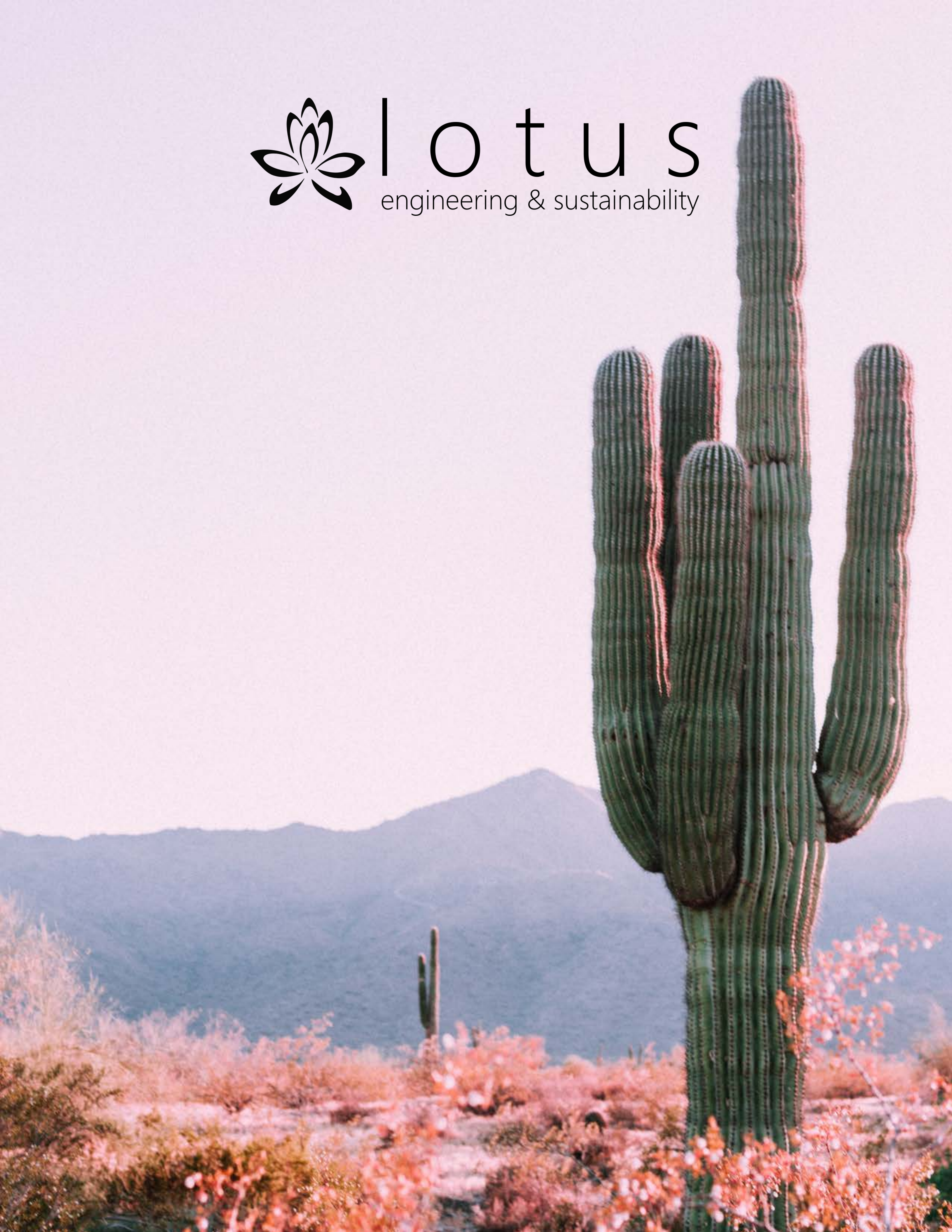


Figure A-1. Map of total consumptive and direct 2018 electricity emissions.

Table A-1. 2018 Direct Electricity Emissions.

Power Plant	Electricity Generation (mt CO_2e)	State	County
Coronado Generating Station	4,191,606.23	Arizona	Apache
Springerville Generating Station	9,834,338.10	Arizona	Apache
Navajo Generating Station	13,958,817.39	Arizona	Coconino
Black Mountain Generating Station	43,634.49	Arizona	Mohave
South Point Energy Center, LLC	110,490.17	Arizona	Mohave
Griffith Energy Project	807,201.76	Arizona	Mohave
Cholla	4,084,002.12	Arizona	Navajo
Craig	7,637,520.19	Colorado	Moffat
Nucla	91,626.36	Colorado	Montrose
Escalante	1,343,155.83	New Mexico	McKinley
Bluffview Power Plant	166,487.68	New Mexico	San Juan
San Juan	542,613.26	New Mexico	San Juan
Four Corners Steam Electric Station	7,713,243.04	New Mexico	San Juan
Huntington	4,983,672.78	Utah	Emery
Hunter	8,126,706.61	Utah	Emery
Currant Creek Power Project	972,505.90	Utah	Juab
Bonanza	3,728,891.87	Utah	Uintah
Nebo Power Station	181,229.93	Utah	Utah
Lake Side Power Plant	1,935,332.83	Utah	Utah
St. George City Power: Millcreek Generation Station	61,719.52	Utah	Washington
Total Direct Emissions	**75,424,796.07**		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