Idaho Wildfire Emissions Estimates

2022 Wildfire Season

State of Idaho
Department of Environmental Quality
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Abbreviations, Acronyms, and Symbols

CO	Carbon Monoxide
DEQ	Idaho Department of Environmental Quality
DOI	United States Department of Interior
EPA	US Environmental Protection Agency
FCCS	Fuel Characteristic Classification System
FEPS	Fire Emissions Production Simulator
FFT	Fuel and Fire Tools
IRWIN	Integrated Reporting of Wildland-Fire Information Project
MTRI	Michigan Tech Research Institute
NAAQS	National Ambient Air Quality Standards
NEI	National Emissions Inventory
NIFC	National Interagency Fire Center
NMOC	Non-Methane Organic Compounds
NO_X	Nitrogen Oxides
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to 2.5 micrometers
USDA	United States Department of Agriculture
USFS	United States Forest Service
VOC	Volatile Organic Compounds
WFEIS	Wildland Fire Emissions Inventory System
WFIGS	Wildland Fire Interagency Geospatial Services

Executive Summary

Every year wildfires consume hundreds of thousands of acres of land across Idaho and millions more throughout the Western US. These fires are often the largest sources of many air pollutants including carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), oxides of nitrogen (NO_X), and volatile organic compounds (VOC). Emissions of these pollutants into the air vary from year-to-year based on the number, size, and location of the wildfires. Estimating emissions from wildfires is a rapidly advancing science and there is much uncertainty involved. Annual wildfire emissions estimates provided by the Idaho Department of Environmental Quality (DEQ) are based on the latest methods and scientific literature on wildfire emission factors and estimation. DEQ has made every effort to provide the best estimates of air pollutant emissions from wildfire in a timely manner using the tools available.

The 2022 wildfire season saw a total of 417,229 acres burned by wildfire in Idaho. This is below Idaho's 10-year average of around 600,000 acres. Wildfires in Idaho released over 100,000 tons of $PM_{2.5}$ and 750,000 tons of CO gas. Additionally, around 9,200 tons of NO_X and 175,000 tons of VOC (the two main ozone precursor pollutants) were emitted into the atmosphere. Wildfires once again are estimated to represent the single largest source of $PM_{2.5}$, CO, and VOC in Idaho in 2022.

1 Introduction

Wildfires are an annual occurrence in the Western US and generally occur in Idaho from mid-summer to early autumn. In an average season, the Western US (comprising Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) experiences approximately 5 million acres of wildfires (NIFC, 2021). In addition to the immediate, direct danger, wildfires negatively impact the air quality in downwind communities for extended periods. Wildfire smoke settles into communities for days to weeks at a time, resulting in an increased risk for a variety of acute and chronic health impacts in the affected population.

Hundreds of different chemicals are present in wildfire smoke, including large amounts of the criteria air pollutants regulated by the Federal Clean Air Act: carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), oxides of nitrogen (NO_X), and volatile organic compounds (VOC). While wildfires generally do not impact a community's compliance with the national ambient air quality standards (NAAQS) because the US Environmental Protection Agency (EPA) has a rule by which they can be classified as "exceptional events", it is valuable to assess the magnitude of wildfire emissions for planning purposes and to evaluate the potential for health impacts in affected areas. The purpose of this report is to provide a reasonable estimate of the total emissions of CO, $PM_{2.5}$, NO_X, and VOC from Idaho wildfires in 2022 and to compare these estimates to previous years and to other major sources of air pollutants.

2 Methods

2.1 Tools

The Michigan Tech Research Institute (MTRI) has developed an online tool called the Wildland Fire Emissions Inventory System (WFEIS) that combines a variety of input fire boundaries and modeled fuel moisture values with the US Forest Service's (USFS) Fuel and Fire Tools (FFT) suite of tools (French et al., 2014). This program allows users to estimate fire emissions rapidly and accurately. The FFT combines several tools from the USFS including the Fire Emissions Production Simulator (FEPS), the Consume model, and the Fuel Characteristic Classification System (FCCS) into one tool that can accurately estimate emissions from wildland fires (FERA, 2021). The FFT uses fuels data classified into fuelbeds, environmental variables, and fire weather information to calculate fire behavior, fuel consumption, heat release, and pollutant emissions for a variety of chemical species.

2.2 Geographic Information

The most complete wildfire perimeter database is available from the National Interagency Fire Center (NIFC) through the Wildland Fire Interagency Geospatial Services (WFIGS) Group (NIFC, 2022). This database contains the most readily available, complete, and accurate set of wildland

fire perimeters. This is the same data that NIFC uses to develop its year-end statistics on wildland fires. The data is developed through the Integrated Reporting of Wildland-Fire Information (IRWIN) project (Forests and Rangelands, 2019). IRWIN is managed by the Forests and Rangelands joint partnership between the US Department of Interior (DOI) and the US Department of Agriculture (USDA). The goal of IRWIN is to enable end-to-end fire reporting capability by consolidating data entered into existing applications used to manage wildland fire incidents. A unique record is developed for every wildland fire incident and is based on input from incident reports, GPS data, and infrared imagery from fixed-wing aircraft and satellite platforms.

The wildfire perimeter database, *WFIGS_ARCHIVE*, contains one perimeter for each fire covering all areas burned by that fire and does not overlap with previously burnt areas. The database should include all wildfires for 2022 to-date, but it is a working database that will not be finalized until spring/summer 2023. The final dataset includes 349 individual wildfires ranging from just a few hundred square feet to over 130,000 acres from the Moose Fire northwest of Salmon, for a total of 417,229 acres.

2.3 Calculations

The archive wildfire perimeters (including 2022 year-to-date wildfire perimeters) were provided to the WFEIS from the WFIGS. Fuel moisture options were left as the defaults which include modeled values based on the burn location and day for 1000-hr fuel, duff, and litter. The FCCS fuelbed system was used for the fuel loadings with default canopy consumption values for each fuel bed. Blackened shrub was left at the default value of 50%. DEQ downloaded the resulting SHP and CSV files for the purpose of this analysis.

In addition to emissions information, the WFEIS also provides outputs of fuelbed types burned. Analyzing the vegetation types that were burned by wildfires can provide some context for comparison between years as emissions vary amongst the different types. DEQ combined the detailed FCCS vegetation types from WFEIS into five broad categories to simplify the reporting. All *forest* vegetation types are included in the “timber” category; the *grassland* and *shrubland* vegetation types are combined as “rangeland”; and all managed croplands including trees, grasses, and row crops are combined as “cropland”. All “other” categories that represent mostly urban areas, barren land, wetlands, and snow/ice/water are combined.

3 Results

3.1 Total Wildfire Emissions

Wildfires in Idaho released over 100,000 tons of $PM_{2.5}$ and 750,000 tons of CO gas in 2022. Additionally, around 9,200 tons of NOx and 175,000 tons of VOC (the two main ozone precursor pollutants) were emitted into the atmosphere. Note that non-methane organic compounds (NMOC) are used as a surrogate for VOC. This data is summarized below in **Table 1**.

Table 1. Estimated air pollutant emissions for all Idaho wildfires in 2022.

	$PM_{2.5}$	CO	NOx	VOC
Total Emissions (metric tons)	112,951.67	751,334.35	9,210.52	175,438.92

3.2 Emissions by Vegetation Type

The vegetation types for all areas burned are summarized in **Table 2** while the detailed FCCS fuelbed types are included in **Appendix A**. Timber accounted for well over half (57%) of the burned acreage in 2022, while rangeland makes up just over 37% of the total acreage burned.

Table 2. 2022 wildfire areas by vegetation type.

Vegetation Type	Area (acres)	Percent of Total Area
Timber	239,603.48	57.4%
Rangeland	155,619.38	37.3%
Cropland	4,239.00	1.0%
Other	17,767.48	4.3%
Totals	**417,229.34**	**100%**

Total wildfire emissions by vegetation type are summarized below in **Table 3** and **Figure 1**. Most of the emissions came from wildfires that burned timber vegetation types. In 2022, about 97% of the total PM2.5, CO, and VOC wildfire emissions came from timber fires, and 91% of the total NOx wildfire emissions were from timber fires.

Table 3. Estimated air pollutant emissions in metric tons for all Idaho wildfires in 2022.

Vegetation Type	Acres Burned	$PM_{2.5}$	CO	NOx	VOC
Timber	239,603.48	110,149.29	732,643.34	8,429.32	169,329.07
Rangeland	155,619.38	2,725.60	18,432.03	759.96	5,990.13
Cropland	4,239.00	53.17	170.55	14.53	81.94
Other	17,767.48	23.62	88.43	6.70	37.78
Totals	**417,229.34**	**112,951.67**	**751,334.35**	**9,210.52**	**175,438.92**

4 Discussion

The 2022 season saw a 3% decrease in acreage burned compared to 2021 with 417,229 acres consumed by wildfire in Idaho compared to just over 430,000 in 2021. This is still well below the 2011-2020 average of 601,826 acres. Despite this relatively low acreage year, there was still a significant amount of air pollutant emissions released into the atmosphere. Timber fires made up the majority of the acres burned. They also resulted in the highest emissions out of all the vegetation types because the fuel loading tends to be higher for timber fires than other vegetation types, and they also burn for longer periods of time.

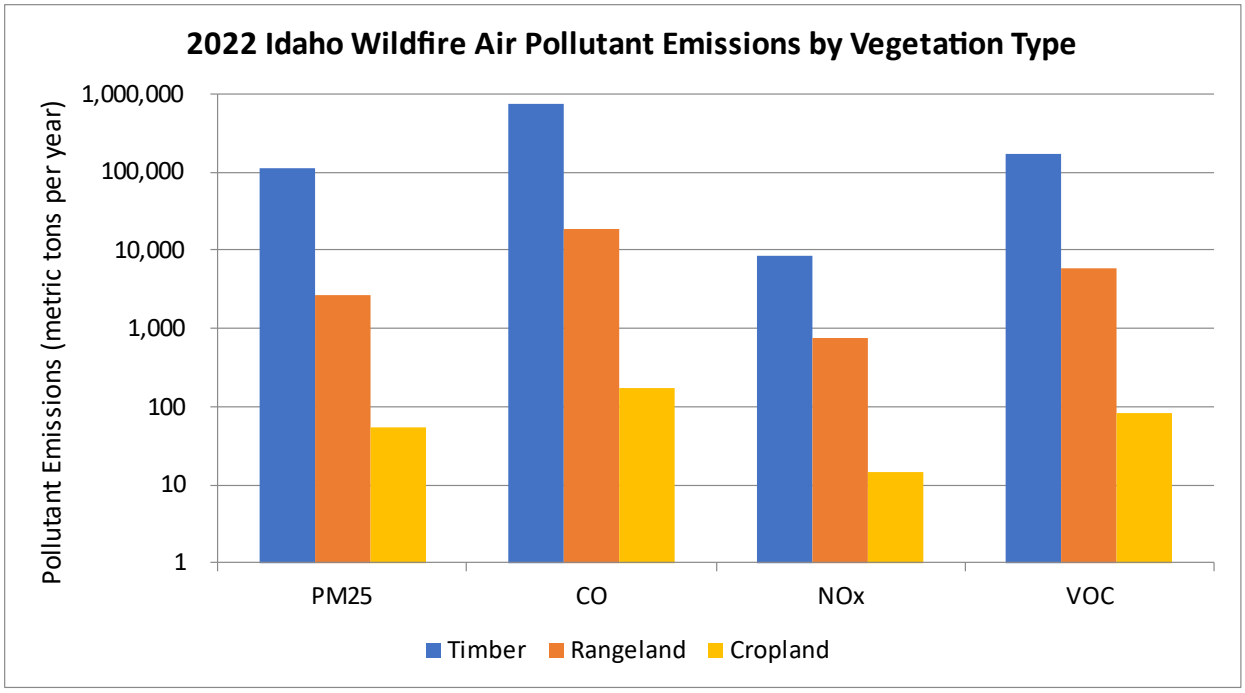

Figure 1. 2022 Idaho wildfire air pollutant emissions by vegetation type.

Note that the vertical axis is using a logarithmic scale as the emissions from rangelands and croplands were so much smaller than those from timber that they were not visible using a normal scale.

4.1 Comparison to Previous Years

Wildfire emissions can vary significantly from year-to-year depending on numerous factors including the number of acres burned, the vegetation types burned, and fuel moisture content. A comparison of the 2022 emissions to previous years is provided in **Figure 2** below. Emissions in 2022 were about average for the past ten years, and there was a 19-21% increase in emissions from 2021 depending on pollutant.

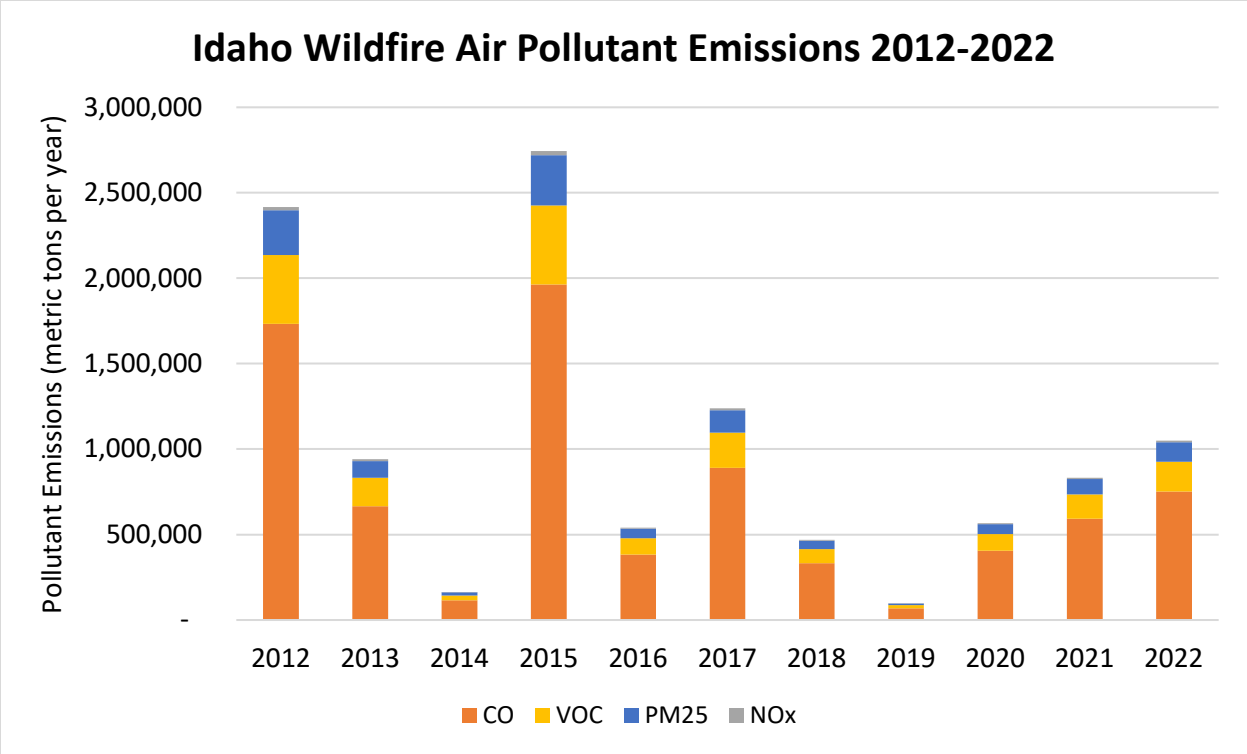

Figure 2. Idaho wildfire air pollutant emissions by year from 2012-2022 as calculated by the WFEIS.

Historic fire emissions were also calculated in WFEIS using the same default emissions/consumption inputs used for the 2022 calculations. The historic wildfire perimeters are also from WFIGS and are available within the WFEIS tool (labeled NIFS perimeters).

4.2 Comparison to Other Sources

Wildfire emissions represent one of the single largest sources of air pollutants in Idaho. **Table 4** and **Figure 3** compare 2022 wildfire emissions to the other large sources of air pollutants in Idaho, which include industrial sources, onroad mobile sources (motorcycles, cars, and trucks), and nonroad mobile sources (construction equipment, recreational equipment, airport support equipment, etc.). The industrial, onroad mobile, and nonroad mobile data were compiled for submittal to EPA for the 2017 NEI and are the most recently available data for these categories (NEI 2017). Emissions from these categories do not change significantly from year-to-year.

Wildfires were the largest individual source of $PM_{2.5}$, CO, and VOC in Idaho in 2022, emitting orders of magnitude more of these pollutants than any other source. Wildfires in 2022 emitted more of each of these pollutants into the air than all industrial, onroad mobile, and nonroad mobile sources in the entire state combined including more than 33 times as much $PM_{2.5}$, more than five times as much VOC, and almost three times as much CO gas.

Table 4. 2022 Idaho wildfire emissions compared to other large sources in metric tons per year.

Source	$PM_{2.5}$	CO	NOx	VOC
2022 Wildfires	112,951.67	751,334.35	9,210.52	175,438.92
2017 Industrial Sources	980.67	11,000.54	6,800.26	1,506.84
2017 Onroad Mobile Sources	2,718.68	131,034.65	35,513.99	15,717.62
2017 Nonroad Mobile Sources	723.70	75,495.76	7,009.38	9,939.36

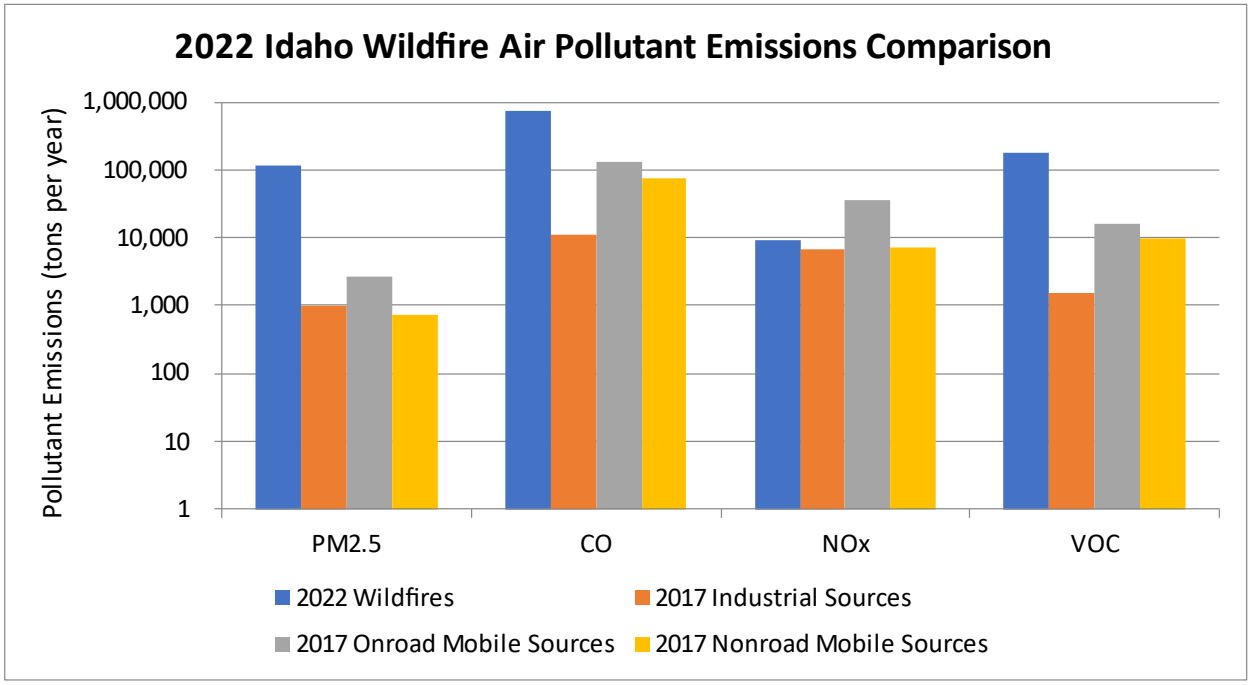

Figure 3. 2022 Idaho wildfire air pollutant emissions compared to other large sources.

Note that the vertical axis is using a logarithmic scale as the emissions from anthropogenic sources were so much smaller than those from wildfire that they were not visible using a normal scale.

5 Conclusions

The 2022 wildfire season in Idaho was below the 10-year average in terms of acres burned with approximately 417,229 acres affected by wildfire. Idaho DEQ utilized the WFEIS developed by the MTRI to estimate the air pollutant emissions from these wildfires. The results from this tool indicate that despite the below average acreage burned, wildfires in Idaho were still the single largest source of $PM_{2.5}$, CO, and VOC in the state in 2022.

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Appendix A. Detailed FCCS Fuelbed Types Within Wildfire Perimeters

Table 5. FCCS fuelbed types within 2022 wildfire burned areas in Idaho as calculated by the Wildland Fire Emissions Inventory System (WFEIS).

FCCS ID	FCCS Fuelbed	DEQ Grouping	Area (acres)	Percent of Total
1223	Wheat field - post harvest	Cropland	543.13	0.13%
1244	Other crop fields - post harvest	Cropland	2206.36	0.53%
1247	Miscellaneous vegetable or fruit field - post harvest	Cropland	0.74	0.00%
1261	Fallow field - growing season	Cropland	1161.62	0.28%
1273	Tree fruit field - no inter-row groundcover	Cropland	0.25	0.00%
1281	Pasture, hay, or alfalfa field - grazed or harvested	Cropland	326.91	0.08%
0	Urban/Bare ground	Other	15,588.06	3.74%
489	Interior West ruderal riparian scrub	Other	39.78	0.01%
493	Temperate Pacific freshwater emergent marsh	Other	425.51	0.10%
494	Inter-mountain basins alkaline closed depression	Other	378.06	0.09%
531	Rocky Mountain alpine-montane wet meadow	Other	292.81	0.07%
532	Western ruderal marsh or wet meadow	Other	1,043.26	0.25%
30	Turbinella oak-alderleaf mountain mahogany shrubland	Rangeland	206.58	0.05%
56	Sagebrush shrubland - exotic species	Rangeland	22,058.62	5.29%
57	Wheatgrass-cheatgrass grassland	Rangeland	5,924.72	1.42%
62	Huckleberry-heather shrublands - 7 years post wildfire	Rangeland	14,785.48	3.54%
69	Western juniper/sagebrush-bitterbrush shrubland	Rangeland	27,872.63	6.68%
213	Wheatgrass-cheatgrass grassland - post prescribed burn	Rangeland	12,932.23	3.10%
233	Sagebrush shrubland	Rangeland	412.90	0.10%
234	Sagebrush shrubland - post prescribed burn	Rangeland	18.53	0.00%
235	Idaho fescue-bluebunch wheatgrass grassland - postfire	Rangeland	16,108.94	3.86%
236	Tobosa-grama grassland	Rangeland	4.69	0.00%
302	Willow/sedge grassland	Rangeland	518.91	0.12%
307	Paloverde shrubland	Rangeland	2.72	0.00%
308	Low sagebrush shrubland	Rangeland	25,201.23	6.04%
310	Greasewood shrubland	Rangeland	590.32	0.14%
311	Saltbush shrubland	Rangeland	1,313.09	0.31%
313	Mountain mahogany shrubland	Rangeland	12,080.97	2.90%
315	Showy sedge-black alpine sedge grassland	Rangeland	5,450.04	1.31%
318	Bluejoint reedgrass-water sedge grassland	Rangeland	0	0.00%
334	Mountain heather tundra shrubland	Rangeland	212.01	0.05%
401	Holly-privet shrubland	Rangeland	520.89	0.12%
498	Interior western North American temperate ruderal grassland & shrubland	Rangeland	5,854.29	1.40%

528	Great Basin & Intermountain ruderal shrubland	Rangeland	1,993.36	0.48%
529	Great Basin & Intermountain Introduced Annual and Biennial Forbland	Rangeland	1,556.24	0.37%
1	Black cottonwood-Douglas-fir-quaking aspen forest	Timber	120.58	0.03%
2	Western hemlock-western redcedar-Douglas-fir forest	Timber	19,497.92	4.67%
20	Western juniper/curl-leaf mountain mahogany woodland	Timber	1,783.57	0.43%
22	Mature lodgepole pine forest	Timber	57,997.34	13.90%
52	Douglas-fir-Pacific ponderosa pine/oceanspray forest	Timber	46,427.12	11.13%
53	Pacific ponderosa pine forest	Timber	15,027.63	3.60%
59	Subalpine fir-Engelmann spruce-Douglas-fir-lodgepole pine forest	Timber	81,367.06	19.50%
61	Whitebark pine/subalpine fir forest	Timber	13,432.36	3.22%
67	Interior ponderosa pine-Douglas-fir forest	Timber	1,181.63	0.28%
210	Pinyon-Utah juniper woodland	Timber	209.54	0.05%
219	Ponderosa pine-white fir/quaking aspen forest	Timber	0.00	0.00%
222	Interior ponderosa pine forest	Timber	1.73	0.00%
224	Quaking aspen forest	Timber	691.63	0.17%
273	Engelmann spruce-Douglas-fir-white fir-ponderosa pine forest	Timber	19.03	0.00%
286	Limber pine-ponderosa pine forest	Timber	3.95	0.00%
304	Engelmann spruce-subalpine fir/horsetail forest	Timber	1,740.82	0.42%
317	Bigtooth maple forest	Timber	9.14	0.00%
320	Western larch forest	Timber	9.88	0.00%
409	Virginia pine-chestnut oak/little bluestem forest	Timber	1.73	0.00%
426	Sugarberry/acacia forest	Timber	13.84	0.00%
427	Red spruce-northern white cedar-tamarack forest	Timber	12.36	0.00%
496	Western larch savanna	Timber	54.61	0.01%