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California Forest Biomass Pile Data Collection

Prepared for the Joint Institute for Wood Products Innovation, an advisory committee to the California Board of Forestry

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List of Acronyms

APCD	Air Pollution Control District
APCO	Air Pollution Control Officer
AQMD	Air Quality Management District
CAL FIRE	California Department of Forestry and Fire Protection
CARB	California Air Resources Board
CAPCOA	California Air Pollution Control Officers Association
OPR	[California Governor's] Office of Planning and Research
PFIRS	Prescribed Fire Information and Reporting System
SMP	Smoke Management Plan
SRA	State Responsibility Area
US EPA	United States Environmental Protection Agency
USFS	United State Forest Service
WUI	Wildland Urban Interface

Executive Summary

To meet the challenge of declining forest health conditions and increasing frequency and severity of wildfire over the last decade, California and the USFS have set a goal of treating one million acres of wildland per year by 2025. This goal will require removal and subsequent disposal of an estimated 5 – 15 million bone dry tons of forest biomass waste annually from a range of vegetation management projects for forest restoration, as estimated by the Wood Utilization Work Group of the California Wildfire and Forest Resilience Task Force.

In response to the Joint Institute for Wood Products Innovation's Request for Proposal #9CA05280 to help state leaders understand the status of existing forest biomass, this report seeks to quantify the number of forest biomass piles that have accumulated annually from 2018 – 2021 and to provide an inventory of forest biomass pile material potentially available for wood and biomass utilization (Part I). This report also aims to determine the number of forest biomass pile burn permits issued by California air districts from 2018 – 2021 to provide information about intentional anthropogenic burning, including open pile burning as a waste disposal method, prescribed burning[1], and the total acreage and tonnage of burn piles in California (Part II). We do not analyze accidental or intentional anthropogenic wildfires or lightning-caused wildfire impacts. This report also reviews how air districts permit and track burning projects to better understand the complex regulatory framework around managed burning in California.

Part I: California Burn Pile Mapping and Quantification

This project focused on mapping existing hand and machine piles across California resulting from vegetation management projects. Piles of slash from vegetation treatments consisting of brush, branches, treetops, biomass trees, and other woody debris are generally called burn piles. Burn piles have been used for decades across California to aggregate, burn, and dispose of woody residue from forest management operations, hazard tree removal, preparation for prescribed burning, residential forest management, and agricultural waste. While these piles can vary greatly in size, distribution, and material composition, they all serve the purpose of facilitating combustion of low-value woody and vegetative material, in what has been typically viewed as a low-cost method. As forest management activities have expanded into and near the WUI for the purposes of fuels reduction, piles are being constructed closer to communities, where their existence and disposal via burning pose potential logistical, fire hazard, and smoke impact issues.

<u>The key questions addressed in this study include:</u>

- How many acres of hand and machine piles are there in forested lands of California?
- What is the total estimated tonnage of hand and machine piles for non-agricultural lands of California?
- How are the acres and tonnage of piles distributed across California air districts?
- How much of that material is within 100 feet of a road, by air district?

The pile mapping portion of this project estimates **there are potentially 150,000 acres of piles of forest biomass, representing approximately 1,000,000 tons of material in piles**

[1] Prescribed burning is included because California air districts generally do not differentiate between the two in their regulatory oversight and data tracking – see Part II of this report for detail.

currently on the landscape, with 78% of this material occurring on public lands. 19% of this material, or 27,385 acres and 195,938 tons, is accessible via existing road networks.

By material type, there are 125,501 acres and 769,087 tons of forest biomass piles, and 20,580 acres and 244,485 tons of shrub/chaparral piles. In other words, 76% of total tons of piles consist of forest biomass, while 24% are chaparral. These estimates include removals of material killed by fire, insects, and disease where those removals were recorded in the online treatment databases used in the analysis. Often these types of removals may be individual or clusters of trees in residential areas, hazard trees along roads or other facilities and may not be recorded in area treatment databases. Piles accrued on landownerships where landowners do not burn would need to be disposed of using alternate methods such as chipping to limit future accumulations.

Air districts with the greatest acreage of piles tend to be in heavily forested regions where piles are generated by fuels reduction and forest management activities on both public and private lands.

Cutting and piling of woody material whether by hand or machine is a necessary treatment for forest management, hazardous fuels reduction, prescribed fire preparation, and hazard tree management. With that said, together, the total acreage of piles created (including those adjacent to communities), potential issue they pose to wildfire control, potential escapes, emissions, and burning costs all suggest that alternatives to pile construction and burning be explored. This is not a recommendation to ban or eliminate pile burning. It is a recommendation to build them only in areas where the use of machines for harvesting, chipping, and hauling are not viable options rather than as a default treatment in all areas. This would help minimize impacts to communities in the WUI and increase fire crew capacity for implementing local and larger scale prescribed burns for fuels reduction and ecological restoration instead of having them burn and tend to piles of slash that could otherwise be chipped and spread or hauled for use in energy production or other forest products. When considering the true costs of burning piles, particularly large machine piles accessible to existing road networks, it is likely that paying for removal via machine is comparable with the costs of burning in many cases. In addition, burning of these piles may have impacts on local air quality and public health. Further study assessing public health impacts of pile burning, the influence of the Million Acre Strategy and State of California funding for fuels reduction on burn pile creation or reduction may help inform strategies for reducing this material.

Part II: Regulation of Anthropogenic Intentional Burning in California

To help state leaders understand the current fate of forest biomass, Part II seeks to provide information about intentional anthropogenic burning, including open pile burning as a waste disposal method and prescribed burning. This report does not analyze accidental or intentional anthropogenic wildfires or lightning-caused wildfire impacts. While this overall project intended to examine “open pile” burning specifically, we included prescribed burning because California air districts generally do not differentiate between the two in their regulatory oversight and data tracking—this will be discussed further throughout this report.

In summary, Part II of this report:

- Discusses the regulation of California's open pile burning and prescribed fire in forested settings by air districts, as well as by other entities such as CAL FIRE, local fire districts, cities, and counties.
- Provides statewide data pertaining to air quality burn permits issued by California air districts, including total acres burned, total tons per acre, and the degree to which requested burns are successfully implemented.
- Describes how air districts track and permit burning projects.
- Summarizes state program updates that are underway for tracking and permitting burns.

I. Legal Context to Prescribed Burning and Historical Background

In any given location in California, a resident, property manager, or business seeking to burn could be subject to up to four different agency regulations related to open burning: a local fire agency, an air district, the city or county, and/or CAL FIRE. To determine which permits might apply, the burner must investigate regional requirements. The definitions of types of burns and what permits apply is a patchwork of information. Understanding the legal context to burning in California is important when using burn permit data to quantify the amount of burning happening statewide.

II. Data Collection of Intentional Anthropogenic Burning Statewide

Following an analysis of reported PFIRS information on tons of biomass burned (the best available dataset for quantifying burn permits and associated burning information statewide) from July 2018 – June 2021, we found that the statewide average for biomass burned **is 12.9 tons per acre**. This value should be interpreted cautiously, recognizing that calculating biomass tons per acre is up to the person entering burn data into PFIRS. There could also be variation in estimated tons per acre from air district to air district. This demonstrates that the PFIRS platform could benefit from standardized tons per acre or tons per pile estimates that users could easily select based on their project and regional environmental factors.

Overall, 72% of the acres requested to be burned statewide by practitioners entering data into PFIRS were successfully completed. This value must also be interpreted cautiously, as it only captures trends in burns that are *reported* to PFIRS by practitioners. As the acreage requests were approved by air districts, there could be other factors contributing to completion rates, such as implementation costs, available staff, or the COVID-19 pandemic.

PFIRS and CAPCOA data were used for this study to quantify the total acres burned from July 2018 – June 2021 across all air districts statewide. The top five air districts for total acres burned during the period analyzed included North Coast, Modoc, Monterey Bay, Lake, and Siskiyou. **These five air districts burned a total of 172,023 acres, which represents more than 50% of the total acres burned across the state from 2018 – 2021.** Furthermore, 81% of total forested lands in California are within the top half of air districts for acres burned during the study period.

III. Air District Interviews

To confirm the data collected on burning and to better understand how burns are tracked by air districts, we interviewed 18 air districts, or the top half where most forest burning is occurring based on results from the statewide acres burned analysis. The most significant takeaway from those interviews is that tracking data on burning is challenging. Some districts have the staffing and tools to closely track information, but most do not. Most districts agree that the PFIRS

system is the data collection method of choice for forest-related burning in California, but many districts are frustrated by the program's interface due to its complexity and administrative challenges related to accurately entering data. Fortunately, efforts are underway by California Air Resources Board (CARB), which manages PFIRS, to improve the platform. More resources are needed to ensure that districts, state agencies, and policy makers have access to the best available data on burning in California. Another key finding is that a district denial of a burn request is rare, at 1.6% of total requests in the study period, and can be due to a variety of reasons, but not always due to smoke impact concerns. However, most districts that deny a day-of request to burn typically work with the applicant to find a suitable alternative burn day.

Part III. Overall Conclusion and Recommendations

Burn piles can accumulate due to a variety of reasons, including access, funding, capacity for removal, and local land management comfort with various treatments. Part I of the report showed that air districts with the most acres of piles, and tons of biomass within those piles, as well as where those piles are close to roads, were in air districts that had a high portion of forest cover and/or recent wildfire activity. This is also the case for where burning is occurring, as described in Part II. This is likely reflective of day-to-day forest management and fuels reduction activities on private industrial timberlands and on public lands.

When comparing the outcomes of the two parts of this report, however, there does not appear to be a correlation (beyond being in a forested area) between the districts where there are piles and where burning is occurring. It appears that burning activities is not necessarily based on biomass availability, but rather, other factors such as access to work force or funding. In the future, biomass removal priorities should consider places where there is easily accessible material, where such material is a significant fire threat to a populated or sensitive area, or where burning such material would generate smoke impacts to the public.

Following an analysis of existing piles across the landscape, as well as relevant laws and regulations pertaining to open burning in California, synthesizing available burn permit data, and interviewing 18 air districts where majority of forest-related open burning occurs, we make the following recommendations.

General Recommendations:

- CARB and sister agencies should continue to improve the PFIRS data system and work to include all air districts in the implementation of its use. Relatedly, relevant agencies should develop a more integrated tracking system for every type of burner and organization implementing burning activities.

- The California Wildfire and Forest Resilience Taskforce in partnership with CARB should consider a new approach Title 17 Agricultural Burn Reports collected by CARB so they can be most useful in the non-forest, agricultural burning sector, and perhaps for tracking larger non-agricultural burning and consider how definition amendments in the state's Title 17 statutes could be helpful.
- With an increase in the number of CAL FIRE "no burn" days due to public safety concerns, non-federal prescribed fire crews funded by the state, local governments, and nonprofit groups, need to have other work lined up so that they are not sent away to wildfires and remain available and "on call" for prescribed fires when conditions allow.

- The Department of Conservation, CalRecycle, and Joint Institute for Wood Products Innovation should support the removal of biomass wood waste from private non-industrial forested lands, especially within populated areas, through rural green waste hauling programs, and do so by creating an incentive program for local governments that include funding and training.
- Support development of value-added wood product markets from biomass to create complementary and ongoing partnerships that support forest restoration activities. Consider prioritizing those regions with the greatest tonnage of material within 100 feet of a road included that have an active wood products industry, as this would give the greatest short term potential reduction on potential pile burning and decay emissions.
- Consider using results of this study to help focus state forest health-related grant funds to areas with higher potential biomass material accumulations in the WUI.

Pile Management Recommendations

- Consider providing users with standard pile weights based on pile type (machine, hand), size, and spacing that would provide pre-estimated pile tonnages as standard inputs. The pile tonnage estimates can also be refined via the new application being developed by the California Office of Programs and Research (OPR), Cal Poly (San Luis Obispo), and Amazon.com. Once completed, the application will allow users to scan piles using a smart phone or tablet and quickly calculate pile volume and location.
- Forest managers should avoid creating piles in the WUI intended for burning, and prioritize funds available for chipping, burning, and removal of existing piles within the WUI—particularly those within 100 feet of a road. Limiting the burning of piles in the WUI will allow for more prescribed fire which allows land managers to achieve forest restoration and wildfire risk reduction goals.
- Forest managers should prioritize mechanical thinning and biomass removal in lieu of hand thinning and piling when feasible (such as for large treatment areas with gentle topography, and not in remote or sensitive areas) to ensure work is completed in an efficient and timely manner. Instead, build piles only in areas where the use of machines for harvesting, chipping, and hauling are not viable options.

Further Study Recommendations

- The cost of chipping biomass piles and top decks is not necessarily more expensive than burning. Thus, the cost per pile of burning needs further study to systematically determine true burning costs, including costs of potential mop up and escape, and also including non-monetary direct costs such as smoke impacts to communities, potential carbon emissions, and impacts on resource staffing for other prescribed fire projects.
- Residential burning and smaller burns that are not covered by Smoke Management Plans cause most citizen complaints (rather than prescribed fires). CARB and CAPCOA should consider convening conversations with air districts about how to tackle small burning regulation. If there is interest, the state should supply funding and technical support to air districts and put data tracking systems in place to better understand small burning impacts on air quality and public health.
- CAPCOA and the State Fire Marshal should convene meetings with the local fire agencies and the air districts and support those agencies that may want to create one stop permitting shops. Consider how this might also work in conjunction with CAL FIRE's new online burn permit platform for landowners in their jurisdictions.

- Develop a comprehensive strategy for amending the myriad of state definitions around anthropogenic burning that develops recommendations for changes in state law.
- Analyze the correlation between acres and tons of biomass burned and the proximity to a biomass conversion facility within ~50 miles.
- Provide additional research on how burning piles may impact WUI specific emissions and related human health.

Part I: California Burn Pile Mapping and Quantification

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Section 1: Overview

Piles of slash from vegetation treatments consisting of brush, branches, treetops and other woody debris are generally called burn piles. Burn piles have been used for decades across California as a simple means to aggregate, burn, and dispose of woody residue from forest management operations, hazard tree removal, preparation for prescribed burning, residential forest management, and agricultural waste. While these piles can vary greatly in size, distribution, and material composition, they all serve the purpose of facilitating combustion of low-value woody and vegetative material, in what has been typically viewed as a low-cost method.

As forest management activities have expanded into and near the WUI for the purposes of fuels reduction, piles are being constructed closer to communities, where their existence and disposal via burning pose potential logistical, fire hazard, and smoke impact issues. In addition, recent large megafires, such as the 2020 CZU Complex in Santa Cruz County or the 2021 Dixie Fire in Plumas, Lassen, Shasta, and Butte Counties, have created a “surge” in machine piles and log decks as hazard trees, powerlines, road right of ways, and other lands are cleared of dead and dying trees. Finally, extensive drought-induced mortality, particularly in the southern Sierra region, has created both burn piles and “cull decks” of low value material, distributed across both public and private lands.

While all burn piles share the common goal of existing to be burned, they are not all created equally, and all have location and pile type challenges for disposal using both fire, chipping, biochar, or other mechanical means. Understanding the sources and distribution of these piles is crucial in reducing their volume effectively at a statewide level.

Project Research Focus

The first phase of this project is to quantify the number of forest biomass piles in California that have accumulated annually from 2018 – 2021 as well as total acres and tons of piles. The second phase quantified the acres and tons of piles within 100 feet of existing road networks.

The key questions addressed include:

- How many acres of hand and machine piles are there in forested lands of California?
- What is the total estimated tonnage of hand and machine piles for non-agricultural lands of California?
- How are the acres and tonnage of piles distributed across California air districts?
- How much of that material is within 100 feet of a road, by air district?

Section 2: Methods

Burn Pile Types

Burn piles can generally be classified as “hand piles” and “machine piles,” but there is a wide range of variability within and between pile types as described below. The differences between the methods used to construct these piles, the materials within the pile, and their location can influence the degree of difficulty and risk of burning them.

Hand Piles

Hand piles are typically constructed of either chainsaw or, in limited cases, crosscut saw cut live or dead conifer, brush, or hardwood vegetation or existing accumulated dead and down fuels. Cut materials can be up to 14” in diameter, though typical projects focus on trees up to 8-10” in diameter. Materials are piled by hand into piles ranging from 6’-8’ tall and 6’-12’ in diameter. These piles are usually covered with plastic or craft paper, allowed to cure for a season, and ignited when weather and staffing conditions specified in a burn plan are met. Hand piles are placed in open areas, typically 40-60’ apart, resulting in 15-20 piles per acre. Hand piles may also be scattered along roads or trails, or individual hazard trees or brush may be cut and piled for removal (Photos 1-4).

Photos 1-4. Examples of hand piles in forest and shrub fuel types.




Machine Piles

Machine piles can be constructed using a bulldozer, brush rake, or grapple. These piles can consist of slash, limb material, fire-killed trees, shrubs, hardwoods, or naturally accumulated fuels (Photos 5-8). They may also be created from the same material pushed into a burn pile using a bulldozer with a blade or brush rake. In limited cases, piles of brush are ripped out of the ground with a machine and piled for burning. Material in machine piles is often larger than that found in hand piles, with tree bole wood typically up to 30” in diameter included in the piles. Machine piles created using a dozer blade may also have more dirt interspersed within the pile and a dirt “berm” around the edges of the pile, which impact ease of mop up if woody debris is mixed in with the dirt.

Machine piles can range from sizes similar to those of hand piles up to 40’ in diameter and 15’ tall. Machine piles are typically built on or near logging site landings but can be dispersed in the forest or brush fields as well. Due to pile size and varying degrees of moisture and dirt in these piles, they can take more resources to ignite, hold, and mop up. These piles are often ignited in late fall, ahead of winter storms due to the long duration of burning.

Photos 5-8. Examples of machine piles in forest and shrub fuel types.

Top Decks, Cull Decks, Fireline Decks, and Firewood

Another class of machine pile that may not initially be designed for burning, but later be burned due to low-market value, includes top decks (typically conifers), cull decks, fire line decks, and firewood (Photos 9-12).

Top decks are created by separating tops from sawlogs at a logging site's landing, typically using a stroke de-limber or processor, or by hand with a chainsaw, and later placed in piles using a log loader. In some cases, top decks are chipped, with material hauled off-site or potentially spread in place for erosion control. Top decks can be burned as well, and given size and burn duration, pose some of the same control and mop up issues previously described for large machine piles. Where top decks are not chipped or burned, they can sit for several years and can pose fire control problems if ignited during a wildfire (Johns, 2021).

During large wildfires, contingency lines (or fire lines) are created as fallback positions for fire suppression or potential firing operations. These lines are created using a mechanical harvester that typically removes smaller trees or, in some cases, all trees within 25-150' of a road edge, decking trees with limbs to be processed at a future date. In some cases these trees are processed, but log lengths may be inconsistent or, due to sitting outside without being sprinkled, may end up checking or staining before a buyer can be secured. These decks are often too large to safely burn given the compactness of the piles and size of the material. They may also be cut at odd lengths that sawmills cannot easily process or that would yield non-standard board lengths, which cannot be easily sold as lumber.

Cull decks may result from residual, non-merchantable logs left on a landing after harvest operations resulting from hazard tree clearing along roads, removing insect-killed trees, or from falling of fire-killed trees which are no longer merchantable. Like other piles, cull decks pose similar issues related to burning as larger top decks and contingency lines. Additionally, due to typically high levels of rot and decay, cull piles cannot be hauled away in whole form on a standard log truck as they cannot safely span the log truck bunks without breaking in transit.

While not the focus of this analysis, firewood is created in large quantities from contingency line construction and hazard tree removal. Typically, wood on public lands is bucked by work crews and, in limited cases, left available for the public to haul and use for personal use. When stacked in rounds, it is difficult to light and burn due to its round shape.

Photos 9-12. Examples of top decks, log decks, and firewood piles.

Determining Burn Pile Locations and Tons of Material

The probability of existing burn pile locations from 2018-2022 was determined spatially using reported wildfire fuels treatment and timber harvest locations. The probability of the presence of burn piles was further refined based on prescribed burn activity, wildfire occurrence after pile creation, and heat detected from satellites during the prescribed burn season. Actual pile locations were added to an online web map by landowners within specific ownerships for validation. The tons of material per acre by pile type (hand piles and machine piles) and material (tree or shrub) were determined by utilizing reported tonnage per acre estimates from the PFIRS dataset analysis. The steps for assigning probability of piles existing on the landscape are described in detail in Attachment 1.

Section 3: Results

The potential total acres of piles, tons of material in piles, and total acres reported burned by air district are shown in Table 1. Results are displayed by air district to stay consistent with results in Part II of this report that assesses the number of burn permits issued by each air district for the same study period. The acres and tons of piles by air district were ranked by acres of piles. The 12 air districts with the greatest potential acres of burn piles typically included extensive forested regions, large areas of public lands, and an active commercial forest products industry. Air districts with lower amounts of piles were typically in the coastal or foothill regions of California. Total tons of material generally followed the same trend, as this estimate uses total acres to estimate total tons. The top 10 and bottom 10 districts in terms of total acres of piles were generally the top and bottom ten in terms of total acres burned, as identified in Part II of this report. Exceptions were Monterey Bay and Lake County Air Districts, which showed a relatively high acreage of acres burned compared to acres and tons of piles. Approximately 78% of the acres of piles were on public lands. These estimates include removals of material killed by fire, insects, and disease where those removals were recorded in the online treatment databases used in the analysis. Often these types of removals may be individual or clusters of trees in residential areas, hazard trees along roads or other facilities and may not be recorded in area treatment databases. Piles accrued on landownerships where landowners do not burn would need to be disposed of using alternate methods such as chipping to limit future accumulations.

A map illustrating the total estimated acres of piles by air district can be found below in Figure 1.

Table 1a. Acres and tons of hand and machine piles by air district, ranked by total acres of piles.

Air District Name	Total Acres of Piles	*Rank of Acres of Piles*	Total Tons of Piles	*Rank of Tons of Piles*
	Years 2018-2022			
Siskiyou	25,081	1	109,818	3
San Joaquin Valley	16,130	2	47,734	9
Northern Sierra	15,028	3	129,865	2
Tuolumne	11,732	4	41,338	10
Lassen	10,918	5	36,726	11
Placer	10,472	6	136,282	1
Shasta	9,467	7	48,685	8
Modoc	9,083	8	57,939	5
North Coast	5,845	9	71,859	4
South Coast	5,259	10	54,771	7
Calaveras	3,616	11	11,778	19
Butte	2,906	12	30,491	14
Great Basin	2,638	13	25,723	15
Kern	2,397	14	56,723	6
Tehama	2,296	15	31,049	13

Air District Name	Total Acres of Piles	*Rank of Acres of Piles*	Total Tons of Piles	*Rank of Tons of Piles*
	Years 2018-2022			
Mariposa	1,733	16	3,097	25
El Dorado	1,726	17	12,783	18
Bay Area	1,704	18	7,590	21
Amador	1,455	19	6,821	22
Feather River	1,311	20	15,507	16
Mendocino	1,232	21	14,899	17
Mojave Desert	942	22	6,802	23
San Diego	826	23	7,642	20
Santa Barbara	820	24	34,606	12
Ventura	750	25	1,058	29
Glenn	495	26	2,128	27
Antelope Valley	480	27	4,891	24
San Luis Obispo	393	28	1,214	28
Northern Sonoma	390	29	454	31
Colusa	185	30	15	32
Monterey Bay	109	31	867	30
Lake	109	32	2,408	26
Yolo-Solano	49	33	0	33
Sacramento Metro	0	34	0	34
Imperial	0	35	0	35
Total	**147,579**		**1,013,565**	

Table 1b summarizes the total acres and tons per acre from Table 1a by vegetation type (forest, shrublands, chaparral) by air district.

Table 1b. Acres and tons of hand and machine piles by pile vegetation type by air district, alphabetically.

Air District Name	Pile Vegetation Type	Total Acres	Total Tons
Amador	Forest	1,368	5,988
	Shrublands and Chaparral	88	833
Antelope Valley	Forest	1	6
	Shrublands and Chaparral	479	4,886
Bay Area	Forest	462	5,750
	Grass/Herbaceous	16	-
	Shrublands and Chaparral	1,226	1,840

Air District Name	Pile Vegetation Type	Total Acres	Total Tons
Butte	Forest	2,906	30,491
Calaveras	Forest	3,076	8,386
	Grass/Herbaceous	95	-
	Shrublands and Chaparral	445	3,392
Colusa			
	Forest	1	15
	Grass/Herbaceous	183	-
El Dorado	Forest	1,599	11,949
	Grass/Herbaceous	107	-
	Shrublands and Chaparral	20	834
Feather River	Forest	1,311	15,507
	Shrublands and Chaparral	0	0
Glenn	Forest	495	2,128
Great Basin	Forest	1,142	7,996
	Shrublands and Chaparral	1,496	17,727
Kern	Forest	2,231	56,074
	Grass/Herbaceous	21	-
	Shrublands and Chaparral	144	650
Lake	Forest	90	1,215
	Shrublands and Chaparral	19	1,193
Lassen	Forest	10,630	30,518
	Shrublands and Chaparral	288	6,208
Mariposa	Forest	1,614	2,500
	Shrublands and Chaparral	119	597
Mendocino	Forest	1,104	14,740
	Grass/Herbaceous	0	-
	Shrublands and Chaparral	128	160
Modoc	Forest	4,063	35,852

Air District Name	Pile Vegetation Type	Total Acres	Total Tons
	Shrublands and Chaparral	5,020	22,087
Mojave Desert	Forest	3	27
	Shrublands and Chaparral	940	6,775
Monterey Bay	Forest	105	867
	Grass/Herbaceous	5	-
North Coast	Forest	5,583	66,578
	Shrublands and Chaparral	262	5,282
Northern Sierra	Forest	14,243	103,930
	Grass/Herbaceous	1	-
	Shrublands and Chaparral	784	25,935
Northern Sonoma	Forest	1	15
	Grass/Herbaceous	23	-
	Shrublands and Chaparral	366	440
Placer	Forest	8,913	71,490
	Grass/Herbaceous	1	-
	Shrublands and Chaparral	1,557	64,792
San Diego	Forest	272	3,216
	Grass/Herbaceous	2	-
	Shrublands and Chaparral	552	4,427
San Joaquin Valley	Forest	15,885	47,352
	Grass/Herbaceous	31	-
	Shrublands and Chaparral	214	382
San Luis Obispo	Forest	36	628
	Grass/Herbaceous	21	-
	Shrublands and Chaparral	336	586
Santa Barbara	Forest	96	829
	Shrublands and Chaparral	725	33,778
Shasta	Forest	9,284	46,607
	Grass/Herbaceous	14	-

Air District Name	Pile Vegetation Type	Total Acres	Total Tons
	Shrublands and Chaparral	168	2,078
Siskiyou	Forest	23,797	105,509
	Grass/Herbaceous	739	-
	Shrublands and Chaparral	545	4,310
South Coast	Forest	2,258	31,367
	Grass/Herbaceous	2	-
	Shrublands and Chaparral	2,999	23,404
Tehama	Forest	1,556	24,454
	Grass/Herbaceous	19	-
	Shrublands and Chaparral	721	6,594
Tuolumne	Forest	10,920	36,783
	Grass/Herbaceous	158	-
	Shrublands and Chaparral	653	4,556
Ventura	Forest	456	320
	Grass/Herbaceous	7	-
	Shrublands and Chaparral	286	739
Yolo-Solano	Grass/Herbaceous	49	-
	Grand Total	**147,579**	**1,013,565**

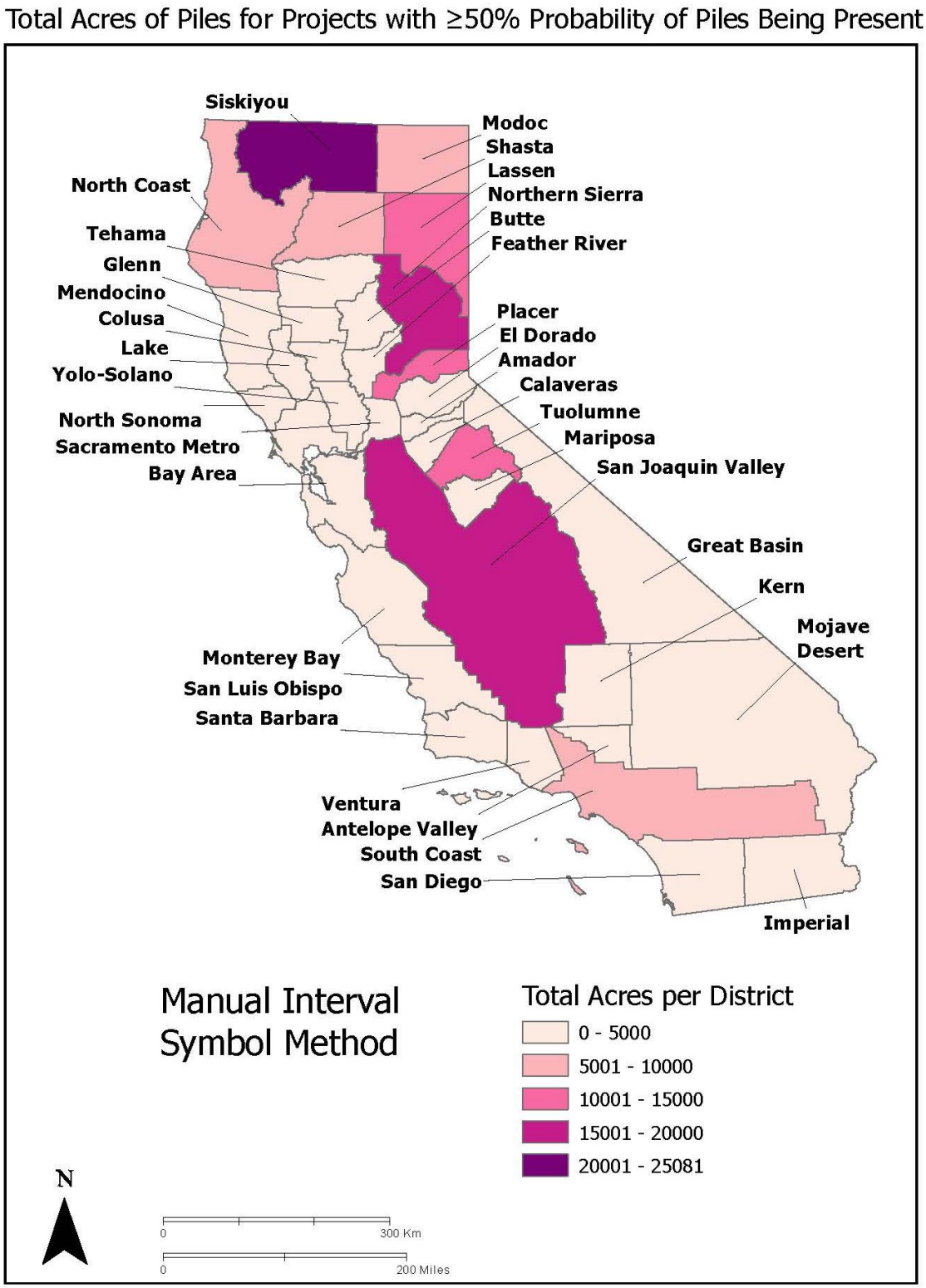
The top 10 air districts with the most acres and tons of material within 100 feet of a road (Table 2) were also within in the top 12 air districts with the greatest overall acreage and tons of hand and machine piled material. These air districts share common traits of extensive forestland, extensive public lands with active fuels management programs, and an active forest products industry.

Table 2. Acres and tons of hand and machine piles within 100 feet of roads by air district, ranked by total acres of piles.

Air District Name	Total Acres of Piles	*Rank of Acres of Piles Within 100 Feet of Roads*	Total Tons of Piles	*Rank of Tons of Piles Within 100 Feet of Roads*
San Joaquin Valley	5,292	1	15,582	6
Siskiyou	5,056	2	22,003	2
Northern Sierra	2,506	3	33,489	1

Air District Name	Total Acres of Piles	*Rank of Acres of Piles Within 100 Feet of Roads*	Total Tons of Piles	*Rank of Tons of Piles Within 100 Feet of Roads*
Tuolumne	1,691	4	6,590	9
Placer	1,487	5	18,007	3
North Coast	1,370	6	16,359	5
Lassen	1,197	7	4,072	15
South Coast	1,124	8	10,997	7
Shasta	883	9	4,200	13
Kern	715	10	17,425	4
Calaveras	659	11	1,999	18
Mariposa	650	12	1,412	21
Great Basin	527	13	4,802	12
Modoc	500	14	3,914	16
Tehama	478	15	5,555	11
Mendocino	466	16	5,797	10
Butte	392	17	4,168	14
Ventura	384	18	626	25
Northern Sonoma	302	19	346	28
Bay Area	291	20	1,695	20
Feather River	273	21	3,229	17
Amador	209	22	1,356	22
Santa Barbara	207	23	7,237	8
San Diego	202	24	1,814	19
El Dorado	159	25	1,132	23
Antelope Valley	99	26	1,009	24
Glenn	88	27	380	26
San Luis Obispo	81	28	165	29
Mojave Desert	50	29	374	27
Yolo-Solano	35	30	0	33
Monterey Bay	7	31	134	30
Lake	5	32	60	31
Colusa	1	33	9	32
Imperial	0	34	0	34
Sacramento Metro	0	34	0	34
Total	**27,385**		**195,938**	

Figure 1: Map of Total Estimated Acres of Piles by Air District



Section 4: Discussion, Recommendations, and Conclusion

Total Acres and Tons of Piles by Air District

The air districts and counties with the highest number of acres and tons of piles were also air districts and counties that had a high portion of forest cover and/or recent wildfire activity. This is likely reflective of day-to-day forest management activities on private industrial timberlands as well as additional fuels reduction and forest management activities on public lands.

Air districts with the greatest tonnage of material within 100 feet of a road included counties with an active wood products industry. Supporting chipping and hauling to a biomass facility or other utilization pathways in these districts would give the greatest short-term potential reduction on potential pile burning and decay emissions.

Reducing Potential Sources of Woody Material To Reduce Overall Acres and Tons of Piled Material

As discussed in the introduction, burn piles can accumulate due to a variety of reasons, including access, funding, capacity for removal, and local land management comfort with various treatments. In this study, we noticed a few lines of manager thinking on pile creation and burning that influence what seem to be small decisions that lead to large accumulations of burn piles on a landscape. These assumptions are further discussed below:

a) Assumption: Hand thinning, piling, and burning by hand crews is easier to plan and implement than mechanical treatments in terms of environmental analysis processes. Hand thinning, piling, and burning can be an effective treatment which limits use of heavy or even light equipment in sensitive areas and steep slopes, but we documented cases of hand thinning and pile burn units that were several thousand acres, relatively gentle slopes (<35%), that required several years to implement.

   Recommendation: Mechanical thinning should be used in lieu of hand thinning and piling when treatment areas are large, have slopes less than 35%, and are in areas not considered sensitive to ensure work is completed in an efficient and timely manner.

Photos 13-14. Example pile and top decks.

b) Assumption: Burning piles and top decks is lower cost when compared with chipping. There is an assumption that building and burning piles is the lowest cost option to slash disposal when compared with additional costs of chipping and hauling low-value woody material. On private lands there is limited in-house burning capacity, so private sector consultants are typically hired to manage burns. Public lands (i.e., USFS), however, have paid fire crews on staff. Paid fire crews are covered by existing funds, so their use during a regular season is not considered a new cost. We talked with experienced fire fighters and determined that the three large burn piles or three similar size large top decks (Photos 13-14) could be ignited by a single five-person engine crew (one day) and patrolled by a single five-person engine crew (three days). Additional patrol by a one-person patrol rig (slip on unit) could patrol three more days until the pile was no longer burning. If the piles required additional mop up, likely a water tender and potentially a bulldozer would be needed for at least two days. Such a scenario could cost between $1,500 and $2,500 and does not account for the potential costs of an escape, emitted carbon when compared with biomass-generated electricity, or the potential smoke impacts to local communities. In contrast, these piles would cost between $3,000-$4,000 each to chip and haul to a facility within 60 miles or, in the case of the stand-alone burn piles, ~$2,500 to chip and spread on site.

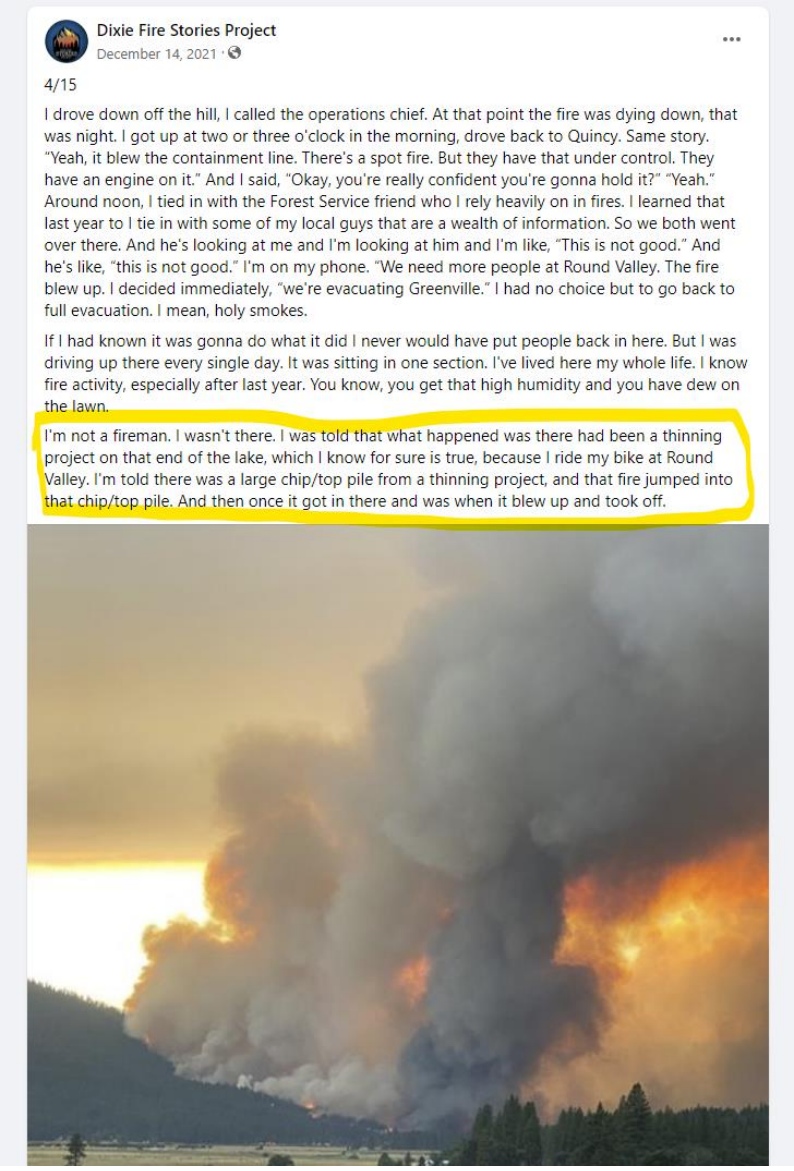
   Recommendation: The cost per pile of burning needs further study to determine true burning costs, including the costs of potential mop up and escape and non-monetary direct costs, such as smoke impacts to communities, potential carbon emissions, and impacts on resource staffing for other prescribed fire projects.

c) Assumption: Piles are created in the WUI and pose smoke issues or other logistical problems during wildfires**.** In some cases, piles are created in the WUI as part of fuel reduction projects to better protect the WUI, but their proximity to communities results in smoke impacts to its residents and air quality issues. This results lower production rates (acres per day) of burning, which delays project implementation and creates potential risks of piles burning and escaping toward

a community, as well as potential control problems in a wildfire (Photo 15-next page) (Johns, 2021).

Recommendation: Avoid creating piles in the WUI intended for burning, and prioritize funds available for chipping, and removal of existing piles within the WUI. Limiting the burning of piles in the WUI will allow for more prescribed fire which allows land managers to achieve forest restoration and wildfire risk reduction goals. Provide additional research on how burning piles may impact WUI specific emissions and related human health

Photo 15. Screenshot from Sherriff Todd Johns interview discussing challenges with burn piles associated with the Dixie Fire (Johns, 2021).



d) Assumption: There are limited biomass or other wood utilization facilities close to piled materials that can accept small diameter material and the cost to deliver piled material is not competitive with other feedstock. Many regions of California who are expanding implementation of fuel treatments are a far distance (>60 miles) from existing biomass and small log processing facilities. There is extensive work being done by the Wildfire and Forest Resilience Task Force, the private and non-profit sectors, and the USFS to address this, but a lack of local facilities can lead to creation of additional top decks and piles. It should be noted that there is potential to expand simple wood products, such as firewood processing facilities or portable firewood processors or biochar machines (Photos 15-16) which can be used in the field to better utilize cull decks that are still sound.

Recommendation: Continue investments in the development of local wood products and utilization industries that have the equipment and facilities with potential to commercialize low-value woody material. Assess the potential effects of how implementation of the Million Acre Strategy and/or related State of California funding for fuels reduction may increase or decrease piled material.

Photos 15 and 16. Examples of portable firewood processor and the Tigercat 6050 "Carbonator 500" biochar machine.

e) Assumption: Top and log or cull decks are assumed to have a positive value in appraisal. On public lands, top decks and log or cull decks are appraised and often given a minimum bid value of $500. Often these small deck sales projects do not sell, resulting in the material remaining on site or being burned or decaying over time. Much of this material actually has a negative value when chipping, trucking, and other disposal costs are factored into the project value. In areas where log deck sales were available during this study, several unsold log/cull decks were up for sale at minimum bid value but remained unsold. (https://www.fs.usda.gov/resources/plumas/landmanagement/resourcemanagement).

Recommendation: Where possible contractually, use service contracts to process decks and cull material in lieu of attempting to sell it. In many cases, the material has a negative value when considering chipping and other removal costs.

f) Standardize tonnage estimate input process for PFIRS. There can be wide variation in tonnage burned estimates in PFIRS due to a lack of a standardized input process for users.

Recommendation: Consider providing users with standard pile weights based on pile type (machine, hand), size, and spacing that would provide pre-estimated pile tonnages as standard inputs. The pile tonnage estimates can also be refined via a new application (currently unnamed) being developed by the California Governor's Office of Planning and Research (OPR), Cal Poly, San Luis Obispo, and Amazon that will allow users to scan piles using a smart phone or tablet and quickly calculate pile volume and location. Spatial Informatics Group is currently beta testing this application by comparing field-based measurements against application calculated pile volumes in partnership with the application designer.

Conclusion

Cutting and piling of woody material whether by hand or machine is a necessary treatment for forest management, hazardous fuels reduction, prescribed fire preparation, and hazard tree management. With that said, together, the total acreage of piles created (including those adjacent to communities), potential issue they pose to wildfire control, potential escapes, emissions, and burning costs all suggest that alternatives to pile construction and burning be explored. This is not a recommendation to ban or eliminate pile burning. It is a recommendation to build them only in areas where the use of machines for harvesting, chipping, and hauling are not viable options rather than as a default treatment in all areas. This would help minimize impacts to communities in the WUI and increase fire crew capacity for implementing local and larger scale prescribed burns for fuels reduction and ecological restoration instead of having them burn and tend to piles of slash that could otherwise be chipped and spread or hauled for use in energy production or other forest products. When considering the true costs of burning piles, particularly large machine piles accessible to existing road networks, it is likely that paying for removal via machine is comparable with the costs of burning in many cases.

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Attachment 1: Methods for Estimation of Pile Locations and Tonnage

Overview

The process for estimating the weight and distribution of burn piles on the landscape starts with estimating the probability of burn piles existing within a fuels treatment area (Figure 1). To accomplish this fuels treatments data were aggregated and assigned probabilities of burn piles being present. Next the probabilities were reduced by the presence of fire. The result was validated using local observations. Finally, weights of piles were assigned to fuels treatment areas and the results were clipped to within 100ft of roads.

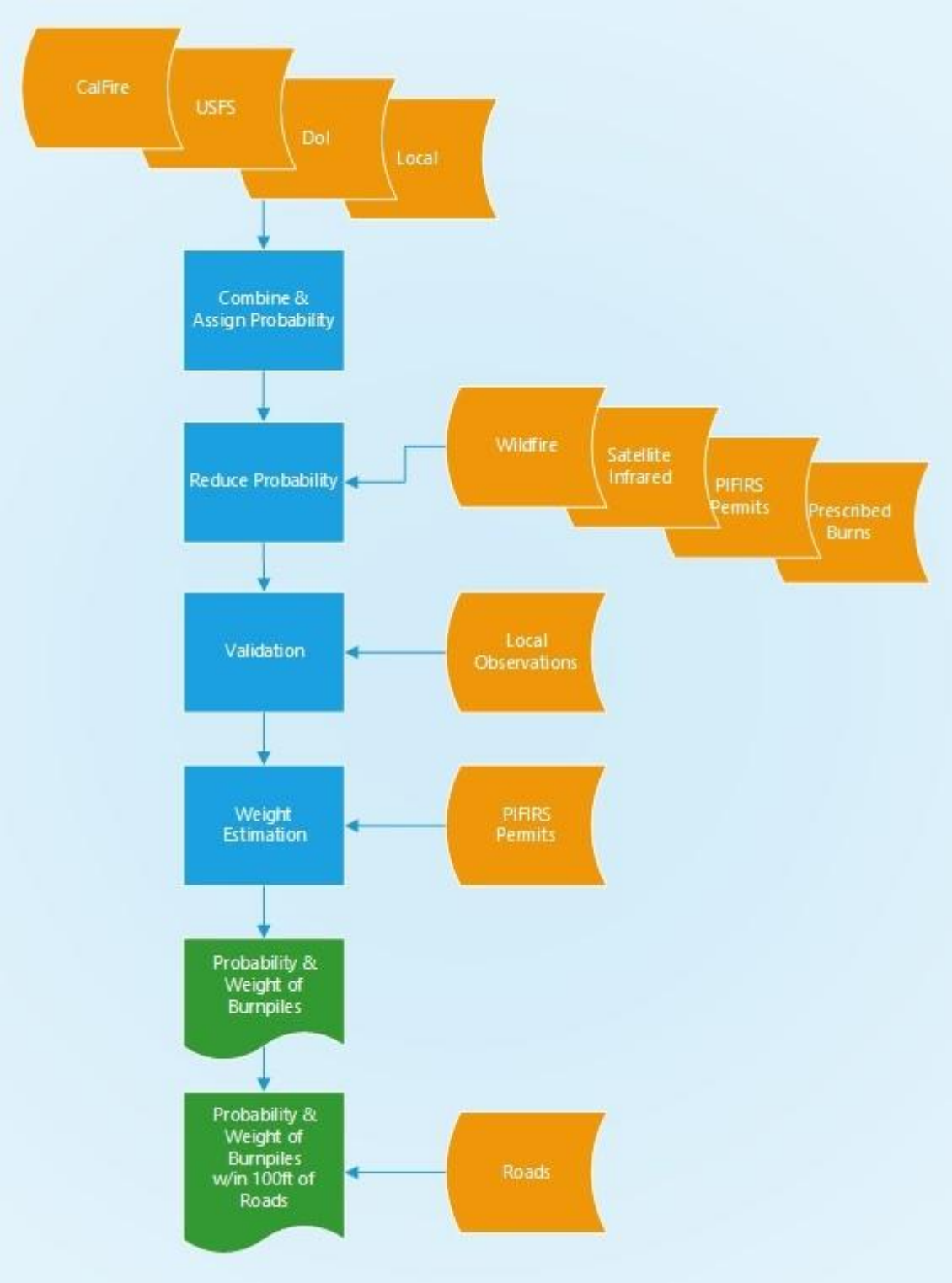


Figure 1. Process for aggregating fuels treatments data and assigning probability of burn pile occurrence and weight of burn piles.

Step 1: Assign probability of creating piles for each Activity Type.
Publicly available wildfire fuels treatment data from the various such as USFS FACTS, CalMAPPER, and California Timber Harvest Plans, were aggregated and classified into a single database of activity types (Table 1). Each fuel reduction activity type was assigned a probability of burn piles being created by the activity (Table 2).

Table 1. Fuels treatment data sources used in the analysis.

Data Source	Database Name	Reference
U.S. Forest Service	Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS)	USFS 2023
U.S. Department of Interior	National Fire Plan Operations and Reporting System (NFPORS)	USDOI 2022a USDOI 2022b
U.S. Bureau of Land Management	BLM CA Vegetation Treatment Area Completed Polygons	BLM 2022
California Air Resources Board	Prescribed Fire Information Reporting System (PFIRS) database	CARB 2022
California Department of Forestry and Fire Prevention	California Timber Harvest Plans	CALFIRE 2023b
California Board of Forestry and Fire Protection	California Vegetation Treatment Program (CalVTP)	BOF 2022
National Park Service	Completed Treatment Perimeters	NPS 2022
California Department of Forestry and Fire Prevention	CAL FIRE Management Activity Project Planning & Event Reporter (CalMAPPER)	CALFIRE 2023a

Table 2. Probability of burn piles being present for each activity type.

Fuels Treatment Activity Type	Probability of Burn Piles
Chipping	50%
Clearcut	100%
Commercial Thin	100%
Group Selection Harvest	100%
Handline	100%
Lop and Scatter	0%
Mastication/Chaining/Crushing	0%
Mowing	0%
Oak Woodland Management	100%
Piling	100%
Precommercial Thinning (Manual & Mechanical)	100%
Pruning	100%
Roadway Clearance	50%
Sanitation and Salvage Harvest	100%
Seed Tree Prep Step	100%
Seed Tree Removal Step	100%
Seed Tree Seed Step	100%
Shelterwood Prep Step	100%
Shelterwood Removal Step	100%
Shelterwood Seed Step	100%
Single Tree Selection	100%
Site Prep	100%

Fuels Treatment Activity Type	Probability of Burn Piles
Transition Harvest	100%
Tree Release and Weed	100%
Trees Felled (>6in dbh)	100%
Utility Right of Way Clearance	50%
Variable Retention Harvest	100%
Yarding/Biomass Removal	100%

Step 2: Reduce Probability by Age of Activity

Piles were assumed to decay or degrade by 10% per year or within 10 years no longer be present or be considered wildfire fuel. For example, the probability of piles being present in 2022 is 100% while the probability of piles being present in 2013 is 10%.

Step 3: Reduce Probability by Incidence of Fire

Prescribed fire locations (PFIRS), satellite thermal hotspot detections (VIIRS), wildfire severity assessments (MTBS/RAVG), as well as mapped follow up treatments were used to reduce burn piles occurrence probabilities (CARB 2022, NASA 2023, EROS-GTAC 2021, EROS-GTAC 2022).

When there was a prescribed fire treatment recorded in PFIRS after the activity and the PFIRS location was within 300-meters of the activity then the probability of burn piles was reduced by 80% (20% probability of finding a burn pile) (Table 3). The 300-meter buffer was used because the location data in PFIRS is of varying accuracy.

VIIRS hotspots were evaluated for clusters over multi-week time periods. Clusters are generally created from factories, mining operations, and other industrial activities. Clusters were removed from the analysis. VIIRS hotspots used in the analysis were limited to the prescribed fire season which was defined as October 1st through June 15th. If VIIRS hotspot(s) from the prescribed fire season was detected within an activity area and after an activity occurred, then the probability of burn piles was reduced by 50%.

Burn severity mosaics from the MTBS (2013-2021) and RAVG (2022) databases were used to reduce the probability of burn piles. Activity polygons were intersected with the MTBS and RAVG mosaics. High and moderate intensity wildfire reduced the probability of burn piles by 100% (0% probability of finding a burn pile). Low severity wildfire reduced the probability of burn piles by 50%.

Subsequent treatment by broadcast burning or pile burning reduced the probability of finding piles by 100% (0% probability of finding a pile).

Table 3. Burn pile probability reduction factors by subsequent fire activity.

	Probability of Burn Piles	
Criteria	**Yes**	**No**
PFIRS w/in 300 Meters	20%	100%
VIIRS Hotspot w/in polygon	50%	100%
Wildfire High-Moderate	0%	100%
Wildfire Low	50%	100%
Broadcast Burn	0%	100%
Pile Burning	0%	100%

Example 1:

Thinning Manual (Hand Pile)	100%	
Treatment 3 years old	70%	
No Wildfire is present	100%	
No PIFIRS data w/in 300 yards	100%	
No VIIRS Hotspots w/in polygon		100%
Probability of finding burn piles		**70%**

Example 2:

Road Way Clearance	50%	
Treatment 3 years old	70%	
Low Intensity Wildfire	50%	
No PIFIRS data w/in 300 yards	100%	
VIIRS Hotspots w/in polygon	50%	
Probability of finding burn piles		**18%**

Example 3:

Thinning (Mechanical)	100%	
Treatment 3 years old	70%	
High Intensity Wildfire	**0%**	
No PIFIRS data w/in 300 yards	100%	
VIIRS Hotspots w/in polygon	50%	
Probability of finding burn piles		**0%**

Step 4: Field Validation with Landowners

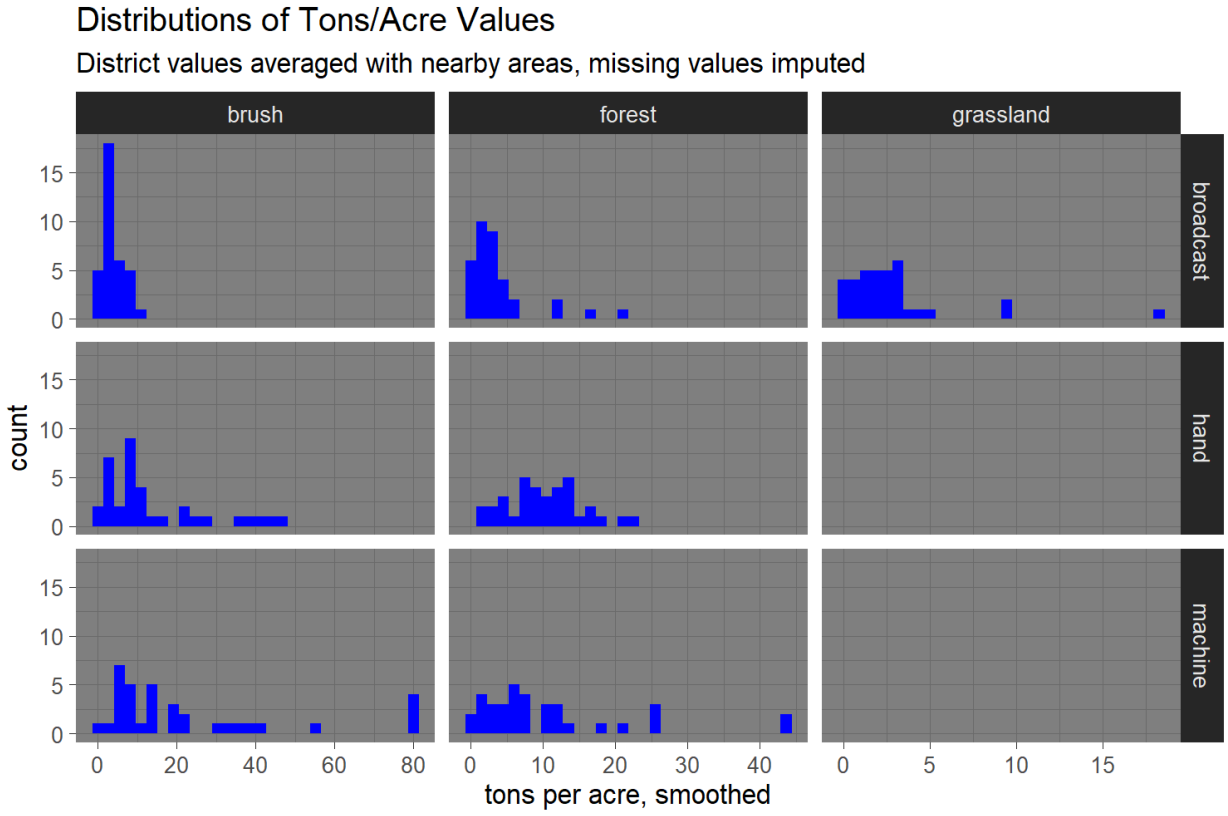
Landowners from across California were contacted and invited to review pile locations within their ownerships. Participants were given a map of estimated pile locations and

asked to refine, add, or remove locations where they had better information. The map was public, allowing editing and updates-the map remains open for future additions and refinement as we had limited feedback from contacted landowners.

Step 5: Estimating Pile Volumes and Weights

User input data on tonnage burned varied widely in PFRIS. While we don't have the information to determine conclusively the reason for this, one hypothesis is that the extremely high tons per acre estimates in some districts could have been the result of data entry practices such as recording "acres burned" as the acreage of large burn piles themselves, rather than the total acreage of the treated area from which the pile material was derived. To address this uncertainty, we first excluded data for burns where tons per acre exceeded an improbably high level of 100 tons per acre. Note this level of fuel loading is possible in clear cut areas where all slash and cull are left on site to burn, but this older practice does not seem to be in common use within the period of data we assessed.

Additionally, we used the median (rather than the mean) of tons per acre of all burns within the district to minimize the impact of high outliers. Further, we smoothed this result across districts using the median of tons per acre estimates for all reported burns in adjacent surrounding districts during the study period.



PFIRS data, burn pile volumes and net weights were estimated using the R package called "mice" (aka, multiple imputation with chained equations), from the University of

Washington. Multiple imputations fit models based on complete records to find relationships with other variables. A district that tends to have other high values, will get a higher imputed value for another value than another district that's systematically lower. The R package "mice" runs through this process multiple times (5 iterations) and averages the runs to create a smoothed imputed result for each district, pile type, and vegetation category.

First, gross weights are estimated by selecting hand or machine piles, entering dimensions, species composition, number of piles, and one of seven stylized shapes. The gross weight is then converted to net weight by applying a packing ratio. This packing ratio, which can range between 10%-25%, is estimated using a relational diagram. The final step calculates particulate matter emissions by estimating percent consumption. These weights were applied to hand or machine piles to estimate the total tonnage of these types of piles.

The result of this part of the analysis produced an estimated weight for the 3 burn types (broadcast, hand pile, and machine pile) in each of the 3 broad vegetation types (forest, brush, and grassland) for each of the 35 air districts (CAL FIRE 2015). These results were joined with the results of the probability estimation to create a spatial dataset of fuels treatments with estimated probability of burn pile presence and estimated weight (tons) of burn piles.

Step 6: Accessibility of Piles

The results of the previous step were clipped to within 100 feet of known road networks (USGS 2023). The tonnage of these piles was summarized by ownership type (public, private), county, air district and broad vegetation type.

Part II: The Regulation of Intentional Anthropogenic Burning in California

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Introduction

There is broad consensus around the critical need to increase the pace and scale of ecosystem restoration and fire resiliency in California. Declining forest health conditions caused by a century of fire suppression and single-species harvest practices have left much of California's forests in an overstocked and overcrowded state[2,3]. These conditions combined with drought and other climate change impacts have led to a rise of high-severity wildfires and insect-induced tree mortality.

To meet this challenge, the California Wildfire and Forest Resilience Task Force (Task Force) has identified the need to scale up forest restoration activities to improve forest resiliency and help reduce wildfire risk. California and the USFS have set a goal of treating one million acres of forest land per year by 2025[4]. CARB also determined in its "2022 Scoping Plan for Achieving Carbon Neutrality" that advancing forest management practices that remove biomass (unwanted vegetation) to promote ecosystem resilience is a critical component of achieving carbon neutrality.

Typical forest restoration practices involve mechanical thinning or other vegetation treatments, and/or prescribed fire, to restore landscapes to more resilient conditions. In post-fire forests, or in landscapes that have experienced widespread tree mortality, dead tree or vegetation removal is often necessary as they can pose public safety hazards posed by dead trees located near infrastructure. Additionally, vegetation removal is often needed to accelerate reforestation processes.

While not all forests in California are overstocked, research has indicated that at least for dry conifer forests, density management goals need to be more intensive in order to adequately achieve desired resilient forest conditions.[5] With the contemporary increase and impacts of drought and wildfire, resilience in frequent-fire forests may hinge on creating stands with significantly lower densities and minimal competition, which will therefore generate large quantities of biomass waste material.

The goal of treating one million acres of forest land per year will require removal and subsequent disposal of at least an additional 5 – 15 million bone dry tons of forest biomass waste annually.[6] Without outlets for biomass material, it is often open-pile burned in the forest or left in large piles. While pile burning is a cost-effective method for land managers to dispose of unwanted forest biomass, it can result in smoke and other negative air quality impacts that could impact public health when they occur near populated areas. Furthermore, in some instances smoke from open pile burning may

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[2] https://wildfiretaskforce.org/wp-content/uploads/2022/04/californiawildfireandforestresilienceactionplan.pdf
[3] https://lhc.ca.gov/report/fire-mountain-rethinking-forest-management-sierra-nevada
[4] https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf
[5] North, M.P., Tompkins, R.E., Bernal, A.A., Collins, B.M., Stephens, S.L., York, R.A. (2022). Operational resilience in western US frequent-fire forests. Forest Ecology and Management, 507, 120004. https://doi.org/10.1016/j.foreco.2021.120004
[6] https://www.csgcalifornia.com/blog/state-and-federal-agencies-release-first-of-its-kind-biomass-utilization-strategy/

displace an air basin's capacity to accept large landscape-level prescribed fire projects near populated areas that are designed to improve ecosystem health and resiliency.

Therefore, if open pile burning is to be limited, this will create an even greater need for alternative uses of this material. Other higher end biomass utilization pathways for this material will help sequester carbon, minimize emissions and air quality impacts from burning, and allow for greater prescribed fire opportunities. This will require collaboration among state and federal agencies and air districts to identify strategies in advancing waste disposal options for forest biomass material.

To help state leaders understand the current fate of forest biomass, this report seeks to provide information about intentional anthropogenic burning, including open pile burning as a waste disposal method and prescribed burning. This report does not analyze accidental or intentional anthropogenic wildfires or lightning-caused wildfire impacts. While this overall project is funded by the Joint Institute for Wood Products Innovation and is intended to examine "open pile" burning specifically, we included prescribed burning because California air districts generally do not differentiate between the two in their regulatory oversight and data tracking—this will be discussed further throughout this report. For a full spatial analysis on quantifying burn piles statewide, see Part I of this report produced by Spatial Informatics Group titled "California Burn Pile Mapping and Quantification."

In summary, this report:

- Discusses the regulation of California's open pile burning and prescribed fire in forested settings by air districts, as well as by other entities such as CAL FIRE, local fire districts, cities, and counties.
- Provides statewide data pertaining to air quality burn permits issued by California air districts, including total acres burned, total tons per acre, and the degree to which requested burns are successfully implemented.
- Describes how air districts track and permit burning projects.
- Summarizes state program updates that are underway for tracking and permitting burns.

Section 1: Legal Context to Prescribed Burning and Historical Background

The Authority to Regulate Burning

Air pollution control districts (air districts) were created by the state of California as regional authorities that are subject to the powers and duties of CARB and the US EPA. Air districts must adopt and enforce rules and regulations to achieve and maintain the state and federal ambient air quality standards in all areas affected by emission sources under their jurisdiction, and shall enforce all applicable provisions of state and federal law.[7] Air districts have the power to pass their own rules to enforce and achieve their mandated goals.[8] The control of smoke emissions is within districts' purview and has been a part of the regulatory landscape in California since 1970 as part of the original requirements under prior Health and Safety Code Sections. A map of all air districts in California is included in Figure 1.

Figure 1. Map of all air districts in California (credit to California Air Resources Board)

[7] California Health and Safety Code 40001
[8] Id.

Local government, including special districts, generally have the authority to be more stringent than state law, unless the state "occupies the field."[9] The state occupies the field when it explicitly defines the spectrum of local authority in a given context through a statute or regulation. When a law is explicit about the breadth of local governmental authority, a local agency must be consistent with that law and cannot be more lenient or stringent.[10] Otherwise, state laws set the low bar for regulatory compliance so that local agencies can generally be more restrictive. This is important to consider when looking at the interplay of state, air district, county, city, and fire district burn rules.

According to the California Health and Safety Code governing open burning in the state, all burning activities are categorized into two main groups: non-agricultural or agricultural burning. Each has very different regulatory settings, thus it is important to understand which category encompasses the burning in question. It is important to note that the definition of prescribed burning is included under the definition of agricultural burning, which has resulted in much confusion among the public when using these terms. This will be discussed further in this report.

Public policy, as written in state laws, has tasked air districts and fire agencies with permitting since many who burn are not always knowledgeable about fire science and smoke management, thus permit programs have relevance and purpose in educating the public. Air district permits include important information about air quality conditions and reducing smoke. Fire agency permits include fire safety information and are issued for set time frames depending on where the burning is located. To set the context for burning in California, the categories of burning will be reviewed, followed by an explanation of the implications of these definitions.

Non-Agricultural Burning

In the case of regulating non-agricultural burning, California Health and Safety Code Section 41800 (adopted in 1975) states that, "Except as otherwise provided in this chapter, no person shall use open outdoor fires for the purpose of disposal or burning of petroleum wastes, demolition debris, tires, tar, **trees, wood waste,** or other combustible or flammable solid or liquid waste; or for metal salvage or burning of motor vehicle bodies." This section superseded an earlier Health and Safety Code.

This general prohibition on the use of burning as a waste removal process by the state is qualified by subsequent sections of the law. The first explicit exception to the general prohibition against burning includes some explicit circumstances, including the disposal of Russian thistle,[11] solid waste dumps in some narrow circumstances,[12] and three other situations including: 1) Burning for the disposal of the combustible or flammable solid waste of a single- or two-family dwelling on its premises; 2) Open outdoor fires

[9] Nolo Plain English Law Dictionary
[10] Id. Also see California Constitution, Article XI Sec. 7, and the Supremacy Clause of the United States Constitution.
[11] California Health and Safety Code 41809
[12] California Health and Safety Code 41808

used only for cooking food for human beings or for recreational purposes; and 3) the burning, in a respectful and dignified manner, of an unserviceable American flag that is no longer fit for display.[13] These narrow exceptions to the basic prohibition are subject to the interpretation of each air district. Many air districts interpret these exceptions very narrowly and may use other provisions of law that generally prohibit all open burning within their district. In conclusion, there are air districts and other government agencies such as municipalities or fire agencies that have eliminated some of the burning that was exempted under this section.

Residential "Backyard" or "Dooryard" Burning

As mentioned above, residential burning is defined as an "open outdoor fire for the disposal of the combustible or flammable solid waste of a single- or two-family dwelling on its premises."[14] Many air districts allow residential burning with no permit, some allow it through issuing a burn permit, some with a joint fire and air permit, while others or other county agencies have eliminated residential burning altogether. Note that the distinction between "one- or two-family dwelling" language in the statute is subject to interpretation. The urban or rural nature of an area plays an important role in this interpretation. Additionally, lot size can play a role in an air district's process of determining if a permit is required, because larger lots allow for more space between neighbors for smoke dispersal. Also, burns that are over 10 acres require an SMP, so smaller acre burns may or may not be regulated or require a permit, including residential burns.

Additionally, in 2004 CARB adopted an Airborne Toxic Control Measure (ATCM) for Residential Waste Burning to reduce emissions of toxic air contaminants from outdoor residential waste burning of "disallowed combustibles" within enclosed or partially enclosed vessels, such as incinerators or burn barrels, or in pits or piles on the ground.[15] The ATCM continued to provide for the burning of vegetation. While the focus of this report is mainly on pile burning and prescribed fire, a discussion of how residential burning is regulated is included in "Section 3: Air District Interviews" in Part II of this report.

Right of Way Clearance Burning

Another exception to the general prohibition is when public entities or utilities use outdoor burning for levee, reservoir, or ditch maintenance, if permitted by the air district and relevant fire agencies.[16] Such burning must take place on days that would otherwise allow for agricultural burning, and permission from the landowner must be obtained if burning is managed by a public agency occurring on private land to avoid claims of trespass, condemnation, or a "taking" under constitutional law. Note that if

[13] California Health and Safety Code 41806
[14] California Health and Safety Code 41806
[15] 17 CCR 93113
[16] California Health and Safety Code 41804.5. This is the only place in this Article where fire agencies are mentioned.

these burns are taking place at a designated waste disposal site, CARB approval is also needed.[17]

If burning to clear a right of way, levee, reservoir, or ditch is needed, a permit can be issued by the air district. The state statute goes into detail specifying how the material must be prepared for such burning. The district uses that language, in the conditional permit "as specified by the Air Pollution Control Officer having jurisdiction."[18]

Land Development Clearing

When a landowner is clearing land for residential or commercial purposes, including a home building site, a development, or conversion of timberlands, they may wish to burn vegetation. This third exception to the general prohibition has an additional state law requirement that air districts must have a rule in place to handle these requests.[19] It is noted that it appears most, if not all, districts do have a rule in place on this topic. Without an air district process in place to permit this type of burning, each burn project would need to get approval from the respective district's board with CARB approved criteria on a case-by-case basis.

Public Officer Exception

The final exception to the general prohibition under non-agricultural burning is the "public officer" exception. A public officer that is otherwise granted legal authority to start a fire can set or allow a fire to burn when such fire is necessary for several different purposes such as in an emergency, a teaching context for training government personnel, or to abate a disease or pest outbreak, all of which, and more, are described in the statute.[20] This means that the use of fire in these cases is allowed by law, and in most cases, does not need a permit. If there is a lack of urgency associated with a potential fire threat, as compared with an imminent threat, then the regular permit process generally provides enough time required to obtain an air district burn permit.

CAL FIRE Permits in State Responsibility Areas (SRA)

CAL FIRE issues burn permits for residential, non-agricultural burning and agricultural burning in SRAs (and Local Responsibility Areas if a contract is in place for them to provide such services pursuant to an agreement with the local agency) relating to the burning of brush, stumps, logs, fallen timber, fallows, slash, grass-covered land, brush-covered land, forest-covered land, or other flammable material.[21] CAL FIRE has three burn permit types: Residential Burn Permits (LE-62A), General Burning Permits (LE-5), and Broadcast Burn Permits (LE-7/8). Broadcast burn permits are used for prescribed fire, while general burn permits are used for pile burning greater than 4' x 4' in size, agricultural burning, and other non-agricultural burning. CAL FIRE burn permit requirements are broken down into Zone A and Zone B. Zone A includes Mono, Inyo, San Bernardino, Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Diego,

[17] California Health and Safety Code 41808
[18] California Health and Safety Code 41807
[19] Health and Safety Code Section 41802-41804
[20] California Health and Safety Code 41801; See also Section 13055.
[21] Public Resources Code 4423

and Imperial Counties. Zone B includes all other counties in California. Permits are required year-round in Zone A; whereas, in Zone B, permits are required from May 1 until CAL FIRE declares that hazardous fire conditions have abated for that year (PRC 4423).

This authority, however, does not usurp or remove the requirement for air districts to continue to satisfy its mandates to issue permits for non-agricultural burning.

Conclusion: The Extent of Non-Agricultural Burning is Limited

Generally, the state and air districts do not allow the use of outdoor burning for waste disposal given the associated particulate matter, toxic air contaminants, and carbon dioxide that are released in large quantities can have serious impacts on human health and the environment. The exceptions laid out above have been made available for each air district to use at their discretion, based on the geographic and climatological variations and population of their area. Despite these exemptions, in some cases burning is warranted, but the lack of an applicable exemption can make it difficult for an air district to approve a nonagricultural burn project.

Agricultural Burning

The state takes a more permissive approach to the use of open burning in agricultural settings. Health and Safety Code Section 41850 states that:

> "It is the intent of the Legislature, by the enactment of this article, that agricultural burning be reasonably regulated and not be prohibited. The state board and the districts shall take into consideration, in adopting rules and regulations for purposes of this article, various factors, including, but not limited to, the population in an area, the geographical characteristics, the meteorological conditions, the economic and technical impact of such rules and regulations, and the importance of a viable agricultural economy in the state."

Under this law, agricultural burning, including forest health-related prescribed fire is legal. Otherwise, it would be prohibited. It is also important to note that in 1970 the state developed agricultural burning requirements that included forest management or range management, though not identified specifically as prescribed burning.

The state defines "Agricultural burning" as open outdoor fires used in any of the following:

> "(a) Agricultural operations in the growing of crops or raising of fowl or animals, or open outdoor fires used in forest management, range improvement, or the improvement of land for wildlife and game habitat, or disease or pest prevention.
> (b) The operation or maintenance of a system for the delivery of water for the purposes specified in subdivision (a).
> (c) Wildland vegetation management burning.
>
> > (1) For purposes of this subdivision, wildland vegetation management burning is the use of prescribed burning conducted by a public agency, or

through a cooperative agreement or contract involving a public agency, to burn land predominantly covered with chaparral, trees, grass, or standing brush.
(2) For purposes of this subdivision, prescribed burning is the planned application and confinement of fire to wildland fuels on lands selected in advance of that application to achieve any of the following objectives:
(A) Prevention of high-intensity wildland fires through reduction of the volume and continuity of wildland fuels.
(B) Watershed management.
(C) Range improvement.
(D) Vegetation management.
(E) Forest improvement.
(F) Wildlife habitat improvement.
(G) Air quality maintenance.
(3) The planned application of fire may include natural or accidental ignition.
(Amended by Stats. 2004, Ch. 693, Sec. 1. Effective January 1, 2005.)" [22]

The placement of forest improvement and fire prevention, and generally open space management burning within the definition of "agricultural burning," may need a closer review from a policy perspective to promote increased use of beneficial prescribed fire on the landscape and because prescribed fire is a forest management tool, not a method for waste disposal as otherwise is typical in "agricultural" burning. It is important to note that this definition was changed in two separate Health and Safety Code Sections (39001 and 42311.2), and in two sections of the Public Resources Code Sections (4464 and 4475) so that there was consistency between the air and fire disciplines. This will be delved into more deeply in the Recommendations Section of this report.

Permitting Agricultural Burning (Including Prescribed Fire and Open Pile Burning in a Forest Setting)

State law sets out a general rule that agricultural burning requires a permit,[23] unless an air district has adopted a rule based on a finding by its board that agricultural burning does not significantly affect air quality in that district.[24]

The state legislature requires that CARB establish guidelines for regulation of agricultural burning, including prescribed fire projects.[25] The most recent amendment of those regulations was adopted in 2001 and is referred to as the "Smoke Management Guidelines."[26] This requires an air district to adopt a "Smoke Management Program,"

[22] Health and Safety Code 39011
[23] Health and Safety Code Section 41852
[24] Health and Safety Code Section 41852.5
[25] Health and Safety Code 41856 and 41859
[26] 17 CCR 80100 et. Seq.

under which those who want to burn, whether burn piles or prescribed fire-broadcast burns, can submit a SMP to the air district if required. Plans have specific state requirements for projects over 10, 100, and 250 acres in size. More specific detail related to these programs within pertinent districts is in “Section 3: Air District Interviews” of Part II of this report. Note that within this regulation, air districts are given the discretion to permit a burn on a CARB-designated “No Burn Day” when specific criteria are met for imminent and substantial economic loss (Health and Safety Code 41862).[27]

As mentioned above, Cal FIRE regulates fire safety permits for burning in SRAs.

State Regulation of Agricultural Burning by CAL FIRE

The Public Resources Code 4423 states that a person shall not burn in any SRA without a permit from CAL FIRE. The issuance of CAL FIRE agricultural burn permits, however, are “subject to the rules and regulations of the [local air] district,”[28] and air districts are tasked with reviewing permits with consultation from designated agencies.[29] There are also CAL FIRE regulations that apply to private landowners when they dispose of wood waste produced as a result of defensible space-related activities around their homes.[30] CAL FIRE has a permit process for private landowners wishing to implement pile burning as mentioned above.[31]

California Local Fire District Authority to Regulate Burning

Like air districts, fire districts also have statutes that govern their activities.[32] Specifically pertaining to burning, “If a fire district board has adopted regulations for the control of open fires, no person shall burn any material without a permit. A fire district shall not issue a permit to burn any material which would not be permitted by an air pollution control district or an air quality management district (AQMD), or any other state or federal agency.”[33] The extent of fire agency burn permit governance and authority should be referenced within the fire agency’s governing rule and ordinances and referenced within their burn permit.

As is demonstrated by this language, the legislature deemed that air districts have the responsibility to determine what materials can and cannot be burned by the public in order to continue to support its mandate to reduce public exposure to smoke. Also, based on this provision, the legislature understood that more than one permit may be required for open burning through both local air and fire districts.

Currently Title 17 allows air districts to designate fire agencies located within Local Responsibility Areas (as defined by state Law) as “Designated Agencies.”.[34] These local

[27] 17 CCR 80103
[28] 17 CCR 80120(f) ; District Smoke Management Program, Section 6(A).
[29] 17 CCR 80120(b)
[30] Public Resources Code 4290, Health and Safety Code 41802
[31] Public Resources Code 4491-4494
[32] Health and Safety Code Section 13860 et seq.
[33] Health and Safety Code Section 13874
[34] 17 CCR 80101 (j)

fire agencies (that have been approved by an air district and CARB) can issue permits consistent with their own enabling laws, and those permits are subject to form requirements and review by air districts under Section 80120 of Title 17. These forms are review by air districts to ensure that smoke management issues, apart from the fire safety aspects of the permit, are adequately addressed.

Local City and County Authority to Regulate Burning

Cities and counties have broad constitutional authorities to regulate land use for the benefit of public safety and welfare.[35] This allows such entities to establish ordinances that can limit or prohibit open burning within their jurisdictions. There is at least one local government within each of the 35 air districts that has a burn ban in place, generally in cities with small lots or populated centers. These laws reflect the wishes of residents to avoid smoke and risk of fire escape. Local government ordinances must always be reviewed for relevancy when assessing burn regulations.

US Forest Service Activities

A pivotal tool in understanding burning is the governing document "Air Quality on Wildland and Prescribed Fire (EPA, 1998)," which calls on the USFS to work with state and local agencies when conducting prescribed fire. This document directs public wildland managers to comply with a Smoke Management Program that is put in place, and states that "states and tribes may exercise enforcement authority over wildland owners/managers" when they violate an SMP. It also states that "there is a special need for fires by federal agencies to have burn plans that include smoke management components. Fires managed by federal agencies are most likely to impact air quality in recreation areas and impair the visibility in mandatory Class I Areas. The US EPA encourages federal agencies to include smoke management even in areas where there is no Smoke Management Program in place." Class 1 federal lands include areas such as national parks, national wilderness areas, and national monuments. These areas are granted special air quality protections under Section 162(a) of the federal Clean Air Act.

For reference, 40 CFR Section 51.307 requires the operator of any new major stationary source or major modification located within 100 kilometers of a Class I area to contact the Federal Land Managers for that area.

The general practice is that National Forests contact local air districts to collaborate on smoke management planning based on this direction from the EPA to do so.

Conclusion: Regulating Open Burning in California is Complicated

In any given location in California, a resident, property manager, or business must navigate the jurisdictional oversight and requirements for open burning for at least four regulatory bodies: the local fire agency, air district, city or county, and CAL FIRE. For example, a person could be in a community where CAL FIRE handles residential burning fire safety permits or that could be handled by the city or a fire district. In some locations air district permits are required for the same kind of burning that would not

[35] California Constitution, Article XI Section 7

require a permit within its neighbor air district. To determine if such permits might apply, the burner must investigate permit requirements on websites or make calls to local agencies. There is no single location to access the patchwork of burn information, burn rules, and definition of the different burn types. Fire safety and air quality are important values to communities, which is why there is so much focus on regulating burning. Moving forward, the administrative burden of managing a permit program should be weighed against the motivation to accomplish increased level of prescribed burn activities, while at the same time still achieving public health and safety values.

Section 2: Data Collection of Intentional Anthropogenic Burning Statewide

Introduction

Understanding *where* and *how much* anthropogenic burning is occurring in the state has potential impacts on several important policy issues as further discussed in "Section 5: Recommendations" in Part II of this report. To better understand how prescribed burning is occurring in California, the report investigated air district burn permit activity from July 2018 – June 2021, including the total acres burned, the reported tons per acre of biomass burned, and the success of burning based on burns requested vs burns completed. Answering these three questions can help build a snapshot of the degree of intentional anthropogenic burning occurring in the state. Illegal burning and unregulated burning are not accounted for in this analysis, but they are discussed in Sections 3 and 5 of Part II of this report.

For the purposes of this study, a "burn year" is July 1st – June 30th of the following year as burning typically ends in May or June.

This study includes a three-year window due to data availability and given the project's scope of work and budget. However, we acknowledge that this time frame included record drought conditions, extreme wildfire behavior, and the international COVID-19 pandemic, all of which may have affected prescribed fire efforts. Furthermore, inter-annual variability is the nature of prescribed burning in California, so any trends and conclusions made from this analysis should recognize that this study is only a snapshot in time.

At a statewide level, there is not a comprehensive database of all burning across all air districts, vegetation types, and years. There are three different potential sources of information: PFIRS, data collected manually by CAPCOA, and annual reporting air districts submit to CARB.

Three Data Sets Considered for Use

Prescribed Fire Information Reporting System (PFIRS)

Introduction

PFIRS is a web-based platform, originally created by the USFS in the 1990s and now operated and hosted by CARB. It is used for most of the SMP submittals for prescribed burning in the state and facilitates communication among CARB, air districts, burners, and other relevant personnel. By 2017, many SMPs and associated ignition requests went through the system, resulting in comprehensive data collection on SMPs, burn approvals, and emissions information. With the streamlined approach to data management for prescribed burning, PFIRS has become the primary data reporting method of choice among many air districts and land managers.

Most air districts require burn applicants to utilize PFIRS when submitting their SMP and subsequent burn ignition requests. Most of the districts will assist applicants if needed and have staff that are familiar with the program. Some districts began using PFIRS after 2018, including Amador, Antelope Valley, Bay Area, Imperial, Modoc, Mojave, North Coast Unified, Northern Sonoma, San Diego, San Luis Obispo, Ventura, and Yolo Solano. Overall, most entities and state agencies involved, including CAL FIRE, air districts, and CARB, agree that a shift to all air districts using PFIRS is needed.

To submit an SMP, the applicant creates a PFIRS account. Once approved, an SMP with the required information is entered, including the total acres of burning planned, estimated tons per acre based on vegetation to be burned, estimated emissions, vegetation type, burn type (such as broadcast burn vs pile), and burn location. This information comprises the required parts of the SMP needed and is submitted to the air district. Once an SMP is approved a burn permit issuance follows in some districts.

One unique example for streamlining burn permits is at the Mendocino County AQMD, where staff use their own submission portal for applicants to request a burn, and then the air district staff take that information and input it into PFIRS to generate burn requests. By doing this, Mendocino generates a “global SMP” for the burn season, with close to 50-60 separate burns that the air district manages, thus the burn permit applicants do not submit individual SMPs.

PFIRS has embedded worksheets to aid applicants in calculating estimated emissions, PM10 (particulate matter 10 microns in size and smaller), from a planned burn, both from piles and from broadcast burns (See Appendix A.). These calculations are derived from USFS General Technical Report PNW-GTR-364 (for pile burns), USFS Air Resources “Air Quality Conformity Handbook,” or the US EPA Document AP-42 “Compilation of Air Pollutant Emissions Factors. Volume 1: Stationary Point and Area Sources.” Most air districts that use PFIRS have burn applicants calculate anticipated emissions using these worksheets. As will be discussed in “Section 3: Air District Interviews” of Part II of this report, several air districts shared that the USFS and CAL FIRE are comfortable calculating emissions from their own burns, and air districts often will support private landowners with their calculations using resources provided on PFIRS or from other sources. As scrutiny increases on the impacts of smoke on air quality, more emphasis and understanding about associated emissions will likely be needed.

PFIRS Data Collection Methods

Staff at CARB that manage PFIRS provided us with PFIRS datasets for each burn year of interest (2017 – 2021), from which we were able to extract data for this study, including total acres of forest biomass burned per year by each air district, tons of biomass per acre, and the burning success rate (acres requested vs acres burned).

PFIRS data were summarized with respect to the total number of acres burned for all burn types and all fuel types except grasslands for the relevant burn years in each analysis. In a small number of cases, entries sharing identical information regarding

location, date, acres burned, and acres requested were assumed to be duplicates and were removed.

However, many air districts did not start using PFIRS until 2019 or later, so solely relying on PFIRS data does not give an adequate representation of statewide burning. Thus, while PFIRS is the best available comprehensive dataset for prescribed fire in California, we acknowledge that it is still an incomplete dataset.

Additionally, according to a CAL FIRE Memo from 2019 (Appendix B), when CAL FIRE is the lead agency on a burn project, they do not input information into PFIRS on pile burns from waste disposal activities. While acreage of a prescribed fire is recorded in PFIRS, pile burning for waste disposal is recorded in the CAL FIRE Management Activity Project Planning and Event Reporter (CalMAPPER), and *not* into PFIRS. This approach does not impact the total number of acres burned, but it could impact emissions-related data veracity. As this report does not do an emissions inventory, this CAL FIRE practice does not impact results, but should be noted for further work that may continue after this effort.

CAPCOA Interview Data

CAPCOA is a non-profit association consisting of the air pollution control officers from the 35 local air districts throughout California that seek to share knowledge, experience, and information. CAPCOA sponsors training opportunities, shares information with air districts and with the public, coordinates efforts to develop rules and ensure consistent application of rules and regulations with state and federal air quality officials, and actively participates in the development and implementation of legislation that speeds progress toward improved air quality and streamlined laws.

The passing of California Senate Bill-1260 funded the 2019 Prescribed Fire Smoke and Monitoring Program, managed by CARB, for smoke monitoring and research to help optimize prescribed burn programs across California. CAPCOA received grant funding from this program to collect data from air districts on burn information and fill in gaps in existing reporting systems, such as from PFIRS, so that updated data on burning is readily available.

CAPCOA collected burn data from 2019 – 2021, specifically on the number of burns and acreage burned. It did not collect data on tons per acre or burn success rates (the amount of burning completed that was reported, relative to the burning requested). Some entries in the CAPCOA data include details on vegetation type, such as slash piles, shrubs, or grassland. For analyses using CAPCOA data, specifically the total acres burned analysis, data on grassland burning was removed. For more detail on how grassland burns were removed from data, see the Statewide Acres Burned Analysis in Section 3 of Part II of this report.

Based on interviews with air districts, CAPCOA had a reasonable basis to estimate some acreages, particularly for districts with limited staff and limited internal data tracking capacity, including those that have not been using PFIRS. For some of these

districts, the data collected by CAPCOA is the best available data for burning and it is therefore included in this assessment. For example, in the Monterey Bay Air Resources District, there are several abandoned military bases with burning activities that are not entered in PFIRS, so CAPCOA, in consultation with the air district, made educated estimates on acres burned for that region. CAPCOA data included all PFIRS data (except for North Coast) with adjustments made where district records show PFIRS is not accurate or is missing burns that are in district records. CAPCOA data was relied on for the Modoc, Monterey, North Coast, Lake, San Joaquin, and Northern Sierra air districts.

Another data set collected by CAPCOA that will be discussed further in Section 3 of Part II of this report is an assessment of denied burns across all air districts from 2019 – 2021 using data in PFIRS provided by CARB staff. This data shows instances when a request to burn on any given day was denied by the air district after a permit was issued or an SMP was approved (if required). We confirmed this data during air district interviews, and results of this work can be found in “Section 3: “Burn Denials” of Part II of this report.

Title 17 Agricultural Burn Reports to CARB

CARB requires through Title 17 Section 80130 that all air districts submit a report of agricultural burning (including prescribed burning) by February 15 each calendar year. The reports must estimate acreage, type of burning, and emissions estimates if available from open burning in agricultural operations (note that the state definition of agricultural burning includes bona fide agricultural burning, forest management, range improvement, and wildland vegetation management burning operations). Reports list counties where burning occurred and are also required by CARB to report when burns were authorized on a CARB “No Burn Day.”

The data provided by CARB staff for this report was from 2018-2021. It contained 500+ separate data tables in many different formats and contained many data entry issues. Data mining techniques were used to identify relevant data fields and extract dates and location information. Keywords were used to identify vegetation types to parse out forest-related burning from agricultural burning. Even with such efforts, the data was sporadic and inconsistent. CARB data did not prove to be useful when analyzing the amount of forest-related “agricultural burning” permitting that occurred.

One aspect of the CARB required Agricultural Burn Reports that is interesting and may prove useful for future analysis is that these reports could be used to estimate emissions from *non-forest* prescribed burn-related agricultural burning, although there is still some confusion between those sources in some air districts.

Three Statistics that Describe Intentional Burning

To determine total acres of intentional forest-related burning in California, the number of burn permits secured for burning activities within each air district was collected. The nature of burn permits, however, is to allow burning any time otherwise not prohibited by

a fire agency, CARB, or the air district. Once a burner has an approved SMP and/or permit, they check in to the respective district to find out if it is a burn day or they submit an ignition request to obtain permission for burning. The number of burn permits does not necessarily reflect the actual burn acres. PFIRS asks burners to complete the required after-burn follow-up reporting in order to track actual acres burned. Additionally, this follow-up by the burners should include the amount of tons of biomass per acre being burned on average, as well as how many burns were planned and carried out versus planned and never accomplished. Each of these will be discussed.

Tons of Biomass Burned Per Acre Analysis

Introduction

Given the large quantities of biomass material in California that needs to be removed from forested regions, and because is expensive to remove and has low economic value, fire is often relied upon as a waste disposal mechanism. To better understand the quantity of biomass disposed of in burn pile operations, PFIRS data was assessed looking at the biomass tons per acre burned from summer 2017[36] – summer 2021, as burners must submit an estimated tonnage of biomass for their planned burn. PFIRS data is the best available resource for biomass tons per acre burned as it is not included in CAPCOA data and reporting is inconsistent in CARB Annual Reports. Thus, this assessment was only done for air districts that have data in PFIRS for the period in question. It is important to note that all data from PFIRS is entered by the user; therefore, the estimated biomass per acre could vary highly from project to project.

Methods

All PFIRS burn data from 2017 – 2021 that included biomass tons per acre accounted for 1,775 separate burns. Some air districts did not start using PFIRS until 2021, so the data may not accurately represent the full spectrum of burning in districts. These air districts include Amador, Antelope Valley, Bay Area, Imperial, Modoc, Mojave, North Coast Unified, Northern Sonoma, San Diego, San Luis Obispo, Ventura, and Yolo Solano.

Furthermore, this tons per acre analysis included an additional year of data (2017-2018) that the other analyses in this report did not because the data on tons per acre were not normally distributed (meaning the data lacked symmetry and contained extreme values). Including an additional year of data allowed the statistical method used (a bootstrap analysis, defined below) to perform better.

Data on biomass tons per acres reported by burners was not normally distributed, and sample sizes and variation were extremely uneven between groups. The numbers of projects reported ranged from five treated areas among six air districts to well over 100 areas treated in another six districts. For example, the El Dorado air district reported

[36] An additional year of data (2017-2018) was included in the tons per acre analysis due to limited data for the general time period in question (2018-2021).

349 treated areas with tonnage during the study period while the Modoc air district reported five.

To address this issue and to provide a more accurate representation of variation and allow for a more robust comparison of differences in the data, we used a bootstrap analysis to examine biomass tons per acre data and construct confidence intervals around estimates. Bootstrap analysis is a statistical technique commonly used to estimate the sampling distribution of a statistic by repeatedly sampling with replacement from the original dataset, particularly in a situation where traditional statistical methods are not feasible or reliable, such as a small sample size, an unknown, or non-normal population distribution; when there are outliers; or when the statistical model is complex. By resampling the data, bootstrap analysis allows us to robustly estimate the variability of the tons of biomass per acre statistic and to make inferences about it with less introduction of bias due to outliers and without requiring assumptions about the underlying distribution of the data.

To construct bootstrap intervals, PFIRS data for all treatment areas for the study period of fall-2017 through spring-2021 (excluding grasslands) were resampled with replacement 2,500 times. For each bootstrap sample, biomass tons per acre were calculated as the total of all tons reported divided by the sum of acres reported. Final point estimates were taken as the median of all estimates from the 2,500 bootstrap samples and 90% confidence interval limits were taken as the 5th and 95th percentiles of estimates from the 2,500 bootstrap samples.

We found that the statewide average biomass burned is 12.9 tons per acre. The results of this analysis are illustrated in Figure 2 and Table 1. Cases where confidence intervals do not overlap with the statewide average of 12.9 tons per acre can be assumed to be significantly different from the statewide average at the 90% confidence level.

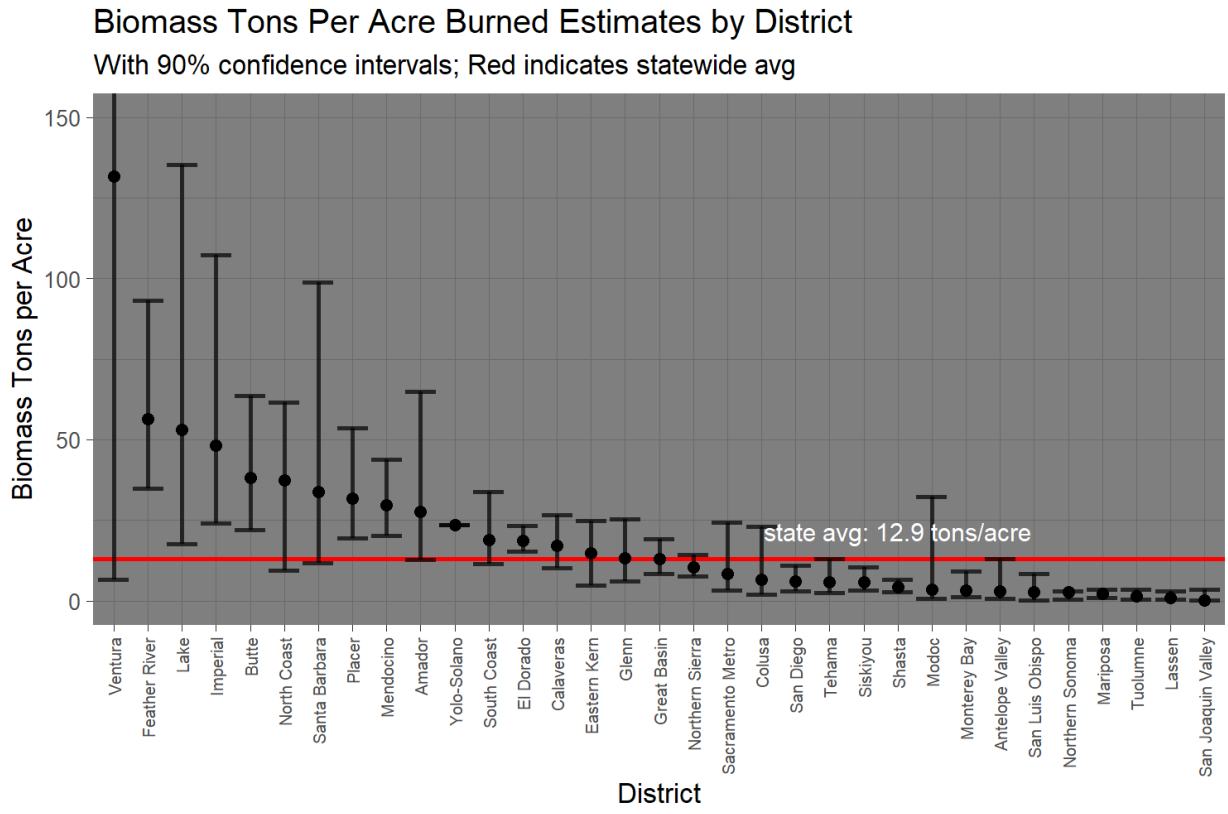

Figure 2. Variation in statewide estimates of biomass tons burned per acre, by air district.

Biomass tons per acre estimates for many air districts were too high to plot on the above chart without making it difficult to interpret variation around the normal ranges for other air districts. Therefore, data for cases where the biomass tons per acre estimate exceeded 100 tons per acre are truncated on the chart above and presented fully in Table 2 below. In many cases, these examples are likely outliers because estimates are based on relatively fewer number of reported burns, such as in Ventura where there are 131.6 tons per acre on average, but for only three burns reported with tons per acre estimates total. However, some air districts (i.e., Butte, El Dorado, Feather River, Placer, and Santa Barbara) still have potential outliers for tons per acre estimates with more than five reported burns (see rows in **bold** in Table 2). Some possible scenarios for this variation could include burning happening at locations with high biomass tonnage per acre, or more specific scenarios such as large quantities of biomass were hauled to a large waste disposal site where it was later burned. Generally, it is not allowed to haul biomass across parcel boundaries, but in some cases biomass is moved within very large tracts of land to be burned in one central location.

Overall, there is some significant variation in reported tons per acre data among some air districts. Air districts with very few burns (less than five) reported with tons per acre over the study period that had extremely high biomass tons per acre estimates or extremely wide ranges in the 90% confidence interval should be interpreted cautiously—see Table 2. These numbers were calculated by the person entering the

burn into PFIRS or into whatever other system an air district was using at the time. Thus, there could be variation in the total tons per acre entered based on who is entering the data.

Table 1. Air district-level biomass tons per acre estimates with lower and upper 90% confidence intervals and number of burns from fall 2017 – spring 2021.

Air District	Tons Per Acre	Low 90% Confidence Interval	Upper 90% Confidence Interval	Total number of burns reported with tons per acre data
Amador	27.63	12.68	64.85	17
Antelope Valley	2.96	0.76	12.98	12
Butte	38.07	21.99	63.71	59
Calaveras	17.02	10.16	26.66	119
Colusa	6.6	2	22.94	12
Eastern Kern	14.88	4.66	24.72	6
El Dorado	18.73	15.28	23.15	349
Feather River	56.31	34.72	93.19	81
Glenn	13.28	6.08	25.39	15
Great Basin	12.92	8.46	19.14	86
Imperial	48.12	24.1	107.23	7
Lake	53.12	17.74	135.22	12
Lassen	0.89	0.3	3.04	13
Mariposa	2.22	0.97	3.54	9
Mendocino	29.66	20.14	43.95	124
Modoc	3.51	0.78	32.3	5
Monterey Bay	3.34	1.17	9.18	34
North Coast	37.35	9.38	61.67	4
Northern Sierra	10.42	7.48	14.34	220
Northern Sonoma	2.65	0.39	2.95	2
Placer	31.76	19.51	53.52	142
Sacramento Metro	8.32	3.36	24.32	9
San Diego	5.96	3.09	10.89	40
San Joaquin Valley	0.16	0.03	3.6	2
San Luis Obispo	2.79	0.18	8.38	6
Santa Barbara	33.78	11.75	98.68	31
Shasta	4.21	2.72	6.7	101
Siskiyou	5.81	3.17	10.34	86
South Coast	19	11.34	33.8	86
Tehama	5.92	2.49	13.05	49
Tuolumne	1.49	0.43	3.58	33
Ventura	131.62	6.49	400	3
Yolo-Solano	23.61	23.61	23.61	1

Table 2. Data for cases from 2017 – 2021 where the biomass tons per acre estimate exceeds 100 tons per acre. Many of these are likely outliers because estimates are based on a small number of burns, except for **bold** rows where more than five burns are reported.

Air District	Fuel Type	Burn Type	Tons per Acre	Lower 90% Confidence Interval	Upper 90% Confidence Interval	Total number of burns reported with tons per acre data
Antelope Valley	natural	hand	105	105	105	1
Butte	**natural**	**hand**	**183.33**	**62.55**	**616.25**	**11**
Butte	natural	machine	229.53	79.22	712.67	2
Calaveras	slash	hand	118	118	118	1
Colusa	brush	hand	246.13	246.13	246.13	1
Colusa	natural	hand	236.2	19.97	1063.55	5
El Dorado	**brush**	**hand**	**582.43**	**325.03**	**961.33**	**21**
El Dorado	**slash**	**broadcast**	**134.74**	**58.33**	**250.95**	**11**
Feather River	natural	machine	153.67	24.18	201	4
Feather River	**slash**	**machine**	**607.88**	**387.69**	**893.42**	**31**
Lake	slash	hand	278.4	118.05	380.83	2
Mendocino	brush	machine	112.1	80	144.2	2
Mendocino	natural	hand	225.71	134.73	642.3	4
Monterey Bay	natural	hand	233	233	233	1
Monterey Bay	slash	machine	351.68	153.25	455.62	2
Placer	**brush**	**hand**	**244.63**	**143.69**	**473.75**	**29**
Placer	**natural**	**machine**	**254.89**	**152.5**	**350.83**	**9**
Placer	slash	broadcast	173.41	106.95	243.9	3
Santa Barbara	**brush**	**hand**	**448.44**	**160.35**	**2294.65**	**7**
Santa Barbara	natural	hand	190.21	152	381.28	2
Santa Barbara	**slash**	**hand**	**281.88**	**45.27**	**678.86**	**9**
South Coast	natural	hand	145.79	37.67	201.37	5
Tehama	brush	broadcast	463.33	386.76	544.41	2
Tehama	slash	machine	128.96	128.96	128.96	1
Ventura	slash	hand	291.21	282.85	400	2

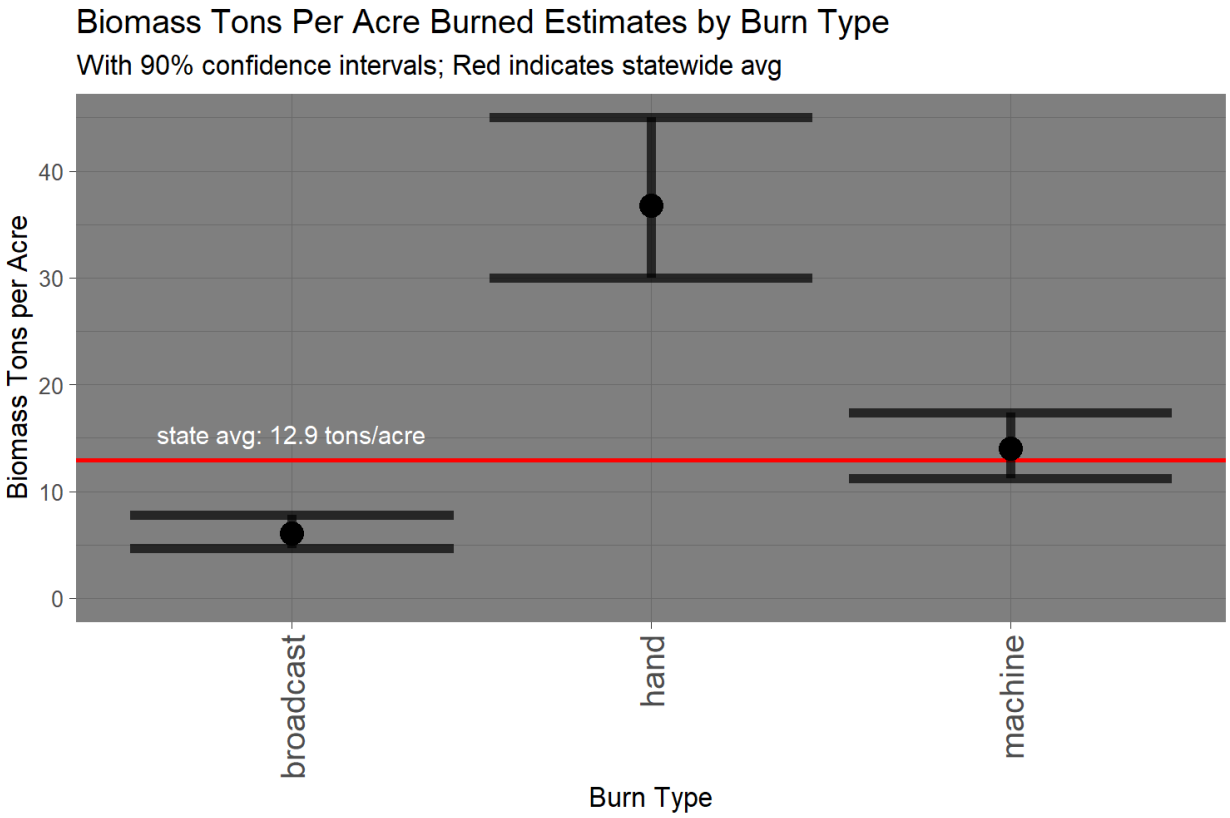

Figure 3. Variation in statewide estimates of biomass tons per acre by burn type.

Figure 3 shows that, on average, hand piles are reported to have more tons of biomass per acre burned reported to PFIRS than the state average of 12.9 tons per acre and compared to other burn pile types (machine piles and broadcast burns). These cases do not overlap with the statewide average and can be assumed to be significantly different.

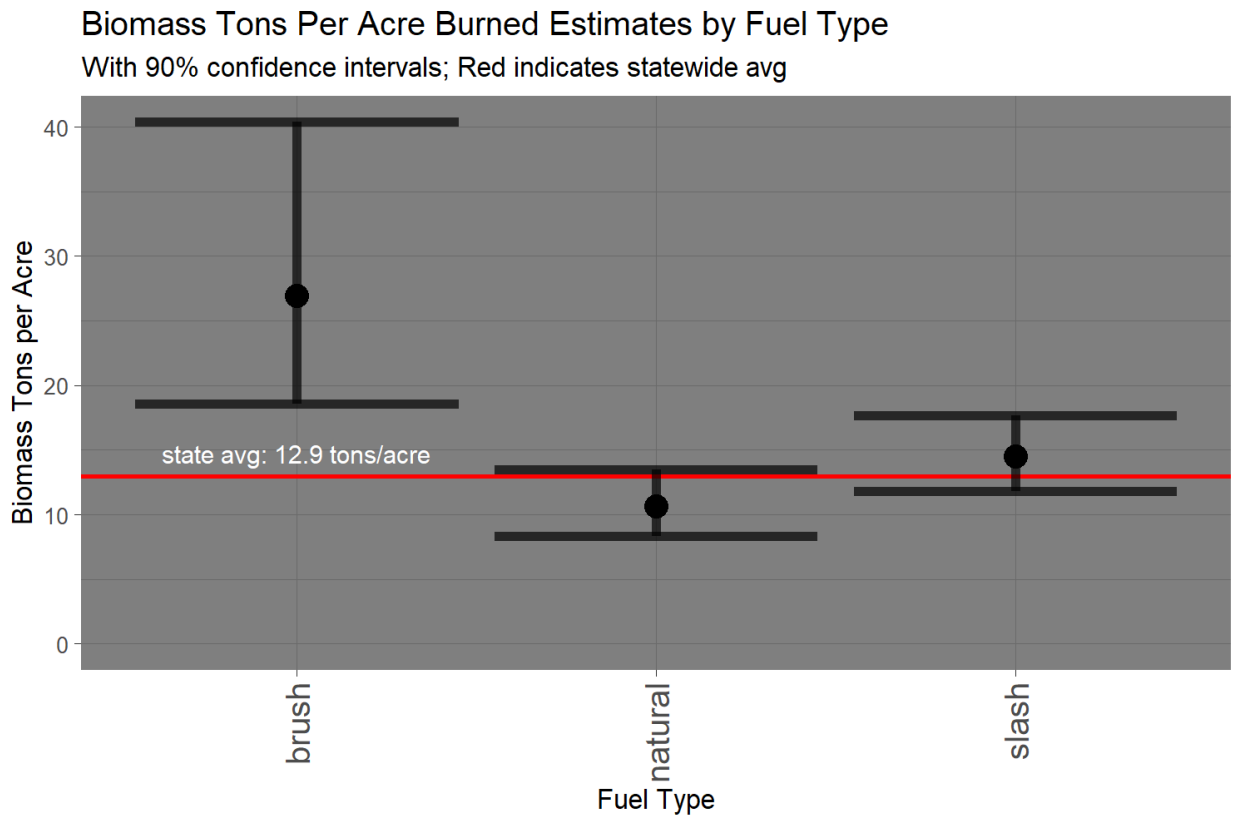

Figure 4. Variation in statewide estimates of biomass tons per acre by fuel type.

Figure 4 shows pile burning involving brush as a fuel type has more tons of biomass per acre reported to PFIRS on average compared to slash (woody material leftover from forest management activities, including treetops, limbs, and small diameter trees) and "natural" fuel types— a combination of all fuel types. Furthermore, all data on brush fuel type is above the statewide average of 12.9 tons per acre.

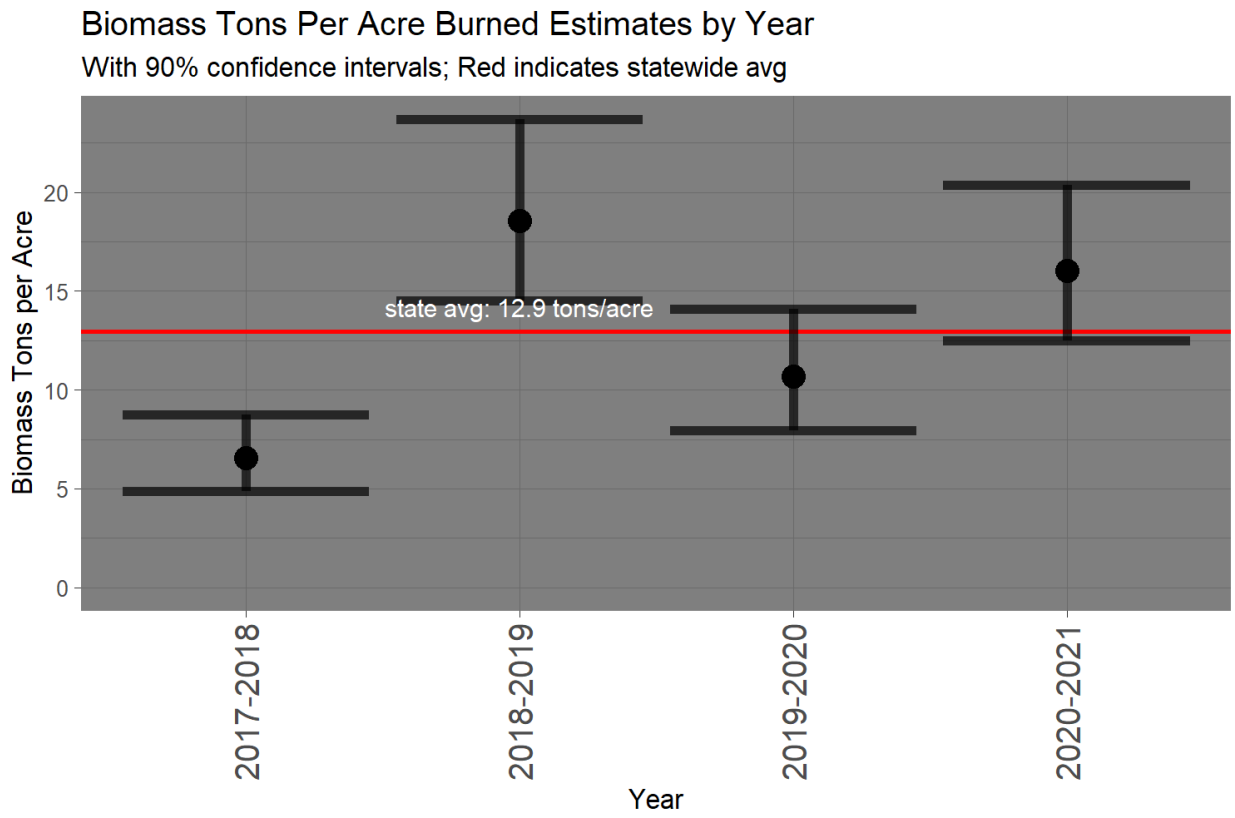

Figure 5. Variation in statewide estimates of biomass tons per acre by burn year.

The reported biomass tons per acre to PFIRS was the highest from 2018-2019 on average and lowest from 2017 – 2018. One possible explanation for low reported tons per acre from 2017 – 2018 could be due to lower usage of PFIRS relative to subsequent years.

Conclusion

The results demonstrate that the statewide average of biomass burned is 12.9 tons per acre. In some locations there is likely more burning due to pile burning occurring within the prescribed fire treatment. Projects with a lower-than-average statewide burn rate could be in locations that have experienced a wildfire or regular treatments. Also, prescribed fire in “brush” vegetation areas always produce more biomass than forested areas.

This analysis also demonstrated some significant variation in reported tons per acre among air districts. An important caveat for interpreting results from this analysis is that all PFIRS data is user reported. Thus, the wide variation of results in the tons per acre analysis demonstrates that the PFIRS platform could benefit from standardized tons per acre or tons per pile estimates that users could easily select based on their project and environmental factors in their region. Continuing with the existing approach that yields such wide ranges of tons per acre could make conducting emissions estimates statewide more challenging for state officials.

Burning Success Analysis

Introduction

A metric to better understand the amount of burning occurring in California beyond the total acres burned is to analyze the burn success rate—that is the ratio of acres planned for burning to the amount of burning that occurs. By doing so, we can better identify potential issues around burning capacity across air districts. The data used in this section was reported by burners after the burn. It is likely that some post-burn reporting is not completed; therefore, underreporting is likely occurring within this data set. It is also very likely that there is ample burning occurring that is not reported to databases, so this success rate does not capture overall burning success statewide. Nevertheless, the data seemed worth consideration for general understanding of burning.

When a burner submits an SMP for a planned burn(s) into PFIRS, they provide the total acres of the planned burn(s). However, not all burners log back into PFIRS after the burn to confirm the total acres that were completed. For example, a burner may only be able to complete half of the proposed burn due to staffing or weather conditions, and the second half of the burn may be postponed.

Methods

We utilized PFIRS data only to analyze the total number of burn requests for our study period. Since some air districts have only recently begun utilizing PFIRS, not all districts are included in our assessment; therefore, the results are not necessarily representative of burn success in Amador, Antelope Valley, Bay Area, Imperial, Modoc, Mojave, North Coast Unified, Northern Sonoma, San Diego, San Luis Obispo, Ventura, and Yolo Solano air districts.

CARB staff advised that while there is some variability in requests versus amounts of burning accomplished, the maximum burn request acreage should be used to infer the intended acreage to be burned for a specific site(s) within a burn year as per an approved SMP. However, upon further investigation, the PFIRS data on burn requests is complex. The “acres requested” field often appears to be the acreage intended to be burned that day, rather than the total acres intended to be burned for that location in a year. This data entry practice, which is required as part of the Title 17 Smoke Management Guidelines, was confirmed as being common during conversations with air district staff. Thus, using the maximum request values for calculating the seasonal burning success rate, as suggested by CARB staff, could vastly underestimate the seasonal goal for data entered as a sequence of daily entries.

We calculated seasonal goals of a burner by taking the sum of all daily requests and inspecting examples of burn histories. It was generally obvious whether they reflected a daily or a seasonal goal for burning (See Table 3.). However, with the volume of data, it was neither practical nor ideal to rely on a non-repeatable manual method to identify burning goals; consequently, we created an automated process to identify daily vs seasonal goals.

The PFIRS report for the three burn seasons from 2018-2021 received from CARB, contains data for 6,635 individual burn days (non-grassland with known vegetation and burn types) that occurred on 1,922 unique burn sites. Of these sites, 1,762 had complete data on both acres burned and acres requested and could be analyzed. At 856 of these sites, all annual burning occurred on a single day and was not affected by the data entry issue mentioned above. The other 906 sites did fall into the data issue mentioned above, so the automated process (described below) was used to glean meaningful information from these sites.

Classifying Acreage Ignition Request Types
To classify whether the burn ignition requests entered into PFIRS reflected daily or seasonal goals, a combination of unsupervised and supervised learning methods was used to create an algorithm to automate the classification process for the 906 burn sites with more than one burn day. We used several statistics to identify key relationships between acres burned and acres requested for the days that burning occurred at each site.

Site statistics that proved the most useful in this process to differentiate daily or seasonal burn requests included the:

- ratio of total acres burned at a site to the sum of acres requested for that site.
- ratio of total acres burned at a site to the maximum value of acres requested for a site.
- average differences between burns and requests over all days normalized by the average of acres requested.
- proportion of days where acres burned equaled acres requested.
- proportion of days where acres burned exceeded acres requested.
- degree of correlation between actual burns and burn requests.

We used these statistics in conjunction with an unsupervised learning algorithm called K-means clustering to efficiently create a set of training data for a machine learning model that could automate the process of classifying sites in terms of whether the entered burn requests reflected a daily or seasonal goals.

Statistics were calculated for each burn location with more than one burn day. K-means clustering identified nine clusters of site types that were similar to each other with respect to the statistics listed above.

A small random sample of sites from each of these nine clusters were then reviewed manually to determine whether clusters were comprised of sites using daily or seasonal request methods. Eight of the clusters were almost exclusively comprised of examples of either the “daily request” or “seasonal request” types and the same request type was then applied to all members of that cluster. The ninth cluster contained 89 burn sites and was much more mixed in terms of daily vs seasonal request methods. Sites in this cluster were not included in the dataset to train the classification algorithm.

With the request types assigned in this manner to sites in the eight relatively pure clusters, we then used the sites from those clusters to train a random forest machine learning algorithm[37] to create a model to assign classifications to all sites in a uniform and repeatable manner. The resulting model was also used to classify request types for sites in the "ninth" cluster mentioned above. Manual review of the results of this process indicates that it works well and is advantageous over manual classification because it is scalable and repeatable on new datasets if the challenge of consistently assigning acreage request types persists.

Table 3 shows several representative examples of the results of this process, including "burn success" (the ratio of acres burned to acres planned) based on each specific burn ("Burn #"). For each example, the final modeled request type is provided as well as both the daily and seasonal types of Acres Requested estimates and the resulting success rates based on each method. Results from the correct method in each example are indicated in **bold** font. The Burn Success columns illustrate the dramatic impact on success rates of using the incorrect method to calculate Acres Requested.

A complete table is available as Appendix C of Part II of this report, with all cluster assignments and final assignments for daily or seasonal requests made by the machine learning model. Table 4 shows the total daily, seasonal, or a blend of daily/seasonal acres requested by each district on which the automated classification was performed.

Table 3. Example of results from the classification process, showing if an air district uses a daily or seasonal goal for reporting acres requested.

											Acres Requested		Burn Success	
Air District	Year	Latitude	Longitude	Burn Date	Acres Burned	Acres Requested	Burn #	Cumulative Burn	Modeled Request Type	Total Acres Burned	Daily Request	Seasonal Request	Daily Request	Seasonal Request
Monterey Bay	2020-2021	36.27	-121.192	6/21/2021	62	77	5	62						
Monterey Bay	2020-2021	36.27	-121.192	6/22/2021	80	65	5	142						
Monterey Bay	2020-2021	36.27	-121.192	6/23/2021	66	65	5	208						
Monterey Bay	2020-2021	36.27	-121.192	6/24/2021	60	65	5	268						
Monterey Bay	2020-2021	36.27	-121.192	6/25/2021	56	67	5	324	daily	324	**339**	77	**0.96**	4.20
Siskiyou	2020-2021	41.928	-122.829	12/17/2020	38	40	5	38						
Siskiyou	2020-2021	41.928	-122.829	1/4/2021	13	40	5	51						
Siskiyou	2020-2021	41.928	-122.829	1/14/2021	13	12	5	64						
Siskiyou	2020-2021	41.928	-122.829	1/21/2021	6	6	5	70						
Siskiyou	2020-2021	41.928	-122.829	2/24/2021	6	6	5	76	daily	76	**104**	40	**0.73**	1.90
El Dorado	2019-2020	38.619	-120.237	11/26/2019	0	500	5	0						
El Dorado	2019-2020	38.619	-120.237	11/27/2019	0	500	5	0						
El Dorado	2019-2020	38.619	-120.237	12/2/2019	200	200	5	200						
El Dorado	2019-2020	38.619	-120.237	12/16/2019	150	200	5	350						
El Dorado	2019-2020	38.619	-120.237	12/17/2019	150	200	5	500	seasonal	500	1600	**500**	0.31	**1.00**
Siskiyou	2018-2019	41.312	-122.196	11/27/2018	150	378	5	150						
Siskiyou	2018-2019	41.312	-122.196	11/28/2018	80	309	5	230						
Siskiyou	2018-2019	41.312	-122.196	12/3/2018	45	69	5	275						
Siskiyou	2018-2019	41.312	-122.196	12/4/2018	20	24	5	295						
Siskiyou	2018-2019	41.312	-122.196	12/10/2018	4	4	5	299	seasonal	299	784	**378**	0.38	**0.79**

[37] A random forest algorithm is an ensemble-based machine learning algorithm that leverages decision trees to classify input data or make predictions. Random forests are effective in improving the accuracy and robustness of the classification or prediction task as the combination of multiple trees helps to overcome the limitations of individual trees, such as overfitting or underfitting. The algorithm introduces randomness in both the feature selection and the data sampling processes to promote diversity and prevent over reliance on specific features or data points, respectively.

Table 4. Total acres by the modeled request type for each air district – from PFIRS data

Air District	Daily Request - Acres	Seasonal Request - Acres	Single Day Burn Request - Acres	Blended Request Type - Acres	Total Acres Requested	Percentage of Acres as Blended Request Type
Amador	1126	391	115	0	1632	0
Antelope Valley	4	5	284	0	293	0
Butte	352	314	706	103	1475	0.07
Calaveras	1328	510	1676	714	4228	0.17
Colusa	508	4	432	0	944	0
Eastern Kern	44	2	13	0	59	0
El Dorado	5205	3392	1720	75	10392	0.01
Feather River	445	772	312	20	1549	0.01
Glenn	291	0	93	0	384	0
Great Basin	576	2240	1728	70	4614	0.02
Imperial	0	111	36	0	147	0
Lake	322	0	135	0	457	0
Lassen	1015	115	392	0	1522	0
Mariposa	39	110	466	166	781	0.21
Mendocino	9428	682	277	103	10490	0.01
Modoc	161	824	30	0	1015	0
Monterey Bay	1496	9037	193	5133	15859	0.32
North Coast	104	0	0	0	104	0
Northern Sierra	3028	1844	2917	102	7891	0.01
Northern Sonoma	98	0	0	0	98	0
Placer	3046	1498	691	89	5324	0.02
Sacramento Metro	0	155	0	0	155	0
San Diego	2406	306	2503	458	5673	0.08
San Joaquin Valley	0	0	10	0	10	0
San Luis Obispo	0	104	582	0	686	0
Santa Barbara	177	24	420	0	621	0
Shasta	3877	2123	9750	2089	17839	0.12
Siskiyou	1896	1674	3035	0	6605	0
South Coast	1197	1090	595	935	3817	0.24
Tehama	1907	1550	1950	0	5407	0
Tuolumne	6574	1115	4043	0	11732	0
Ventura	20	13	1	0	34	0
Yolo-Solano	0	65	0	0	65	0

Analysis of Burning Success Rates
With all sites consistently classified in terms of how to interpret acres requested information, we were then able to calculate a more representative acres requested statistic using the correct method for each site (i.e., taking either the sum or the max of requests) and thus determine success rates by dividing the amount actually burned by acres requested. In other words, the success rate is the sum of acres burned divided by the sum of acres requested.

To generate robust confidence intervals and allow meaningful comparisons of burning success rates between air districts and with other values of interest, we performed a bootstrap analysis in which we resampled the dataset with replacement in 2,500 replicate samples and calculated each district's success rate from each replicate sample. The estimate for each air district's success rate was taken as the median of the 2,500 resulting bootstrap estimates. The lower and upper bounds of the 90% confidence interval were taken, respectively, as the 5th and 90th percentiles of the bootstrap estimates for each air district.

Results

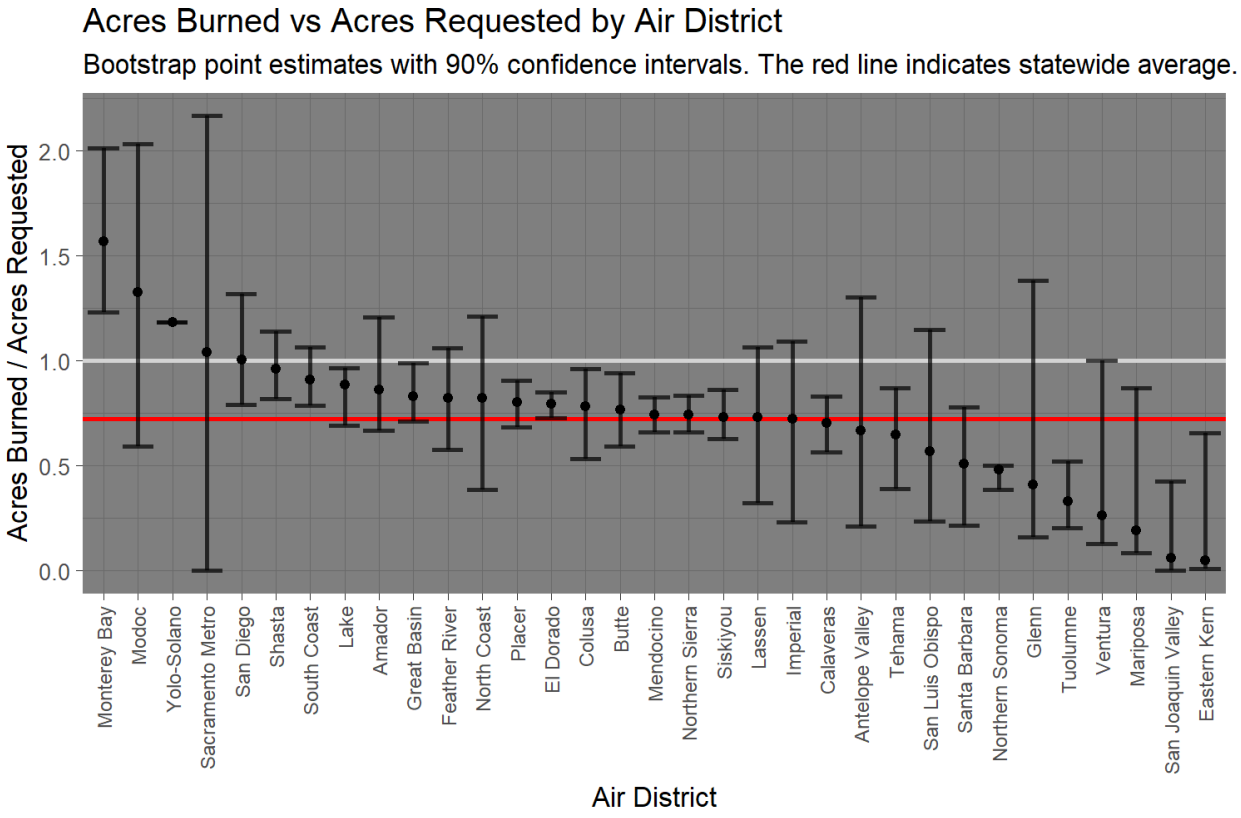

Figure 6. Burning success rates sorted by rates.

Figure 6 shows the results of this analysis with the red line indicating the statewide overage success rate of 0.72 of requested acreage being successfully burned. The light gray line indicates a rate of one, where the amount burned exactly equals the amount requested. Air districts with a confidence interval entirely above or below these reference lines or the point estimate of another district can be assumed to be significantly different at the 90% confidence level.

As is reflected in this data, it appears that in the cases of Monterey Bay, Modoc, Yolo Solano, and Sacramento Metro, there were circumstances where there was an opportunity to do more burning than was requested. In some circumstances that larger burns that are still within the SMP in place can be completed. In other areas, such as Ventura and Eastern Kern, it appears that it may be that goals are set but not fully completed, which could be due to available staff or implementation cost. As to the relatively lower success rate in San Joaquin Valley, it could be attributed to the number of permissive burn days available given the air quality impacts to that region.

It bears repeating that some air districts did not have data in PFIRS for every year of the study period, likely because many did not start using PFIRS until after 2019 or due to a lag in reporting data, so not all burning occurring in those districts may have been represented in PFIRS.

Success of Burning Data Analysis Conclusion

This data helps to illustrate nuances as to whether burning as requested occurred in certain areas. As these acres requested were approved by the air districts, it may not have been the district process preventing these burns from occurring, but rather other factors, such as implementation cost, weather, or available staff. Furthermore, air districts don't create burn projects themselves, so these burning success data are a product of applicants developing and proposing burn projects to the districts.

It is also important to note that these results were impacted by inconsistent reporting to PFIRS. Nevertheless, it is worthwhile to reflect on this data and determine whether more investigation into failed planned burns is warranted, especially if the numbers of acres requested will likely increase as prescribed burning programs expand statewide.

Statewide Acres Burned Analysis

Synthesizing Available Data

A combination of PFIRS and CAPCOA data sets were used to identify total acres burned from 2018 – 2021 based on input from CAPCOA staff and if PFIRS data had gaps in certain years. As previously mentioned, CAPCOA data (instead of PFIRS) was used for Modoc, Monterey, North Coast, Lake, San Joaquin, and Northern Sierra data for 2019 – 2021 (as those were the years for which the data was collected) and, if available, PFIRS was used to supply data for 2018-2019. It should be noted that CAPCOA *includes* PFIRS data.

For some air districts that did not begin using PFIRS until after 2018, we were not able to access data for 2018 – 2019 burn year, and that is reflected in Table 5 as "no data for 2018 – 2019".

Data on grassland burning was removed from PFIRS and CAPCOA data as the scope of this study is to focus on open burning occurring in forested landscapes made up of woody biomass material. Burn entries were removed from PFIRS data if the fuel type entry stated "grassland".

To remove grassland burning from CAPCOA data, we examined entries mentioning "grass" in the "types of fuels burned" field. Entries that *only* mentioned terms like "grass," "forbs", and "tules" were assumed to be 100% grassland, while entries that mentioned "grass" but also included terms related to woody material were assumed to be 50% grass. Table 6 includes all types of grass-related entries in the "types of fuels burned" field and the scores associated with each entry type. These percentages were then applied to each entry's associated acreage to determine the number of acres of grassland burning involves. These grassland acres were then summed by district, and then subtracted from the overall acres burned value for each district.

Table 5. Data sources used for each air district.

Air District	Data Source
Amador	PFIRS data for 2018 – 2021
Antelope Valley	PFIRS data for 2018 – 2021
Bay Area	CAPCOA data 2019 – 2021 (no data for 2018 – 2019)
Butte	PFIRS data for 2018 – 2021
Calaveras	PFIRS data for 2018 – 2021
Colusa	PFIRS data for 2018 – 2021
Eastern Kern	PFIRS data for 2018 – 2021
El Dorado	PFIRS data for 2018 – 2021
Feather River	district provided its own data, 2018 - 2021

Air District	Data Source
Glenn	PFIRS data for 2018 – 2021
Great Basin	PFIRS data for 2018 – 2021
Imperial	PFIRS data for 2018 – 2021
Lake	CAPCOA data for 2019 – 2021 (no data for 2018- 2019)
Lassen	PFIRS data for 2018 – 2021
Mendocino	PFIRS data for 2018 – 2021
Modoc	CAPCOA data for 2019 – 2020 PFIRS data for 2020-2021 (no data for 2018- 2019)
Mojave	PFIRS data for 2018 – 2021
Monterey Bay	PFIRS data for 2018 CAPCOA data for 2019 - 2021
North Coast	district provided data 2018 – 2019 CAPCOA data for 2019 – 2021
Northern Sierra	PFIRS data for 2018 CAPCOA data for 2019 - 2021
Northern Sonoma	PFIRS data for 2018 – 2021
Placer	PFIRS data for 2018 – 2021
Sacramento Metro	PFIRS data for 2018 – 2021
San Diego	PFIRS data for 2019 – 2021 (no data for 2018- 2019)
San Joaquin Valley	PFIRS data for 2018 CAPCOA data for 2019 - 2021
San Luis Obispo	PFIRS data for 2018 – 2021
Santa Barbara	PFIRS data for 2018 – 2021
Shasta	PFIRS data for 2018 – 2021
Siskiyou	PFIRS data for 2018 – 2021
South Coast	district provided its own data, 2018 - 2021
Tehama	PFIRS data for 2018 – 2021
Tuolumne	PFIRS data for 2018 – 2021
Ventura	PFIRS data for 2018 – 2021
Yolo Solano	PFIRS data for 2018 – 2021

Table 6. Types of fuel type entries in CAPCOA data that include grass.

Types of Fuel Burned – from CAPCOA Entries	Count	Acres	Percentage grass
Grass	49	8928.12	100%
Brush and Grass	8	7625	50%

Types of Fuel Burned – from CAPCOA Entries	Count	Acres	Percentage grass
Grassland	55	5969.9	100%
Grassland, intermittent brush	4	3466	50%
DRY GRASS	7	2455	100%
Upland Annual Grasses	9	1765	100%
tumbleweed & desert grass	1	1133	100%
NON-NATIVE GRASSLAND	11	1067	100%
grass/forbs	3	880	100%
Native Grasses	5	792	100%
grass, shrub, and oak litter	1	700	50%
Grassland, Broadcast	6	620	100%
Grass, brush, Douglas fir/oak woodland	3	320.7	50%
Annual grass	1	250	100%
Annual Grasses	1	219	100%
Grasses, understory litter, cut and cured brush	1	142.74	50%
Grassland - 100 acres, Shrubs - 45 acres	1	140	67%
Chamise & Grass Oak Woodland	1	121	50%
Wetland Veg, Annual Grasses	1	117	100%
Cured grass, light baccharis, scattered hardwoods	1	83	50%
Dry Grass	1	80	100%
Grass/Brush	2	80	50%
Coastal Sage, Chapparal, Scrub, Grass	1	78	50%
Grass Oak Woodland	1	65	50%
grass	4	62	100%
Grass (continuous)	1	60	100%
GREAT BASIN GRASSLAND	1	52	100%
Grass/Understory	1	50	50%
Grass/Forbes	1	44	100%
Grass/Oak understory	4	42	50%
Grass/Forb	2	20.5	100%
Grass/Forbs	1	20	100%
Annual grass understory/ light slash	1	13	50%
Grassland / oak litter, oak woodland, coyote brush / Douglas fir slash	3	12	50%
Continuous, natural standing grass	1	10	100%
Grass/Tules	1	10	100%
Oak, brush, and grasses	1	10	50%
Dry standing grass	1	8	100%
Grass & Oak Litter	1	7	50%
Grass / Forb, Mixed Chaparral/Montane	2	6	50%
Oak woodland/understory and annual grass	1	6	50%
Ungrazed annual grassland with natural standing	1	5.6	100%

Types of Fuel Burned – from CAPCOA Entries	Count	Acres	Percentage grass
Oak woodland/understory, annual grass	1	3	50%
Grass/Tulie	1	2	100%
Dried grass	1	0	100%
annual grasses	1	0	100%

Not all CAPCOA data included fuel type entries, so it is likely that some of the final data still includes grasslands. However, the districts with the majority of burning occurring shown in Table 7 still have a significant forested acreage within their district boundary, so the data is still relevant in selecting air districts to interview based on where most burning is occurring (see Section 3 of Part II of this report).

Total Acres Burned Results

The total acres of planned forest-related burning from 2018 – 2021 can be found in Table 7, organized in descending order of acres burned. The top five air districts for total acres burned from July 2018 to June 2021 included North Coast, Modoc, Monterey Bay, Lake, and Siskiyou. Those five air districts burned a total of 172,023 acres, which represented more than 50% of the total acres burned across the state for this study period. One statistical outlier of interest is Modoc County, where there was at least one burn in 2020 that totaled roughly 20,000 acres. The air district confirmed that the burn occurred.

Further detail on data from each data set for acres burned from 2018 – 2021 can be found in Appendix D in Part II of this report.

Table 7. Total acres burned and forested acres by air district. Districts highlighted with green were interviewed to assess burning regulations in their district, and districts highlighted with red had a high number of forested acres but were not in the top half of districts for acres burned (see Section 3 of Part II of this report). "No data" means we do not have access to data for the given year.

Air District	2018 – 2019 Acres Burned	2019 – 2020 Acres Burned	2020 – 2021 Acres Burned	Total Acres Burned	Total Forested Acres	% Forested
North Coast	15571	15024	18102	**48697**	4,174,394	83.56%
Modoc	no data	47241	1258	**48499**	989,240	36.81%
Monterey Bay	13163	12376	4942	**30481**	951,524	28.88%
Lake	no data	21108	3500	**24608**	384,133	45.10%
Siskiyou	3746	6792	9201	**19739**	2,806,330	69.18%
Shasta	2505	12769	3352	**18626**	1,808,094	73.44%
San Joaquin Valley	4573	8509	2359	**15441**	3,499,446	23.10%
Mendocino	1698	7211	3968	**12877**	1,783,083	79.32%
Tuolumne	1306	7190	4008	**12504**	988,154	67.79%
El Dorado	2762	7206	1710	**11678**	825,614	72.07%
Northern Sierra	3567	4042	3018	**10627**	2,202,818	75.63%

Air District	2018 – 2019 Acres Burned	2019 – 2020 Acres Burned	2020 – 2021 Acres Burned	Total Acres Burned	Total Forested Acres	% Forested
South Coast*	(district only provided the sum of 3 years)			**7799**	603,419	8.78%
San Diego	no data	1959	3970	**5929**	241,497	8.91%
Tehama	2125	2378	1025	**5528**	1,020,522	53.86%
Placer	1153	2222	2139	**5514**	595,021	61.97%
Great Basin	2318	1910	773	**5001**	1,225,609	13.58%
Calaveras	1328	1953	1322	**4603**	430,234	64.89%
Butte	532	2289	930	**3751**	534,689	49.82%
San Luis Obispo	340	1177	1646	**3163**	434,723	20.46%
Amador	no data	1498	394	**1892**	228,945	59.09%
Bay Area	no data	1035	680	**1214**	1,056,172	27.35%
Santa Barbara	672	145	736	**1553**	292,722	16.65%
Lassen	337	683	502	**1522**	1,027,981	34.17%
Feather River*	(district only provided the sum of 3 years)			**1318**	204,343	25.49%
Sacramento Metro	570	443	206	**1219**	24,310	3.82%
Northern Sonoma	12	0	1119	**1131**	419,197	67.44%
Colusa	228	126	590	**944**	166,299	22.47%
Mariposa	16	353	455	**824**	604,892	64.70%
Glenn	73	661	0	**734**	227,392	26.78%
Yolo Solano	0	321	78	**399**	109,165	11.42%
Antelope Valley	0	272	22	**294**	84,790	10.02%
Imperial	0	18	165	**183**	421	0.01%
Eastern Kern	46	10	3	**59**	420,824	17.34%
Ventura	0	21	13	**34**	243,436	20.39%
Mojave	0	0	0	**0**	259,368	2.00%

* Data was provided by the air district as a 3-year total, and not broken down by year

The results of the acres burned analysis were compared to the Calveg mapping system (a dynamic system managed by the USFS Region 5 that classifies existing vegetation) to determine the percent forest cover in each air district. Calveg estimates indicate that 81.19% of total forested lands in California are within 18 districts, and those districts recorded 94.76% of all forest burning that occurred from 2018 – 2021. Those 18 districts are highlighted in green in Table 7. The percentage of acres burned relative to the total forested acres for each air district is in Table 8.

Table 8. Total acres burned from 2018 – 2021 relative to the total forested acres in each air district.

Air District	Acres Burned 2018 – 2021 as a Percentage of Total Forested Acres
North Coast	1.17%
Modoc	4.90%
Monterey Bay	3.20%

Air District	Acres Burned 2018 – 2021 as a Percentage of Total Forested Acres
Lake	6.41%
Siskiyou	0.70%
Shasta	1.03%
San Joaquin Valley	0.44%
Mendocino	0.72%
Tuolumne	1.27%
El Dorado	1.41%
Northern Sierra	0.48%
South Coast	1.29%
San Diego	2.46%
Tehama	0.54%
Placer	0.93%
Great Basin	0.41%
Calaveras	1.07%
Butte	0.70%
San Luis Obispo	0.73%
Amador	0.83%
Santa Barbara	0.53%
Lassen	0.15%
Feather River	0.64%
Sacramento Metro	5.01%
Bay Area	0.11%
Northern Sonoma	0.27%
Colusa	0.57%
Mariposa	0.14%
Glenn	0.32%
Yolo Solano	0.37%
Antelope Valley	0.35%
Imperial	43.47%
Eastern Kern	0.01%
Ventura	0.01%
Mojave	0.00%

Based on Calveg estimates and results from the acres burned analysis, there are three air districts that have over 500,000 forested acres but burned less than other districts during the study period. These districts are highlighted in red in Table 6: Lassen, Bay Area, and Mariposa. However, Bay Area's "forested" acres in the Calveg database may not reflect populated areas and likely needs further refinement to adequately determine the percentage of wildland forest acres. We surmise that in Mariposa the placement of

the National Park may be impacting acreage of burns, and in Lassen it is likely that the large amount of unpopulated area reduces the priority of the landscape for prescribed fire. More work could be done to determine whether these theories are correct, but such an investigation is outside the scope of this study.

Based on the outcomes of this section and the limitations of time and resources, the top half of the air districts in this table, where the most burning occurred, were selected to be interviewed to fully understand those district practices and to confirm information collected. The interviews are discussed in Section 3 of Part II of this report.

Section 3: Air District Interviews

Overview

The air districts with the highest level of burning based on the acres burned analysis were contacted to answer several in-depth questions about their burn programs and how burning is regulated and managed in their district. Air districts that were interviewed are highlighted in green in Table 6 and identified below in Figure 7. While burning was happening in the other half of the air districts, acres burned were relatively smaller during the study period. It may also be that there was unreported burning happening in those districts that was not picked up by PFIRS or CAPCOA interviews.

Figure 7. Eighteen air districts with the most acres burned from 2018 - 2021 were selected for detailed interviews.

Most of the 17 air districts not interviewed are either small, urban, or in non-forested ecosystems (desert forest ecosystem was not counted as “forest” for the purposes of this study due to different biomass disposal needs compared to other forest types in California). Three of those air districts include between 400,000 - 500,000 acres of forested land (Eastern Kern, Northern Sonoma, and San Luis Obispo), so those districts may be relevant to check in with in subsequent efforts to analyze burning, as well as two counties (Amador and Santa Barbara) with less forested acreage, but still a notable level of forest burning occurring.

Interview Process and Methodology

The eighteen air districts identified above were asked a series of questions to better understand each of their burn permit processes, burn programs, burn rules, burn data tracking, burn ignition request denials, and interactions with other agencies that regulate burning (such as fire districts, CAL FIRE, local government, and special districts). The report also discusses residential burning and other burning in the air district that is below the Title 17 threshold for SMP requirements (less than 10 acres or less than one ton of PM10 emissions). They were also asked to verify the data collected on acres burned for the study period.

Specific interview questions were developed based on input from various agencies (the California Natural Resources Agency, CARB, CAPCOA, Office of Planning and Research, CAL FIRE, California Forest and Wildfire Resilience Task Force, and Department of Conservation) and based on information the Joint Institute for Wood Products Innovation was seeking through this project. A list of specific questions asked and an overview of results for each air district interviewed, as well as a profile with basic information on each district and links to the district's burn regulations, can be found in "Appendix F: District Profiles."

Interviews via Zoom or phone calls were conducted with air districts. The team took detailed notes during interviews and then later shared the notes with the districts. Results from the interviews are detailed below.

The process of these interviews was intended to understand the perspective of the air agencies as far as how they perceive the permitting process, and how they feel the process is supported by other government agencies, or not supported. Further investigation into the opinions of stakeholders in this process, such as burn practitioners, is recommended to get a full picture of the burn permit experience in California.

Results

Air District Burn Permits and Programs

Tracking Burns over 10 Acres or with More than One Ton of Emissions
Most air districts interviewed have their own burn permit that applicants must obtain, in addition to an SMP that must be completed if a burn is planned for over 10 acres or emits more than 1 ton of PM10 emissions. This SMP, as mentioned earlier, is required under California law.[38] The process for obtaining a burn permit or SMP varies across air districts, and not all districts offer templates on their websites, so it is important that burners always call the district or visit the office in person for more information, though many air districts use PFIRS for submitting an SMP. Great Basin and Northern Sierra

[38] 17CCR Section 80140 et.seq

are more stringent than state law and require an SMP for burns greater than one acre. Nine of the districts in our focus group require a district-specific burn permit in addition to an SMP. The other six air districts (Modoc, Lake, San Joaquin, South Coast, San Diego, and Great Basin Unified) do not require a district permit, but rather only an approved SMP.

Burn permits or SMP forms/applications typically require the applicant to submit information related to the burn, such as the burn location (including township and range); the total acreage of the burn and/or property size; the number and size of piles and type of vegetation to be burned; the type of burning activity (such as forest management, agricultural, hazard risk reduction, etc.); and other pertinent information as needed. Often burn permits or SMP applications involve a small fee to be paid to the air district, and once they are processed, they are mailed or emailed to the burner.

Permit or SMP applications generally provide the burner with rules the burner needs to know before burning, including the requirement to always check if it's a permissive burn day and if a pre-burn inspection is required by the air district. Many districts have an online portal for applicants to submit burn permits through, with others either processing all permits over the phone or in person at the district office.

Tracking the Permitting of Burns Less than 10 Acres

Regulating burns that do not trigger an SMP varies highly among air districts. To begin this discussion, it is important to understand if a district defines burning under the SMP threshold to be "residential," and if it has defined residential burning, or it has created multiple categories of burning within its rules. As discussed earlier, residential burning is defined in California Health and Safety Code Section 41806 as an "open outdoor fire for the disposal of the combustible or flammable solid waste of a single-or two-family dwelling on its premises."

Many burn rules for air districts, however, get more specific as to what constitutes residential burning, such as in El Dorado where it is defined as open burning of one pile of material no larger than 4 feet in diameter at the location of a dwelling. Some districts call it "backyard burning," such as in Monterey where it is defined as "Fires for disposal of only the following dry natural vegetation originating from and being burned on the premises of a single-or two-family dwelling."

Meanwhile, some air districts also regulate burning that they consider to be different than residential burning, which is called "other burning" in this document and is considered burning that is under the SMP threshold, but not "residential" because of its size or location, as defined by a district's rules. This distinction between residential and other burning under the SMP threshold is very important to understand to track burning activities. Otherwise, it becomes very difficult to follow information being provided by an air district pertaining to burning.

There are four air districts that distinguish between residential and “other burning” in their rules, and they require a permit for both. These air districts are North Coast, Monterey, Mendocino, and Lake. Nine districts also distinguish between residential and other burning in their rules, but they only require permits for other burning (non-residential burning). These districts are Shasta, Tehama, El Dorado, Northern Sierra, Placer, Tuolumne, Calaveras, Butte, and Siskiyou.

Three air districts prohibit residential burning and require a permit for all other burning. These districts are San Joaquin, San Diego, and South Coast. Each of these air districts has exceptions to the residential prohibition. South Coast allows residential burning for tumbleweeds, San Diego only prohibits residential burning in the San Diego Air Basin (it is allowed in the portion of the Salton Sea Air Basin within their district), and San Joaquin allows for “residential hazard reduction” burning. As for “other burning” San Joaquin requires a permit for all such burning, while South Coast does not issue a permit, but still requires burners obtain a “burn authorization” from the air district before burning, and San Diego defers permitting for other burning to fire districts.

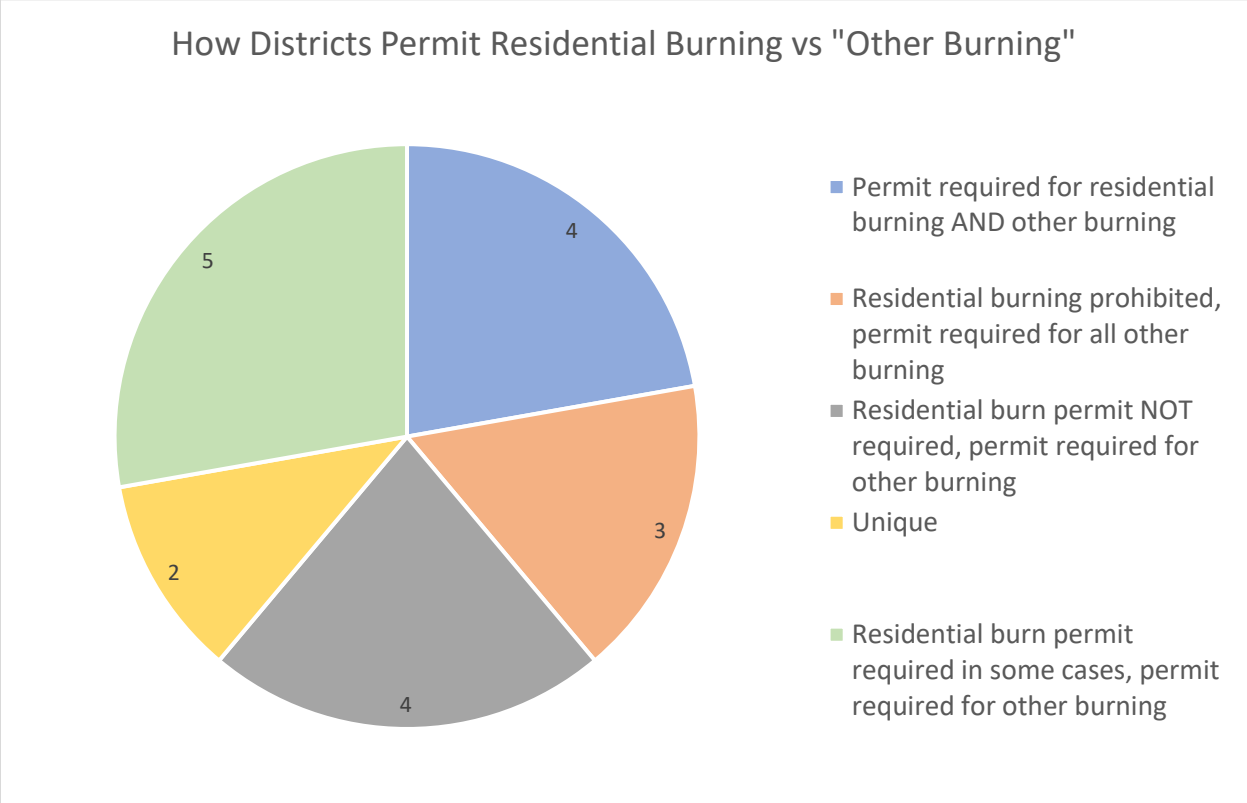

Figure 8. A breakdown of how residential vs other burning is permitted, among air districts interviewed. For detail on “unique,” see yellow rows in Table 9.

It bears repeating that Great Basin requires an SMP for all burns over *one* acre and burns under one acre are considered by the air district to be residential and are not regulated. In Modoc, it appears that burning under 10 acres is unregulated by the air district altogether. These two districts are unique.

Note that air districts are self-funded, primarily through permit fees and need an ongoing source of stable funding to hire staff to provide open burn programs and any additional or enhanced reporting. Permit fees from stationary sources, the districts' primary source of revenue, is not allowed to fund open burn program activities. For example, one small rural air district (Northern Sonoma) issues over 3,300 burn permits per year and the related data acquisition and reporting is inherently limited by the open burn permit fees the district can charge. This is in direct conflict with many burning applicants and other burn advocates who stipulate that open burning should be permitted at no cost.

Table 9. How air districts permit residential burning vs "other burning" color coordinated to match the chart in Figure 8.

Air District	Residential Burn Permit Required?	Permits Issued for Other Burning?
Butte	No, unless a broadcast burn	Yes
Calaveras	No, unless greater than 5 acres	Yes
El Dorado	No, unless greater than 4'x4' pile	Yes
Great Basin	No, and all burns under SMP threshold considered to be residential	No, but SMP required for burns greater than 1 acre
Lake	Yes	Yes
Mendocino	Yes	Yes
Modoc	No	Rule indicates it is unregulated
Monterey Bay	Yes	Yes
North Coast	Yes	Yes
Northern Sierra	No, unless greater than 1 acre	Yes
Placer	No	Yes
San Diego	Residential burning prohibited (in San Diego Air Basin only)	Yes, other burning allowed in certain circumstances
San Joaquin Valley	Residential burning prohibited (except for residential hazard reduction burning, and district issues permits)	Yes, other burning allowed in certain circumstances
Shasta	No	Yes
Siskiyou	No	Yes
South Coast	Residential burning prohibited (except for tumbleweeds)	Yes, other burning allowed in certain circumstances
Tehama	No	Yes
Tuolumne	No, unless greater than 2 acres	Yes

Overall, residential burning is mostly unregulated, and where air district permits are issued, even fewer districts track them. This residential burning occurs in more populated areas where it is most often the basis for public complaints and can most

obviously and visibly impact air quality. More work is needed to understand the impacts of residential burning.

Data Tracking Systems Among Air Districts

Data Reporting

Given the streamlined approach to data management for burning within PFIRS, it has become the data reporting method of choice for prescribed burning among many air districts. However, the amount of burning in the state is likely underreported. Some districts suspect that un-reported burns occur, either because they are small burns that are not regulated, as described above, or because they are unpermitted burns. The lack of reporting could be problematic because without accurate reporting there may not be sufficient information to estimate total smoke/air quality impacts on a given day.

While many air districts are confident in their own internal data tracking systems, some districts express that they struggle to accurately track all burning due to staffing shortages or lack of resources. These districts are mostly based in rural areas with limited population bases and deal with frequent staff turnover. Generally, there is more uninhabited forestland in rural districts, making it likely that more forest management activities are occurring in those areas. One rural district expressed they were “not able to vouch for the accuracy of burn data due to limited staff and not enough resources to accurately track all burning.” This same district had a staff member in charge of reporting data who had resigned before our interview, and the district did not have a replacement for that person.

Managed Wildfire for Resource Benefit

One air district suggested that perhaps burn data could be collected for areas that were prepped and planned for prescribed burning, but instead the prescribed area burned in a wildfire. However, according to conversations with CAL FIRE personnel, they do not enter these acres into PFIRS. Further discussion is needed as to how such situations should be reported. Similarly, backburning during wildfire suppression operations as well as during managed wildfire for resource benefit (wildfires far from population centers that are manageable and benefit the ecosystem) are not counted in any system, as confirmed by several air districts. This is an issue that CARB has been working to address for some time.

Emissions Reporting

As California law states that an SMP is required if a burn emits more than 1 ton of PM10 emissions, CARB received support from air districts to embed worksheets in PFIRS to aid applicants in calculating estimate emissions from a planned burn, both from piles and from broadcast burns (see Appendix A). These worksheets originated with the district smoke management programs. Most air districts that use PFIRS have burn applicants calculate anticipated emissions from these worksheets. Several air districts shared that the USFS and CAL FIRE are very comfortable with calculating emissions for their own burns. The districts support private landowners with their calculations using resources provided on PFIRS or from their smoke management program documentation.

Feedback on PFIRS System
Given that PFIRS is emerging to be the data collection method of choice for open forest-related burning in California, it is important that the platform works efficiently for both burn applicants and for air districts. While a revamp of the program is already underway by CARB in consultation with CAPCOA and many districts, we also solicited feedback from districts on the system to ensure awareness for how PFIRS can be improved.

The most common issues expressed were that the platform is "clunky" and can be complicated to use for those not trained in the platform. To track burns more effectively across the state, a simplified version is needed. Several air districts also expressed frustration with not being able to access applicants' applications for troubleshooting purposes, such as when a user uses a login or when a user enters information incorrectly. A simplified interface would result in better data tracking, and with almost all districts beginning to rely on PFIRS to track forest burning, it's important that the platform is as user friendly as possible. Others expressed desire for PFIRS to keep track of permissive burn days and no burn days within specific air districts, so applicants don't get confused and that a "better emissions estimator and pile size estimator" is needed. One air district suggested that PFIRS also have a call-in option for applicants in more rural areas where Internet connectivity is limited.

Overall, feedback from interviews suggests that there is a need for streamlining reporting data. Several air districts expressed that PFIRS data is the most accurate information available and said not to refer to data in CARB reports; however, others suggested that CARB reporting accuracy will improve if PFIRS data tracking improves.

Most air districts stated during interviews that PFIRS is the best platform currently available for tracking burn data for forest-related burning, despite issues with the system that are currently being worked through with CARB and CAPCOA.

Feedback on CARB Annual Reports
These reports have been required for more than 30 years, but not all air districts consistently report. Some districts have very little burning occurring and may not submit reports. There may also be confusion about whether certain agricultural burning should be included in CARB reports or if they should be reported in PFIRS because, as mentioned earlier, forest-related burning is defined under the law as agricultural burning. Additionally, these reports have not been shown to be used for any constructive purpose over the years, and as such, districts choose to prioritize other more pressing work.

Feedback on New CAL FIRE Online Permit System
Air districts were asked to share their feedback on the new CAL FIRE online permit system. Many air districts did not offer an opinion on the new platform, while a few did offer some insight. The most common critique heard was that the system fails to convey the specific burn requirements and regulations of the respective district. Many

suggested that the system provide a link to the appropriate district's website to find out more information about the permit needed from the district. Some even reported that the system will issue permits for scenarios that might otherwise be prohibited by the districts rules. Thus, some districts have suggested that it would be helpful if district staff could work with CAL FIRE to customize information for their respective air district within the CAL FIRE permit platform. Additionally, CAL FIRE now requires permits for contract areas where they did not previously require permits, making the system very cumbersome, especially with the up to 10-day waiting period that could occur before a permit is issued.

Alternatively, some representatives from air districts expressed enthusiasm for the new platform. Comments include that it works well for their districts, it makes the permitting process efficient so that authorities can better track burning and emissions, and overall that the system is an efficient way for burn applicants to get the permit needed for fire safety. All the air districts want to continue to interact with CAL FIRE to optimize the system.

Burn Denials

CAPCOA collected information on denied burns across air districts from 2019 – 2021, and the breakdown of reasons for burn denials can be found in Figure 9 below. This data was sourced from PFIRS and provided to CAPCOA by CARB staff.

There are two stages when burn activity is approved. First, when an application for a permit or an SMP plan is submitted and then later when the burner calls in an ignition request authorization to burn under their SMP. Based on interviews with air districts and data from CAPCOA, some common reasons for a district to deny a burn or day-of-decision include administrative issues with the permit or SMP (including errors in PFIRS), increased fire danger as determined by CAL FIRE, wind direction or other meteorological conditions that make it unsuitable to burn as determined by CARB or the district, or the wrong day was requested.

Many air districts reiterated during interviews that if a burn is denied due to no-burn day conditions, they work with the burn applicant to find a more suitable day for burning. Air districts also confirmed that most burn requests are approved. One prominent district in the Central Sierra stated that they rarely deny burns for reasons other than fire danger, which is determined by CAL FIRE. Another air district in the northern Sacramento Valley stated their burn denial rate is mostly because of technical difficulties with PFIRS, explaining that if there is an error in the burner's PFIRS entry, the only way to cancel the application is to "deny" the burn in the system and re-enter it.

The information indicates that only 93 denials out of a 5,995 total is a 1.6% denial rate. Of the denied burn total, 19% (17) were denied due to fire danger conditions; 13% (12) were due to smoke in the area or the potential for smoke impacts; 13% (12) were due to technical issues with the application like double entries or the wrong location; 5% (5) were due to rain; 6% (6) were due to the burner canceling the burn; 20% (19) were due to an incorrect date/date passed; and 24% (22) were due to unknown reasons.

(CAPCOA, personal interview 2022). Feedback collected from interviews confirmed the results in Figure 9, supporting the conclusion that not all air district regulations pose a significant barrier to burning. Feedback from air districts highlighted that all districts work with the entity requesting to burn to find a suitable replacement day to burn if their burn request is initially denied.

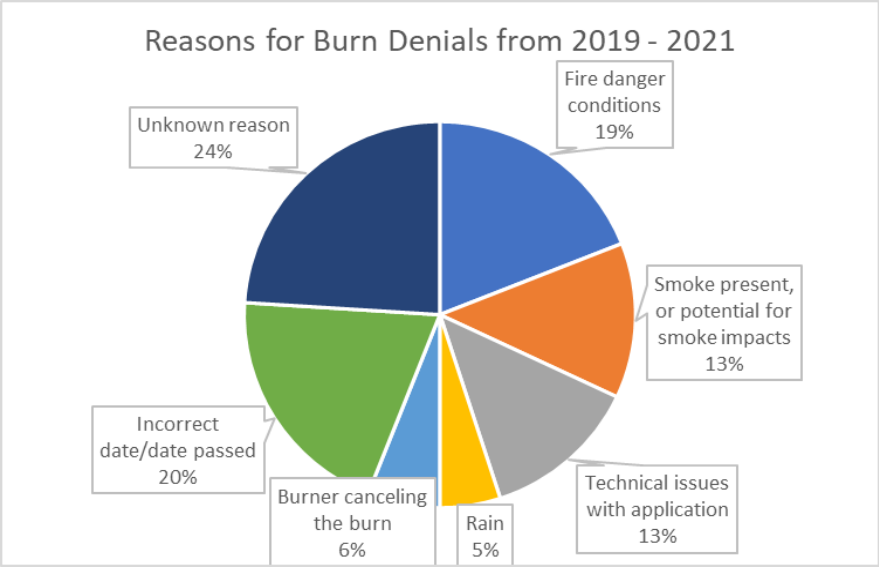

Figure 9. Breakdown of reasons for burn denials from 2019 - 2021, as collected by CAPCOA.

Note that while the PFIRS data collected by CAPCOA was not focused on the denials of the *initial* burn permit or SMP application, air districts generally reported that all such applications are approved if filled out properly.

Collaboration Among Agencies

CARB Burn Day Determinations

Under Title 17, Section 80110 (e) allows air districts to work with CARB to develop a procedure that allows a district to demonstrate that a given day is a burn day through its own analysis of the expected meteorological conditions in its air basin. It is important to note that districts make burn determinations based on air quality concerns and meteorological data, not fire safety. Furthermore, Health and Safety Code Section 41862 and Section 80120(e) of Title 17 allows a district by special permit to authorize prescribed burning on CARB no burn days if the denial of such permit would threaten imminent and substantial economic loss. Such burn approvals are not limited to those requested by public officials, but rather by any entity holding a valid SMP or permit, as applicable.

Based on our interviews with air districts, most districts are aware that they can approve a burn on a CARB no burn day decision. The districts are cautious, however, to approve these burns as approving them can lead to public confusion about what is a “no burn

day" and because very often CARB no burn days coincide with burn bans put in place by CAL FIRE.

USFS and CAL FIRE Burning Activities
The USFS, or their non-profit partners, often request to burn in forested air districts. According to districts, USFS personnel are comfortable using PFIRS and calculating emissions from planned burns and have been required to use PFIRS from their Region Office for many years. According to the Northern Sierra AQMD, it has a strong, trusted working relationship with the USFS. Other districts that were interviewed with a large percentage of federally managed land largely agree. It should be noted that burning on federal lands is outside any CAL FIRE requirements for burning.

Most air districts issue permits separate from CAL FIRE's permitting process and advise burners to always check with CAL FIRE for burning conditions or permit needs prior to burning. In some districts, CAL FIRE itself is one of the leading entities conducting burns. Interviews confirmed this was particularly true for Monterey, Great Basin Unified, and Tehama. Many districts stated they have a good or cooperative relationship with CAL FIRE when it comes to permitting CAL FIRE burns.

Air Districts that Work with Local Fire Agencies to Issue Permits
With the regulating of burning, it is important to repeat from the first section of this paper that in many circumstances, residential burning requires a "fire safety" permit from either CAL FIRE or a local fire agency (which is a different permit than from an air district if required). It is worth noting that several districts either defer their permitting authority of other burns to fire districts or they work cooperatively with the local fire district in issuing the permit. There are three air districts (Lake, San Diego, and Mendocino) that defer permitting of other burns to fire districts, with this dynamic explicitly stated in their rules. It seems that Modoc fits into this category in practice based on their burn rules and the brief interview with staff, but currently the district is understaffed and unable to confirm at this time.

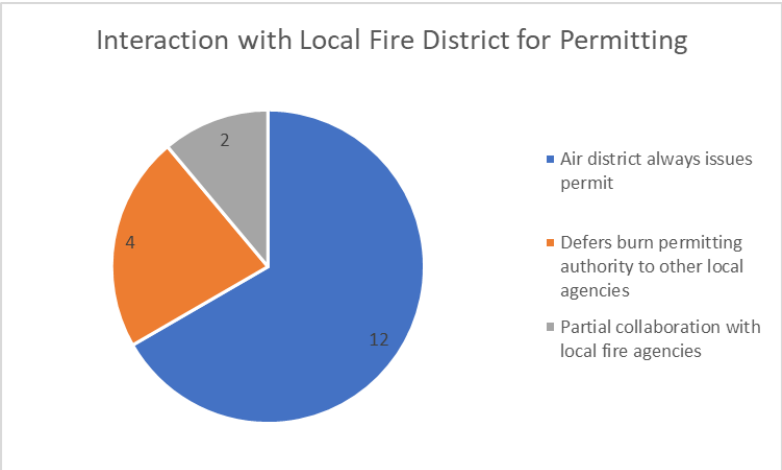

Figure 10. How air districts interact with local fire districts for permitting, among those interviewed

Other air districts among those interviewed partially collaborate with fire districts for issuing permits, including Siskiyou and Monterey. Siskiyou issues permits during the non-fire season. Monterey issues permits when a request by a burner is made, and a fire district has not issued a permit. The remaining air districts among those interviewed issue a district-specific permit for burning and do not defer to fire districts. See Figure 10 for a summary of these results. Another important aspect of regulating burning from the first section of Part II of this report is that beyond air district rules, residential burning is still subject to city and county rules where a district may allow residential burning, but the local city regulations restrict it altogether, as described above.

Conclusion

The most consistent message from the air district focus group was that data tracking information about burning is challenging. As open burning of forest biomass has only more recently become a statewide priority, previous systems were quite basic, and information about smaller outdoor burning is generally nonexistent. Some districts have the staffing and tools to closely track information, but most do not. Most districts agree that the PFIRS system is the data collection method of choice for forest biomass burning in California, but many districts are frustrated by the program's interface. Fortunately, there are efforts to revamp the system, as is discussed more in Section 4 of Part II of this report. More resources are needed to ensure that districts, state agencies, and policy makers have access to the best available data on burning in California.

Burn denials is an issue that is discussed with many stakeholders and state officials. The interview results indicate that air districts' denial of a request to burn are rare at 1.6% of total requests in the study period, and when denied it can be due to a variety of reasons and are more likely due to fire safety than smoke impact concerns. For example, burn requests may be denied due to red flag warnings and fire danger as declared by CAL FIRE for fire safety or for administrative issues with the permit or SMP (including errors submitted in PFIRS). What many air districts made clear is that if they must deny a day-of request to burn, they always work with the applicant to find a suitable alternative opportunity for burning.

Our interviews also demonstrate both variation and similarity among air district burning regulations within our focus group. The air districts mostly implement the Title 17 requirements related to burns over 10 acres or one ton of emissions in similar ways, and nearly all districts issue permits for burns that do not trigger an SMP (which this report refers to as "other burning" for ease of reference) when such burning is not residential in nature. Residential burning, which is defined slightly differently within each air district, is allowed and unpermitted in most districts, while four districts require residential burn permits and two do not allow it. Furthermore, while residential burning may be allowed by the air district, it may be discontinued by the local city or county or another special district.

Another variation among air districts interviewed is the interplay of air districts with local fire districts to issue burn permits is varied. Most air districts issue burn permits;

however, there are six air districts interviewed that either defer their permitting authority to local agencies or are involved in some level of collaboration with local agencies. The process known as “Designated Agencies” is covered in more detail in Section 5 of the first part of this report as a collaboration with local districts could improve efficiencies around permitting burning in California.

In summary, the interviews with the focus group air districts served to confirm PFIRS data, explore concerns over data tracking generally, and discuss current CARB reporting, as well as go over CAPCOA collected data (specifically, burn denial data). Additionally, residential and small burn regulation was explored, and discussions covered how well collaboration with other agencies works within respective districts. Interview summaries are available within Appendix E of Part II of this report.

Section 4: State Program Updates

PFIRS System Update

With a shift toward more widespread use of PFIRS among air districts for reporting prescribed burning in forests, CARB staff recognize the need to update the system to be more efficient in capturing data statewide. The proposed changes to the system will make the interface more user friendly and usable on a smart device. In the last few years, general updates to the system have been slow other than for minor tweaks to improve reporting. CARB is working with Esri (a geographic information system company) to revamp PFIRS, making it an updated, improved product that is more user friendly with more automation. The current target date for release of this version is the summer of 2024.

In 2022, CARB staff released a PFIRS user survey to solicit feedback. Many responses were received from land managers, but fewer responses from air districts. From this feedback, CARB made a priority list of functions that need to be improved, and they are working on building functionality into the new version. Recommendations from this report will also be considered by CARB staff.

Note that at the time of this Report, CARB is also in the process of hiring an additional full-time staff person to help with the management of PFIRS.

New CAL FIRE Online Permit Program

To make the burn permitting process through CAL FIRE more efficient, CAL FIRE launched an online burn permitting system that burners can apply to for CAL FIRE burn permits, including for Residential Burn Permits (LE-62A), General Burning Permits (LE-5), and Broadcast Burn Permits (LE-7/8).

The CAL FIRE terms for a Residential Burn Permit include a maximum pile size of 4 ft by 4 ft. The online platform walks those seeking a permit through the rules around what can be burned and when burning is allowed and points out that burners should always check with local air quality management agency requirements before burning. The system also highlights on the residential burn permit page that the CAL FIRE permit is only valid within the SRA or where CAL FIRE has jurisdictional authority.

General burning includes agricultural burning, incinerator barrel burning, burn piles greater than 4 ft by 4 ft, small plots of grass or weeds, or burns on vacant lands. The permit is also used for project work that could cause a fire, such as outdoor welding or metal work. The process for getting such a permit includes up to a 10-day processing period and may require a site visit by a CAL FIRE battalion chief prior to the burning. A permit is required for each location of burning either by address or Assessor Parcel Number.

Broadcast Burn Permits are now easier to obtain for the controlled application of fire to the land for fuels reduction purposes. They are **not** for pile burning. Materials allowed to be burned under the Broadcast Burn Permit include only vegetation - brush, grass, timber, or timber slash. There are extensive pre-fire requirements for a burner requesting a Broadcast Burn Permit, including a site visit from CAL FIRE. Following the burn, CAL FIRE will look to see what was burned, with the overall goal to have the acres requested successfully treated (according to an interview with CAL FIRE staff).

CAL FIRE tracks all permit data from the online system, but they do not enter this data into PFIRS to avoid double counting of acres. Instead, they make their data available to CARB so that CARB staff can compare CAL FIRE data with what has been logged into PFIRS. Currently it is the responsibility of the burn manager to enter completed burn data into PFIRS via their SMP.

Since burn permits are not required by CAL FIRE in "Zone B," (see page 43 for detail on CAL FIRE permit zones) it is difficult for CAL FIRE to adequately track the annual amount of burning occurring in the state. However, CAL FIRE staff that manage the online burn permit platform have identified that people are requesting burn permits even when permits are not required, indicating that there is a desire to implement burns in a safe manner. It is not known how CAL FIRE staff addressed the requests to burn before the May 1st permit requirement, or if some waiting for a CAL FIRE response did not burn while waiting.

CAL FIRE staff shared that they plan to track reasons for denied permits through their online platform. They will do so through developing a list of options for denied burns that are consistent, standardizing the reasons for denial. This will allow for greater consistency across the state for burn denial reasons. CAL FIRE is working with CAPCOA to ensure that references to air district permit requirements are included within the platform. They also continue to work with districts on the development of SMPs for CAL FIRE-initiated burns.

CARB Title 17 Annual Report

Currently CARB does not plan to update the data reporting practices that are required from air districts under Title 17. CARB staff recognize the lack of enthusiasm on the part of many districts to do this reporting, which could be attributed to the fact that these reports do not seem to have a policy purpose. They also acknowledge that there is a shift among districts in using PFIRS as the primary data tracking system for prescribed fire efforts, which would explain the low level of prescribed fire reporting in the CARB annual reports. The original tracking which is more than 30 years old primarily tracked agricultural waste burning with some forest management and range improvement burning. CARB staff expressed openness to considering a more formal review of this process to look for improvements.

Section 5: Conclusion

Until the last 10 to 15 years, open burning of forest waste was the most accepted way of handling forest biomass waste. The rise in the frequency and intensity of wildfire has changed state and national dialogue on the issues of open burning and disposal of forest waste. There has also been increased momentum over prescribed fire and cultural burning activities to support enhanced forest health, helping to minimize wildfire risk, thereby protecting human health and ecosystem services. Thirdly, climate change is likely to exacerbate forest health issues leading to more serious implications for smoke management. Thus, this report does not intend to belabor the practices of prior generations of forest land management, but rather, focus on the path ahead. Moving forward, the administrative burden of managing permit programs should be weighed against the motivation to accomplish increased level of prescribed burn activities, while at the same time still achieving public health and safety values. For a full discussion of policy recommendations and future actions based on this study, see Part Three of this report.

Part Three: Comprehensive Conclusion and Recommendations

Comparison of Part I and Part II Sections

Part I of the report showed that air districts with the most acres of piles, and tons of biomass within those piles, as well as where those piles are close to roads, were in air districts that had a high portion of forest cover and/or recent wildfire activity. This is also the case for where burning is occurring, as described in Part II. This is likely reflective of day-to-day forest management and fuels reduction activities on private industrial timberlands and on public lands. Similarly, air districts with the greatest tonnage of material within 100 feet of a road include regions with an active wood products industry. A comparison of total acres of piles, total tons of piles, and total acres burned by air district is found below in Table 1.

When comparing the outcomes of the two parts of this report, however, there does not appear to be a correlation (beyond being in a forested area) between the districts where there are piles and where burning is occurring. It appears that burning activities are not necessarily based on biomass availability, but rather, other factors such as access to work force or funding. In the future, biomass removal priorities should consider places where there is easily accessible material, where such material is a significant fire threat to a populated or sensitive area, or where burning such material would generate smoke impacts to the public.

Table 1. Total acres and tons of piles compared to total acres burned by air district. Note that the Total Acres Burned data includes one less year than the data on piles—see methods sections of each report for details on years included in each analysis.

Air District Name	Total Acres of Piles	*Rank of Acres of Piles*	Total Tons of Piles*	*Rank of Tons of Piles*	Total Acres Burned	*Rank of Acres Burned*
	Years 2018-2022				*Years 2018-2021*	
Siskiyou	25,081	1	109,818	3	19,739	5
San Joaquin Valley	16,130	2	47,734	9	15,441	7
Northern Sierra	15,028	3	129,865	2	10,627	11
Tuolumne	11,732	4	41,338	10	12,504	9
Lassen	10,918	5	36,726	11	1,522	23
Placer	10,472	6	136,282	1	5,514	15
Shasta	9,467	7	48,685	8	18,626	6
Modoc	9,083	8	57,939	5	48,499	2
North Coast	5,845	9	71,859	4	47,621	1
South Coast	5,259	10	54,771	7	7,799	12
Calaveras	3,616	11	11,778	19	4,603	17
Butte	2,906	12	30,491	14	3,751	18
Great Basin	2,638	13	25,723	15	5,001	16

Air District Name	Total Acres of Piles	*Rank of Acres of Piles*	Total Tons of Piles*	*Rank of Tons of Piles*	Total Acres Burned	*Rank of Acres Burned*
	Years 2018-2022				*Years 2018-2021*	
Kern	2,397	14	56,723	6	59	33
Tehama	2,296	15	31,049	13	5,528	14
Mariposa	1,733	16	3,097	25	824	28
El Dorado	1,726	17	12,783	18	11,678	10
Bay Area	1,704	18	7,590	21	1,715	21
Amador	1,455	19	6,821	22	1,892	20
Feather River	1,311	20	15,507	16	1,318	24
Mendocino	1,232	21	14,899	17	12,877	8
Mojave Desert	942	22	6,802	23	-	35
San Diego	826	23	7,642	20	5,929	13
Santa Barbara	820	24	34,606	12	1,553	22
Ventura	750	25	1,058	29	34	34
Glenn	495	26	2,128	27	734	29
Antelope Valley	480	27	4,891	24	294	31
San Luis Obispo	393	28	1,214	28	3,163	19
Northern Sonoma	390	29	454	31	1,131	26
Colusa	185	30	15	32	944	27
Monterey Bay	109	31	867	30	30,481	3
Lake	109	32	2,408	26	24,608	4
Yolo-Solano	49	33	0	33	399	30
Sacramento Metro	0	34	0	34	1,219	25
Imperial	0	35	0	35	183	32
Total	**147,579**		**1,013,565**		**260,460**	

*NOTE: Total Tons of Piles is a different metric than the Total Tons of Biomass Burned per Acre as discussed in Part II.

Joint Recommendations

After comparison of the work provided, we offer the following recommendations to support the goals of improved fire protection and reduced open pile burning.

The Need for a Comprehensive Burning Data System

CARB and CAL FIRE both recognize the need for an improved PFIRS system to track information about anthropogenic fire and, particularly, how to motivate those who use the system to come back and fill in information about burn outcomes after a burn has been completed. Similarly, as mentioned in the results of the tons of biomass burned per acre analysis in Section 2 of Part II of this report, PFIRS could benefit from a “menu” of standardized values for tonnage estimates based on fuel type or project type. As the user friendliness of the system is enhanced, this will improve the likelihood it will be used more often and accurately.

Beyond this, the relationship between PFIRS and the Title 17 CARB reporting should be explicitly described and updated. It is recommended that the message is made clear to all those who use PFIRS that forestry-related data should be entered into PFIRS, and that CARB should develop a similar interface for agricultural burning.

Additionally, the state may consider deploying a data tracking system for non-agricultural burning, as well as for agricultural burning under 10 acres that do not trigger an SMP (which consequently may not be required by the local air district to be entered to PFIRS). As mentioned earlier, the amount of burning in the state is likely underreported. This may happen when burn managers do not report results in PFIRS. Some districts also suspect that unreported burns occur either because they are small burns that are not regulated as described above or because they are illegal burns. The lack of reporting could be problematic because without accurate reporting there may not be sufficient information to estimate total smoke impacts on given days, making it hard to protect public health and air quality. A comprehensive, modern, up-to-date online tracking system that also supports rural areas with paper forms would be ideal. This system would be made available by the state to the air districts free of cost and include annual training for district staff.

Permission to Burn is Given, but Lack of Resources Inhibits Activity

Results from our report suggest that the issuance of burn permits and SMPs from air districts are not the bottleneck to burning in California. The vast majority of burn permit and SMP applications are approved, and many districts are comfortable with allowing burning on CARB no burn days when local circumstances are acceptable. The current process for obtaining an SMP seems to work well in most districts, and the information requested to be included within the document seems sufficient to get to the data needed to understand the nature of the burns. Air district personnel have stated during interviews that they always work with practitioners to identify suitable burn days in place of a denied daily request to burn if conditions require the district to call a “no burn day.”

Despite this situation, the perception persists that air districts pose a regulatory barrier to advancing prescribed fire. It would likely be beneficial to continue this work by interviewing prescribed fire practitioners themselves on specifics regarding what they perceive to be the bottlenecks to burning. Due to this ongoing conundrum, air districts should ensure they have a good relationship with their local prescribed burn association, if applicable, or they should consider enhancing local public outreach to demonstrate their desire to see an increase in prescribed fire on the landscape through reasonable smoke management.

It is important to note that for the foreseeable future planned burns with CAL FIRE burn permits will be restricted by CAL FIRE burn bans due to fire weather conditions related to public safety that are outside the purview of air district authority. As public safety is paramount, and climate change continues to exacerbate weather conditions, it may not be safe to increase the number of days that are acceptable to burn.

There are more questions than answers about why some planned/permitted burn projects do not happen in California, as illustrated by the statistical information collected about the burn success rate derived from the PFIRS data. This could be due to a lack of trained professionals and resources to implement burning at the current scale and potentially this means that future expanded scales may be difficult to achieve. This would not be a regulatory barrier, but rather a fiscal and human resources and training problem. These findings point to the need for organized burning events or training sessions for small landowners who could then carry out burn projects and more financial investment in prescribed fire. Associated burn insurance issues are another important area to explore which, at the time of this report, are being investigated by the Wildfire and Forest Resilience Task Force[39].

In conclusion, while there will likely continue to be weather conditions that limit the safety of desired forest burning activities, CAL FIRE and local air districts working together to understand weather conditions can help to maximize burn day opportunities while ensuring public safety. However, to truly maximize burn opportunities, it is paramount to have trained staff prepared and available to burn when conditions are appropriate. While firefighters are excellent trained burners, it is important to have trained personnel *other than firefighters* for burning to truly maximize burn windows and opportunities and build a system around teams that are developed for maximum flexibility and mobility. With more such teams in place, prescribed fire project that are critical to climate and community resilience could happen even if a fire event is happening in other locations, and could improve the overall workforce climate for those who work in this sector.

Changes to Title 17

The Wildfire and Forest Resilience Task Force is working on developing recommended changes to Title 17 and presenting those to CARB to implement more prescribed fire and cultural burning. As mentioned previously, the SMP application and approval process seems to be working in most air districts. Districts have managed their smoke management programs under the current Title 17 regulations since 2001. This includes burns close to urban areas, burns in the wildland urban interface, remote burns, and managed burns. Air districts have balanced the need to burn with public health in minimizing smoke impacts when possible. Through this report there were no issues identified by the districts as problematic within this section.

One important area for discussion is the definition of agricultural burning and non-agricultural burning and the myriad of confusing references to what constitutes forest related burning. Due to the current understanding of the appropriate use of fire and the use of burning as waste disposal for biomass is typical (rather than prescribed fire as a forest management tool - not a method for waste disposal) in “agricultural” burning, a comprehensive look at the state laws defining these terms and other laws described in this report should be reviewed. Additionally, the state may want to consider adding sections around cultural burning. Any changes would need to be agreed upon for both

[39] Personal communication, 2023

fire and air in both of their state regulations as was done in the last definition change to Agricultural Burning.

Another area that could be tackled within a new subsection of Title 17 is how the state may want to regulate smaller (but numerous) burning activities in more suburban communities or in places with high fire risk. Further research would need to be undertaken to determine whether there is enough residential and non-agricultural burning generally occurring to warrant such an undertaking. It bears repeating, however, that many complaints about smoke are likely coming from small residential burns or burns occurring in communities of three- to five-acre parcels where burning is used as a waste disposal mechanism. In many suburban communities it is not air districts that have restricted burning, but other agencies. Whether it is through Title 17, or another state regulation, the promotion and funding of rural green waste disposal programs would go a long way in solving human exposure to smoke from outdoor burning, reducing public concerns.

The final topic area to consider is the way that Title 17 describes how local air districts can go through a process to include local fire agencies within the process as "Designated Agencies," which is discussed below. Opening Title 17 under a new rulemaking process, however, will more than likely mean adhering to new PM2.5 requirements. (Note that many air districts may be designated "non-attainment" districts in the near future by EPA.) The last amendment of Title 17 specifically stated that the changes included PM2.5, but the new standard had not happened yet (so the emissions calculated were PM10, the larger pollutant). Opening the regulations will change the emissions standards and more than likely the concerns over particle pollution.

Air District-Fire District Relationships and Residential Burning

There appears to be significant public confusion as well as confusion at the local fire and air agency level as to when and how smaller burns are permitted. The idea of trying to create a "one stop shop" for residents to get smoke management- and fire safety-related permits is a desirable goal. Fire and air districts (especially in air districts where there are formal relationships between the agencies in the air district rules) should work together to consider the current needs of the system in their region. Additionally, the new CAL FIRE burn permit system should be considered in this context, and if there could be efficiencies in utilizing this system with other jurisdictions. Success in this arena will be more likely if the Office of the State Fire Marshall and CAPCOA, among others work together, and agencies like CARB or CAL FIRE provide funding for software, training legal support for these and fire and air districts so that they can get functioning, consolidated permit systems in place.

Alternatives to Open Pile Burning

The final recommendation is not directly a result of the air district rules analysis, data collection, or interviews, but stems from the comparison of state climate and forest restoration goals with the waste management practices of the past. The state needs to increase the pace and scale of prescribed fire and cultural burning to meet its climate objectives. Current forest waste disposal mechanisms, however, are based on the ease

and cost savings of burning large wood waste piles in place or at landing decks, including some in very inaccessible locations. Burning large piles can impact air basin air quality. When possible, forest waste should be taken off site and processed for higher end uses. Some wood can be chipped and left dispersed on the forest floor, but too much can increase fire risk and, if burned in a wildfire, the high heat can damage soil health. It is also undesirable for forest waste to end up in a landfill or in compost which requires significant water treatments to be useful. Instead, we must look to traditional and innovative wood products such as bioenergy, biochar, and biofuels to sequester carbon or to displace fossil fuels to help solve this challenge. The air emissions from wood products and bioenergy are much less than from open pile burning[40]. This is why CAPCOA and many air districts support alternative wood use pathways to open burning[41].

Strategic Pile Burning

Cutting and piling of woody material whether by hand or machine is a necessary treatment for forest management, hazardous fuels reduction, prescribed fire unit preparation, and hazard tree management. With that said, together, the total acreage of piles created, potential issues they pose to wildfire control, potential escapes, emissions, and burning costs all suggest that alternatives to pile construction and burning be explored. To be clear, this is not a suggestion to ban or eliminate the burning of piles, but an emphasis that they should be built in areas where the use of machines for harvesting, chipping, and hauling are not a viable option, not as a default treatment in all areas. In an ideal world, limited fire crew capacity would be used implementing local and larger scale prescribed burns for fuels reduction and ecological restoration versus burning and tending piles of slash that could otherwise be chipped and spread or hauled for use in energy production or other forest products. When all of the costs of burning piles, particularly large machine piles accessible on existing road networks, we may find that paying for removal via machine is comparable with the costs of burning in many cases.

Recommendations

This report recommends the following general recommendations:

- CARB and sister agencies should continue to improve the PFIRS data system and work to include all air districts in the implementation of its use. Relatedly, relevant agencies should develop a more integrated tracking system for every type of burner and organization implementing burning activities.

- The California Wildfire and Forest Resilience Taskforce in partnership with CARB should consider a new approach Title 17 Agricultural Burn Reports collected by CARB so they can be most useful in the non-forest, agricultural burning sector, and perhaps for tracking larger non-agricultural burning and consider how definition amendments in the state Title 17 statute could be helpful.

[40] https://escholarship.org/content/qt29d705xw/qt29d705xw.pdf
[41] CAPCOA statement 2021

- With an increase in the number of CAL FIRE “no burn” days due to public safety concerns, non-federal prescribed fire crews funded by the state, local governments, and nonprofit groups, need to be more flexible and truly “on call” at all times of the year, and not dependent on personnel who might otherwise be already working on wildfires.

- The Department of Conservation, CalRecycle, and Joint Institute for Wood Products Innovation should support the removal of biomass wood waste from private non-industrial forested lands, especially within populated areas, through rural green waste hauling programs, and do so by creating an incentive program for local governments that include funding and training.

- Support development of value-added wood product markets from biomass to create complementary and ongoing partnerships that support forest restoration activities. Consider prioritizing those regions with the greatest tonnage of material within 100 feet of a road included that have an active wood products industry, as this would give the greatest short term potential reduction on potential pile burning and decay emissions.

- Consider using results of this study to help focus state forest health-related grant funds to areas with higher potential biomass material accumulations in the WUI.

Pile Management Recommendations

- Consider providing users with standard pile weights based on pile type (machine, hand), size, and spacing that would provide pre-estimated pile tonnages as standard inputs. The pile tonnage estimates can also be refined via the new application being developed by the California Office of Programs and Research (OPR), Cal Poly (San Luis Obispo), and Amazon.com. Once completed, the application will allow users to scan piles using a smart phone or tablet and quickly calculate pile volume and location.

- Forest managers should avoid creating piles in the WUI intended for burning, and prioritize funds available for chipping, burning, and removal of existing piles within the WUI. Limiting the burning of piles in the WUI will allow for more prescribed fire which allows land managers to achieve forest restoration and wildfire risk reduction goals.

- Forest managers should prioritize mechanical thinning and biomass removal in lieu of hand thinning and piling when feasible (such as for large treatment areas with gentle topography, and not in remote or sensitive areas) to ensure work is completed in an efficient and timely manner. Instead, build piles only in areas where the use of machines for harvesting, chipping, and hauling are not viable options.

Further Study Recommendations

- The cost of chipping biomass piles and top decks is not necessarily more expensive than burning. Thus, the cost per pile of burning needs further study to systematically determine true burning costs, including costs of potential mop up and escape, and also including non-monetary direct costs such as smoke impacts to communities, potential carbon emissions, and impacts on resource staffing for other prescribed fire projects.

- Residential burning and smaller burns that are not covered by SMPs cause most citizen complaints (rather than prescribed fires). CARB and CAPCOA should consider convening conversations with air districts about how to tackle small burning regulation. If there is interest, the state should supply funding and technical support to air districts and put data tracking systems in place to better understand small burning impacts on air quality and public health.

- CAPCOA and the State Fire Marshal should convene meetings with the local fire agencies and the air districts and support those agencies that may want to create one stop permitting shops. Consider how this might also work in conjunction with CAL FIRE's new online permit system for landowners in their jurisdictions.

- Develop a comprehensive strategy for amending the myriad of state definitions around anthropogenic burning that develops recommendations for changes in state law.

- Analyze the correlation between acres and tons of biomass burned and the proximity to a biomass conversion facility within ~50 miles.

- Provide additional research on how burning piles may impact WUI specific emissions and related human health.