MARKET CAPACITY ASSESSMENT

Southern Cascade and Northeastern Sierra Nevada OPR Pilot Project

Prepared for :
Fall River Resource Conservation District

Prepared by :
CLERE Inc.

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Lead Author — Clarke Stevenson, Analyst, CLERE Inc

Project team

- Sharmie Stevenson, Executive Director, Fall River and Pit RCD
- Todd Sloat, Principal, Forest Creek Restoration
- Regine Miller, Project Manager, Headwaters Environmental
- Christiana Darlington, Attorney-at-Law, CLERE Inc
- Zane Peterson, Owner, Peterson Timber Services

Interviewees:

- Chris Christofferson, Forest Supervisor, Modoc National Forest
- Keli McElroy, Ecosystem Staff Officer, Shasta-Trinity National Forest
- Andrew Mueller, Forester, BLM Applegate-Alturas Field Office
- Heidi Rodgers, Forester, BLM Redding Office
- Jeff Pudlicki, WM Beaty
- Galen Smith, Collins Pine
- Jeff Oldson, Burney Forest Power
- Alan Jacobson, Shasta Sustainable Resource Management
- Terrance Rodgers, Golden State Natural Resources (GSNR)
- Chris Trott, CT Bioenergy/GSNR
- Mark Rychlik, California Roundwood
- Doug Lindgren, Tubit Enterprises/Mt. Lassen Biopower/BOH Sawmill
- Hollis Day, Mountain Enterprises
- Roger Lord, Principal, Mason, Bruce & Girard
- Mark Rasmussen, Forest Economist, Mason, Bruce & Girard
- Roy Anderson, Vice President, The Beck Group
- Bill Carlson, Technical Consultant, The Beck Group
- Jason Moghaddas, Spatial Informatics Group

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DEFINITIONS AND ACRONYMS

Forest-based woody biomass: refers to the tree tops, limbs, and bark generated through the harvest of trees and production of lumber. It also refers to small diameter trees (<10 in DBH) or shrubs. Biomass can also go by the names: forest residue, forest biomass waste, excess vegetation, or woody debris.

BDT	-	Bone Dry Tons	MOU	-	Memorandum of Understanding
BLM	-	Bureau of Land Management	MTBS	-	Monitoring Trends in Burn Severity
BOE	-	Board of Equalization	NF	-	National Forest
CADFW	-	CA Department of Fish and Wildlife	OPR	-	Governor's Office of Planning and Research
CAL MAPPER	-	CALFIRE's Management Activity Project Planning and Event Reporter	OSU	-	Oregon State University
CAL VTP	-	California Vegetation Treatment Program	PGE	-	Pacific Gas & Electric
CFIP	-	California Forest Improvement Program	POU	-	Publicly Owned Utilities
DOC	-	Department of Conservation	RAVG	-	Rapid Assessment of Vegetation Condition after Wildfire
EROS	-	US Geological Survey Center for Earth Resources Observation and Science	RCD	-	Resource Conservation District
FACTS	-	USFS Activity Tracking System	RSA	-	Regional Supply Area
FMTF	-	Forest Management Task Force	SPI	-	Sierra Pacific Industries
FSC	-	Fire Safe Council	TCA	-	Terrestrial Condition Assessment
FVS	-	Forest Vegetation Simulator	THP	-	Timber harvest plan
GT	-	Green Tons	USFS	-	US Forest Service
GTAC	-	USFS Geospatial Technology and Applications Center	USFWS	-	US Fish and Wildlife Service
IOU	-	Investor Owned Utilities	VMP	-	Vegetation Management Program
LEMMA	-	Landscape Ecology Mapping and Modeling Analysis	WFRTF	-	Wildfire and Forest Resilience Task Force
MBF	-	Thousand board foot			

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EXECUTIVE SUMMARY

Overview

A century of intensive single-species harvest practices and the suppression of wildfire and cultural burning has led to a landscape with significantly higher stand densities of smaller, more fire-sensitive trees (Hagmann 2021; Cabiyo 2021; Knight 2020). Furthermore, climate-induced events like the 2012-2017 CA drought and the subsequent bark beetle infestation have led to wide-spread tree mortality and an increase in wildfire occurrence, acres burned, and fire severity (Crockett 2018). Over the next century, climate change will further exacerbate natural disturbances and impact the structure and composition of California forests (Stevens-Rumann 2017).

The Southern Cascades and Northern Sierra, as illustrated in Figure 1, has a mature timber market with mixed landowner types who manage the surrounding forests for varying management objectives. In the coming decades, regional strategies to influence wildfire behavior will need to expand fuel reduction and forest restoration treatments, which will produce large quantities of unmerchantable forest-based biomass and sawmill residue. More research is needed to understand market capacity to handle biomass, regional biomass availability based on current market conditions, and the ability for biomass markets to remove barriers to treating additional acres that would have otherwise not been treated.

In 2020, the Governor's Office of Planning and Research (OPR) was provided $3 million from the Wildfire and Forest Resilience Early Action Package to address economic development opportunities. $2.5 million was allocated to support new long-term wood feedstock pilot projects which OPR used to pilot 5 projects throughout the State. The pilots will develop plans to improve feedstock supply chain logistics within each target region through an institutional arrangement with the structure, authority, and resources to aggregate and initiate long-term feedstock contracts. Each project will explore and assess market opportunities of potential woody biomass businesses in their region and commit to increasing feedstock aggregation on all relevant land types, including private and noncommercial land, especially where opportunity exists to produce community fire resilience benefits.

Market Capacity Assessment – Northern Sierra Southern Cascade

The Southern Cascade and Northeastern Sierra Nevada—including Shasta, Lassen, Modoc, and Siskiyou Counties (Figure 1)—has a mature timber market with mixed landowner types who manage the surrounding forests for varying management objectives. In the coming decades, regional strategies to develop community and ecological resilience to high-intensity wildfires will need to expand fuel reduction and forest restoration treatments, which will produce large quantities of unmerchantable sawlog biomass and sawmill residue. Currently, some of the unmerchantable biomass is either pile burned or left in-woods to decay due to a variety of reasons including complicated market dynamics and the high costs of biomass removal. Adding new infrastructure and/or expanding existing infrastructure to handle the expected increases of residue from fuel reduction treatments is a widely supported solution to address these issues (FMTF 2021, Sanchez 2022, Cabiyo 2022).

Led by the Fall River and Pit Resource Conservation Districts (RCD), this Market Capacity Assessment aims to understand and quantify (1) long term average market capacity for forest harvests, (2) how much biomass is currently being generated from those harvests, and (3) how much biomass is being utilized by existing businesses today. This report focuses exclusively on forest-based biomass. Furthermore, due to the lack of a centralized point to anchor haul distances, this report does not analyze how much biomass *could be* removed with improved economics. Rather this report looks at market capacity under current market conditions.

1. Regional Resource Supply Area (RSA)

The Resource Supply Area (RSA) was selected based on natural features on the landscape including: ecoregions, public land boundaries, major highways, county boundaries, and likely areas for continued forest management by the Fall River RCD. The RSA contains over 7.6 million acres. Analysis found that this region contains 1.7 million acres of forested land that is suitable for biomass operations. Of this acreage, 90% can be considered productive timberland which includes mixed conifer and conifer dominant stands. Over 50% of all forested lands are managed by the US Forest Service, while 44% is managed by both large industrial and small private forest landowners.

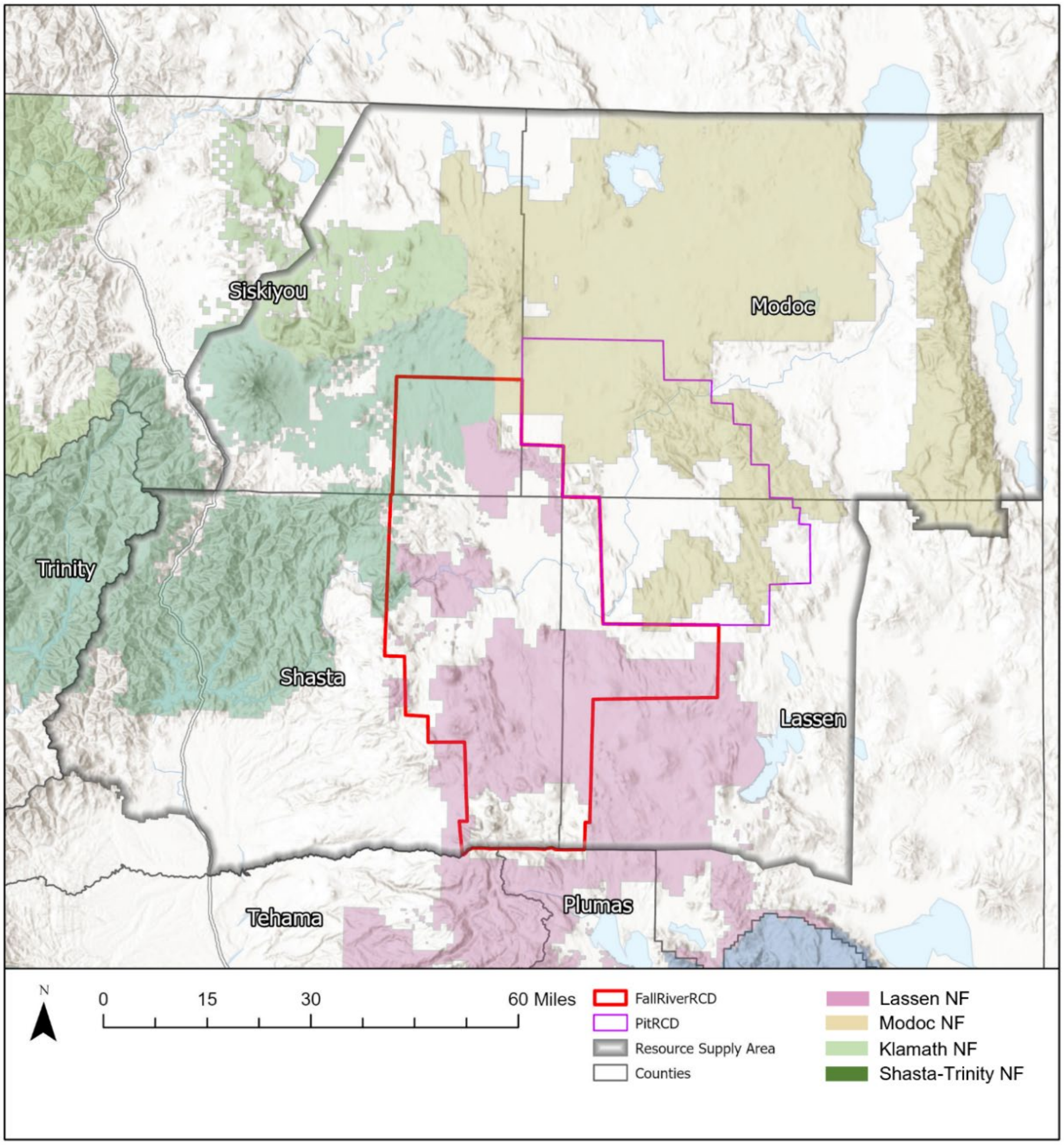

Figure 1: Resource Supply Area (RSA) boundary

In the last decade 1,477,993 acres of land have burned within the RSA due to wildfire. 71% of the acres burned (1,056,046 ac) occurred after 2018. Areas that burned at high severity are still common in a fire prone ecosystem (McIntyre, 2015). However, with increasing amounts of acres burning at higher fire severities than historically present, there is a general concern about future landscape conditions to regenerate as forest (Stephens, 2022). Over 68% of the wildfires in the last decade within the RSA can be considered beneficial. Only 12% of wildfires over the last decade were burned at high-severity. Yet, 99% of high-severity acres burned occurred in 2021. While a ten-year timespan is shorter than the expected historic fire return interval for the region, it is also illustrative of findings on the increasing amount of high severity acres burned across the Western US (Hagmann et al, 2021).

2. How much biomass is being generated in the RSA?

Potentially Available

In this report, potentially available biomass refers to the amount of biomass that is generated within various harvest operations but not necessarily available for the market to utilize. This should not be confused with gross biomass availability which may look at spatially explicit information to estimate the total amount of biomass that could be harvested from the forest. Several different categories of forest biomass exist to estimate potentially available biomass for new market development. These biomass estimates can be categorized as coming from private, public, or "other" lands. The "other" category is to represent fuel reduction projects funded by CAL FIRE and led by RCDs, Fire Safe Councils (FSC), and other non-profits not occurring on public land, or do not always require a Timber Harvest Plan. The following categories analyzed include:

- **Timber harvest residuals:** generated as a byproduct of commercial timber harvests and recorded through the Board of Equalizations (BOE) Timber Yield Tax. This category estimates biomass produced from any operations which cuts and sells trees as sawlogs.
- **Pre-commercial thinning:** timberland owners often use this silvicultural technique to improve stand conditions years before a timber harvest. However, rarely is there a viable market to pay for biomass removal of this material. Therefore, this category is not always recorded.
- **Fuel reduction and forest health:** CAL FIRE separately tracks fuel break and fuel reduction projects funded through their grant projects through their Cal MAPPER portal. These projects are not associated with private or public harvest databases, nor are represented appropriately through the BOE timber harvest records. These projects are growing in funding support and are expected to increase moving into the future.
- **Standing dead and fire killed trees:** Utilizing as many dead trees as ecologically and economically possible is a high priority due to the public safety concerns posed by dead trees to priority infrastructure like powerlines, roads, and buildings, as well as the implications for wildfire risk, and the ability to reestablish productive forests after a disturbance event (The Beck Group, 2017).
    - Concurrent with commercial harvests: Commercial harvest operations will remove some standing dead trees which can be sent to a biomass end-user in some situations.
    - Fire salvage within 100ft from roads: this report focuses on the amount of biomass that can be potentially salvaged within fire footprints from 2018-2021 based on burn severity data. Using a 100ft buffer around roads addresses the need to prioritize hazardous tree removal along ingress and egress routes.
    - Fire salvage within 101-1000ft from roads and above 20in DBH: a larger buffer around roads is applied to estimate additional biomass recovery, where trees above 20in in diameter at breast height (BDH) are considered economically viable.

In addition to estimating the volume removed, market capacity can also be estimated through acres completed per year. Over the last 10 years, the region has completed approximately 40,000 acres per year of forest treatments on private and public land. It is expected to complete at least 44,000 acres per year moving into the future when including CAL FIRE administered fuel reductions projects.

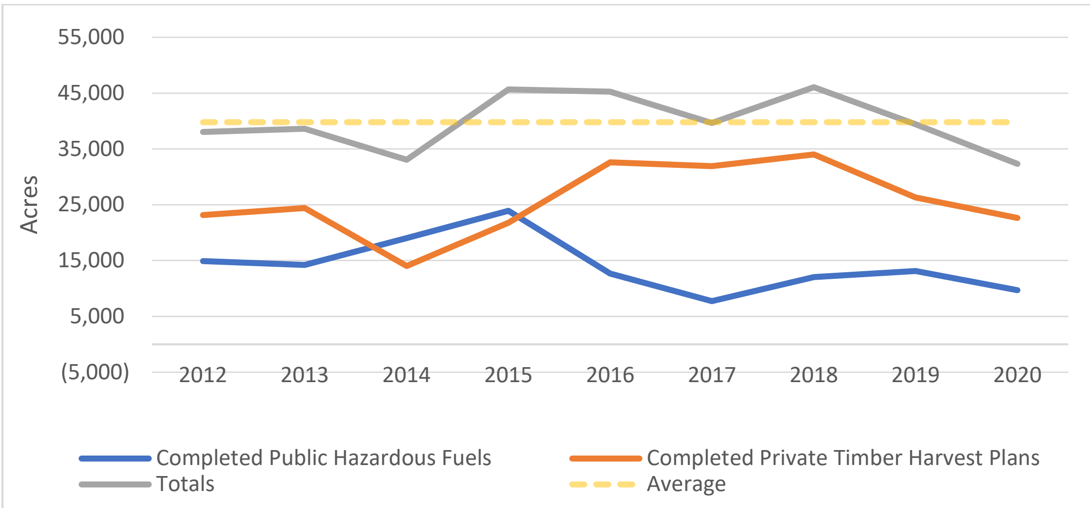

Figure 2: Acres completed within RSA over the last decade

Practically Available

Potentially available biomass estimates are the maximum estimate that could be procured within the RSA based on treated acres. However, the forest sector in general is prone to a variety of economic and environmental constraints which can impact the overall recovery of potential estimates, including: breakage and defects in logs, chip van accessibility, project size, NEPA delays, timber harvest plan costs, contractor availability, and unwillingness or inability for landowners to fund biomass removal (MBG 2019, CT Bioenergy 2018). Practically available biomass estimates are estimated by applying a conversion factor to the Potentially available estimates. This report assumes that 60% of the Potentially available biomass is available to the market for biomass utilization. However, conversion factors were customized for "pre-commercial thinning" and public land's "standing dead concurrently removed with commercial harvests". Very rarely are these feedstock sources made available to or prioritized for market utilization. Therefore, they were given a 0% conversion factor. However, given the presence of more outlets for this type of material, precommercial or mortality removed with harvests on public land may eventually become practically available given more favorable economics. As a reminder, economics is not taken into account in this analysis, but rather is looking at recorded market capacity for biomass over the last decade.

Practically available estimates also include utility vegetation management and sawmill residues into the final estimates. These were found through analysis and interviews with facilities within the region. Vegetation management from Caltrans was not included due to some limitations in reporting and analysis but may be included at a later date.

Our estimates show that there is over 1.1 million BDT practically available to the market within the RSA on an annual basis. 73% of this material is from private lands, while 15% and 12% are from fuel reduction projects funded by CALFIRE and public lands, respectively. These categories were further separated based on how reliable the biomass is made available on an annual basis. Over 938,000 BDT is produced on a sustainable basis. However, 202,000 BDT are opportunistic estimates for biomass procurement and should not be relied on as a recurring annual amount.

Annual Forest-based Biomass Practically Available	Public avg BDT	Private avg BDT	other avg BDT	Totals	
Harvest residue	21,377	184,787	-	206,164	
Pre-commercial harvests	-	-	-	-	
Fuels reductions and forest health	23,061	64,019	125,678	212,758	
Standing dead					
Concurrent with harvests	-	42,982	-	42,982	
Fire salvage - 100ft of roads	17,392	29,716	-	47,108	
Fire salvage - 101-1000ft of roads	21,355	48,209	30,383	99,947	
Practically Available	**83,186**	**369,713**	**156,061**	**608,960**	
Utility vegetation management	-	-	12,000	12,000	
Sawmill residues	53,834	465,342	-	519,175	
GRAND TOTALS	**137,020**	**835,054**	**168,061**	**1,140,135**	
Sustainable basis	**98,272** (±5,000)	**714,147** (±14,000)	**125,678** (±27,000)	**938,098**	82%
Inflated due to mortality and utilities	**38,748** (±18,000)	**120,907** (±37,000)	**42,383** (±14,000)	**202,037**	18%
	12%	73%	15%		

3. How much biomass is being utilized in the RSA?

There are currently six (6) major biomass utilization facilities and seven (7) sawmills operating within or around the RSA. While sawmill and biomass facilities are reliant upon each other in many ways when creating an efficient and effective supply chain, this report mainly focuses on biomass utilization facilities. Furthermore, forest-derived feedstock is only a part of the feedstock mix that a biomass utilization facility can procure from. Agricultural and urban wood waste are also both procurement sources but are not estimated here. There is approximately 783,505 BDT currently being utilized within the RSA.

Name	Type	MW nameplate	procurement within RSA	
Burney Forest Power	Bioenergy	31	100%	
Honey Lake Power	Bioenergy	31	14%	
Roseburg Forest Products Biomass Power	Bioenergy	15	43%	
Shasta Sustainable Resource Management	Bioenergy	55	70%	
Sierra Pacific Anderson Biomass Power II	Bioenergy	30	100%	
Sierra Pacific Burney Biomass Power	Bioenergy	20	100%	
Total		**182**	**783,505 BDT**	
Procured from sawmill residuals			402,529 BDT	51%
Procured from in-woods			381,497 BDT	49%

Net availability was calculated by subtracting the total practically available biomass estimates from the amount currently being utilized. The remainder will be forest based biomass under little competition from existing facilities in the region and can support a new business opportunity for utilization. There is a grand total of 409,646 BDT available for new wood utilization markets based on current and existing capacity within the region to operate. It is important to note that the amount of utilized "in-woods" biomass is less than the "sustainable procurement" estimate. However, the reality of providing an outlet to inflated sources on an ad-hoc basis suggests that there is varying availability in both the sustainable and inflated sources. Furthermore, due to sawmill residues being the lowest cost procurement source for many biomass utilization facilities, the estimated 144,282 BDT net availability may be a high estimate. As such, caution is advised when interpreting these results.

Procurement Source	Practically available feedstock Totals	Biomass Utilized	Net available
In-woods	620,960	356,117	264,843
Sustainable	418,922		
Inflated	159,055		
Sawmill residue	519,175	374,893	144,282
GRAND TOTALS	**1,140,135**	**730,489**	**409,646**

4. How much biomass will be generated based on desired treatment levels in the RSA?

This section of the report has been delayed. The California Resources Agency, Department of Conservation (DOC), and USGS 3DEP recently invested in a large, comprehensive acquisition of quality L1 lidar data in the region, which was collected in 2022. Together with existing QL2 lidar data, the region has a unique opportunity to conduct a precise inventory of biomass and meaningfully inform forest-level project bid packages as well as the Market Capacity Assessment. The 2022 lidar data are currently being processed and quality controlled, and the RCD's partnership with University of Washington and 34 North will continue to coordinate with public agencies for permission to conduct the forest structure and biomass estimation. As the DOC and USGS release the final lidar data, the RCD will immediately process these products to produce a forest structure condition assessment and update the biomass assessment, as needed. This analysis will be sure to include tree growth when projecting treatments into the future. The estimated timeframe to complete the terrestrial condition assessment is slated for the end of 2023.

5. Limitations and Considerations

It is expected that this document will help inform and support ongoing efforts to expand market availability for biomass utilization in order to address the region's community and ecological resilience goals. However, this report may not be suitable as a substitute for feedstock availability assessments required by new biomass utilization business plans. There are a number of aspects that this report fails to address that would be important for a new facility to understand. Rather, this report is most useful to inform efforts to initiate a quasi-public institutional arrangement to aggregate feedstock and lower risk for feedstock procurement contracts. The following are a few limitations to consider:

- **No economic considerations**. This report's goal is to look at the current fiber flow within the region given the current market conditions. As such it does not take into account the amount of biomass that could be available given more favorable economics. There is a reasonable assumption that siting new biomass outlets would provide an increase in biomass availability due to the reduction of haul distances and subsequent haul costs. However, this type of analysis requires a different methodology that was not within the scope of the project and is more appropriate on a case-by-case basis. Additionally, economic considerations to biomass availability have already been completed for all BioRAM facilities through the High Hazard Fuels Availability Study (MB&G, The Beck Group, 2019). Some economic considerations will be included in Tasks 4, 5, and 6 of the OPR project.
- **Market competition for biomass.** Competing demand for biomass was not fully analyzed in this report. Many reports (including this one) have shown that there is little concern regarding the total quantity of biomass supply throughout the state. Nevertheless, the location of the end-user, economics of removal, and access to the material are aspects of market competition that are particularly difficult to quantify for a region as a whole. The dynamics of an ever-changing landscape coupled with the strong relationships between various actors along the supply chain create forecasting competitive prices difficult. Instead, this report uses a simple "net-availability" approach to define how much biomass is produced on an annual basis but not utilized by end-users. However, while this number is quantifiable, the location of the excess biomass is much more difficult to identify and not within the scope of this report.
- **Estimates on how much will be procured in the future has not been completed.** With the exception of standing dead salvage estimates, research focused mostly on the 10-year recorded history of harvest activity. The numbers contained in the report identify the expected availability per year, but there may be more made available over the next decade due to political and funding support. Similarly, this report does not included biomass from PGE distribution lines, Caltrans roadside vegetation clearing, or improved access to small private landowners. With the acquisition of QL2 Lidar data, the team will be better equipped to estimate future biomass and support better forecasting.
- **Workforce capacity and housing availability.** Anecdotally, workforce capacity (especially hauling) is regarded as one of the largest constraints to reach state and regional goals for community and ecological resilience. While economics is also regarded as a critical lever to biomass utilization, the results found in this report may be inferred as a workforce constraint as much as it is an economic constraint. In other words, if the economics were more favorable, there would be more people willing to work in the sector. However, as stakeholder meetings revealed, housing availability and associated city amenities are limited in these rural regions. This discourages a potentially willing workforce from accepting positions in regions with a strong promise for biomass utilization

opportunities, thus linking market capacity back to workforce constraints rather than economics.

- **BioRAM program may end in 2025.** Over the next few years BioRAM—one of the most effective programs to support forest-based biomass utilization—may end. Unless the legislature approves an extension, the loss of this program may redirect a considerable amount of demand for forest-based biomass from participating facilities. This could simultaneously reduce competition demand for forest-based biomass resources as well as potentially strand more biomass out in the woods due to the loss of a subsidized program which targets high hazard fuels. It is hard to know how this will impact the market, but if the program is not continued it will certainly have some impact.

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OVERVIEW

Background

It is well understood that the forest conditions in California have significantly departed from the historical conditions (McIntyre 2015; Knapp 2017; Stevens-Rumann 2017). A century of intensive single-species harvest practices and the suppression of wildfire and cultural burning has led to a landscape with significantly higher stand densities of smaller, more fire-sensitive trees (Hagmann 2021; Cabiyo 2021; Knight 2020). Furthermore, climate-induced events like the 2012-2017 CA drought and the subsequent bark beetle infestation have led to wide-spread tree mortality and an increase in wildfire occurrence, acres burned, and fire severity (Crockett 2018). Over the next century, climate change will further exacerbate natural disturbances and impact the structure and composition of California forests (Stevens-Rumann 2017).

The Southern Cascades and Northern Sierra, as illustrated in Figure 1, has a mature timber market with mixed landowner types who manage the surrounding forests for varying management objectives. In the coming decades, regional strategies to influence wildfire behavior will need to expand fuel reduction and forest restoration treatments, which will produce large quantities of unmerchantable forest-based biomass and sawmill residue. More research is needed to understand regional biomass availability, general breakeven points for landowners, and the ability for biomass markets to remove barriers to treating additional acres that would have otherwise not been treated.

OPR Pilot Projects

In 2020, the Governor's Office of Planning and Research (OPR) was provided $3 million from the Wildfire and Forest Resilience Early Action Package to address economic development opportunities. $2.5 million was allocated to support new long-term wood feedstock pilot projects, $350,000 through an interagency agreement to spur innovation in the wood sector, and $150,000 to administer the development of the pilot projects.

As stated in the Wildfire and Forest Resilience Action Plan Objective 3.10, OPR funded five pilot projects to develop regional strategies to establish reliable access to woody feedstock through a variety of feedstock aggregation mechanisms and organizational innovations. The pilots will develop plans to improve feedstock supply chain logistics within each target region through an institutional arrangement with the structure, authority, and resources to aggregate and initiate long-term feedstock contracts. Each project will explore and assess market opportunities of potential woody biomass businesses in their region and commit to increasing feedstock aggregation on all relevant land types, including private and noncommercial land, especially where opportunity exists to produce community fire resilience benefits. The pilots are distributed across single and multi-county regions in the Central Sierra, the Lake Tahoe Basin, the Shasta and Lassen region, the North Coast and Marin County

Market Capacity Assessment – Northern Sierra Southern Cascade

The Southern Cascades and Northeastern Sierra Nevada—including Shasta, Lassen, Modoc, and Siskiyou Counties (Figure 1)—has a mature timber market with mixed landowner types who manage the surrounding forests for varying management objectives. In the coming decades, regional strategies to develop community and ecological resilience to high-intensity wildfires will need to expand fuel reduction and forest restoration treatments. This will produce large quantities of unmerchantable forest-based biomass and sawmill residue. Currently unmerchantable biomass is either pile burned or left in-woods to decay due to a variety reason including complicated market dynamics and the high costs of removal. A more robust wood products market is seen as a viable option which both addresses the issue and builds the local economy. Adding new infrastructure and/or expanding existing infrastructure to handle expected increases of residue from fuel reduction treatments will be necessary.

However, prospective wood products businesses face high barriers to market entry in California, and often face a near insurmountable challenge in securing long-term feedstock supply contracts. Without a guaranteed supply contract, facilities are not eligible for loans, debt servicing or other financing strategies.

This pilot project, led by the Fall River and Pit Resource Conservation Districts, is one of five projects in CA intended to meet the OPR Pilot Project Criteria. It is informed by several years of state-led work groups to address barriers to wood product market development. Both RCDs are committed to sharing information and will collaborate throughout the project period with all pilot project cohort members.

More research is needed to understand regional biomass availability, general breakeven points for landowners, and the ability for biomass markets to remove barriers to treating additional acres that would have otherwise not been treated. This Market Capacity Assessment aims to understand and quantify (1) long term average market capacity for forest harvests, (2) how much biomass is currently being generated from those harvests, and (3) how much biomass is being utilized by existing businesses today.

The MCA is the Task 3 deliverable for this region's OPR Pilot Project, and will be used to inform the potential to establish new biomass feedstock aggregation entities.

Overview of Methods

The following assessment uses methods from various feedstock feasibility assessments for new facility development. These reports satisfy both due diligence in market supply research and can sometimes draw conclusions about general market demand in the region of interest. They are valid documents for underwriting financial plans as required by major lenders. As such, a variety of methods have been stylized by consulting firms over the years, including: TSS Consulting, Mason, Bruce & Girard (MB&G), the Beck Group, and CT Bioenergy, LLC. Academic research has also conducted feedstock assessments as well, but often on a broader geographic scope to inform policy. Nevertheless, research conducted by California Polytechnic Humboldt State (in partnership with the University of Washington), UC Berkeley, and UC Davis helped inform this report. This report heavily relies on the methods of CT Bioenergy's (2018) analysis for a Biomass Utilization Facility in Tuolumne County, CA.

That said, caution is advised when interpreting the results found in this analysis. This report's findings will be primarily used to inform this region's OPR Pilot Project. Its results may complement individualized research on facility financial strategy, but may be inappropriate as the sole document to build a business model upon.

There are several categorizations of feedstock availability to understand when conducting a biomass availability assessment.

- **Gross potential availability:** is an estimate based on vegetation data either calculated from spatial data or surveys without regard to market capacity. This estimate is useful for projecting biomass estimates from future harvests. It is also useful for new facilities calculating their potential feedstock supply ratio after assuming a more favorable market price for biomass from the construction of their facility.
- **Potentially available:** is the amount of biomass generated from reported harvest activities occurring within the region and is constrained by economic conditions, workforce, and infrastructure available over the timeframe of the analysis.
- **Practically (or "technically") available:** is a fraction of the potentially available amount which accounts for limitations to gather, process, or transport the biomass.
- **Economically available:** refers to the net-availability of biomass under no competition from existing end-users within the region.

This report had a specific goal of understanding the fiber flow of the region under current market conditions. It relied on harvest records to understand market capacity. In other words, the gross potential of biomass availability was seen as less important than the ability for the region to practically mobilize biomass to the market. However, a spatial analysis on the gross potential availability from recently burned acres was conducted to illustrate the variability of biomass market supply due to large wildfires.

Excluding the gross potential estimate limits this report's ability to analyze harder-to-estimate biomass sources including: right-of-way utility corridor vegetation management, roadside vegetation management, and projected harvests on acres given a more favorable market price for biomass were available. These sources of biomass also proved to have more challenging methods to complete due to data acquisition restriction. However, the RCD, in partnership with 34 North, will be creating a comprehensive forestland database from L1 and QL2 lidar data in the next year. This new forestland database will be a more accurate assessment of biomass than the set of raster files used in this report, and can return to the above biomass sources in an addendum to this MCA.

Finally, the market capacity for biomass can be evaluated in two ways and primarily relies on timber harvest capacity. Timber harvest capacity can be estimated by the volume of fiber cut or the acres of land harvested. While some private landowners interviewed for this report manage their land based on the volume of sawlogs cut, the USFS and California's strategy documents rely on treated acres. This report focuses on estimating the volume of biomass produced. However, market capacity is also estimated in treated acres in Section 2.1.1.

1. REGIONAL RESOURCE SUPPLY AREA (RSA)

1.1 Resource Supply Area

The Resource Supply Area (RSA) was selected based on natural features on the landscape including: ecoregions, public land boundaries, major highways, county boundaries, and forest project work wood baskets for wood utilization. The RSA is 7,698,081 acres.

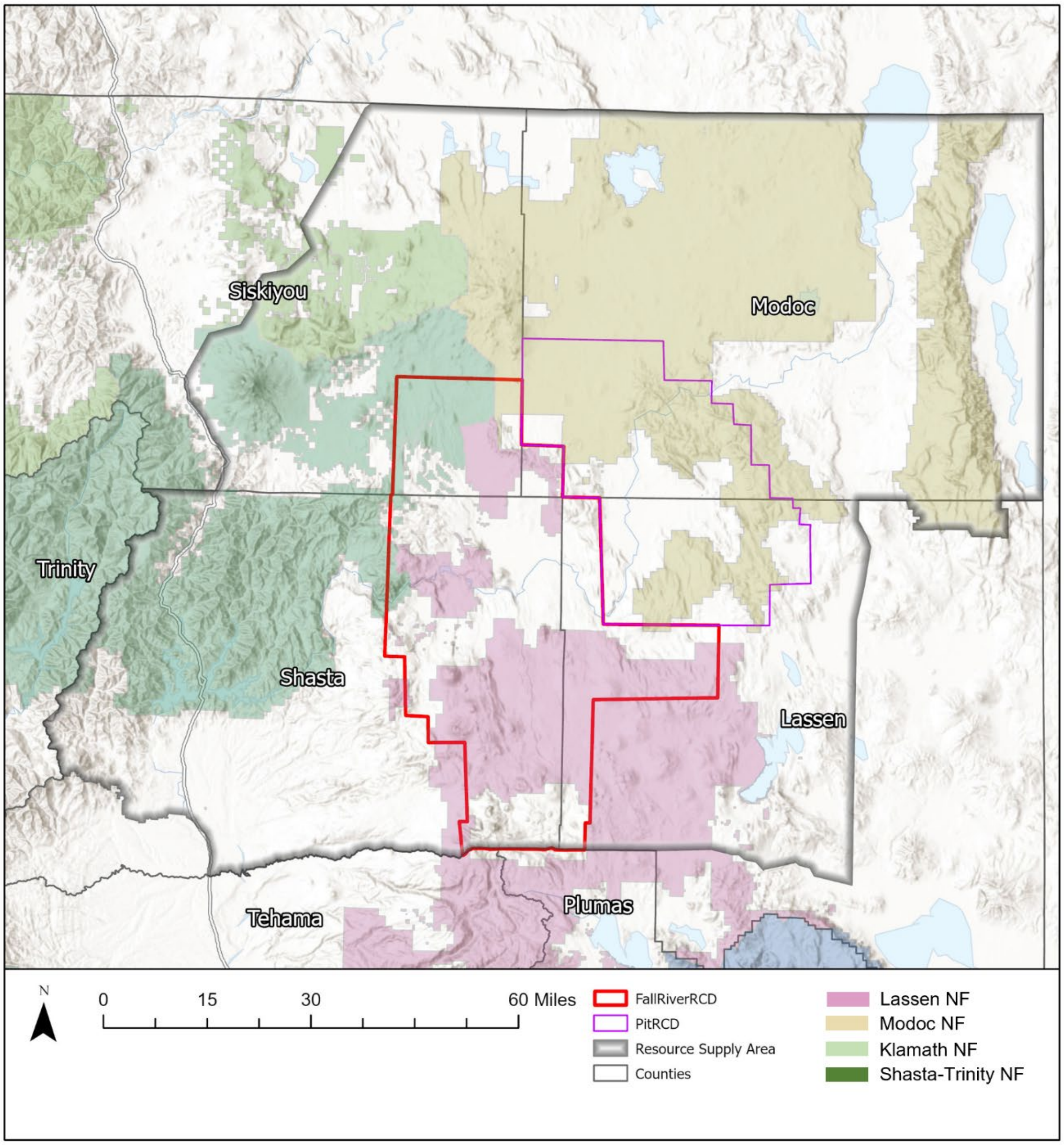


Figure 1: Resource Supply Area with National Forest System land and the Fall River and Pit RCD boundaries

1.2 Biomass Resource Base

There are several operational constraints associated with biomass removal. Due to these factors, analysis focused on what forests were "suitable" for operations. Suitability was developed by eliminating the following areas from analysis:

- slopes greater than 35%
- riparian zones with a 75ft average buffer on all water features
- wild and scenic river corridors – none
- endangered species reserve areas including the California Spotted Owl
- roadless and wilderness areas
- other non-timber management areas.

Additionally, tree mortality and high severity burns areas were included. Tree mortality from pest, drought, and fire within the last five years (2017-2021) are assumed to be eligible for salvage harvesting to biomass facilities under favorable economic conditions (CT Bioenergy, 2018). Salvage for lumber production occurs within the first two years post-fire (MBG, 2021).

1.2.1 Vegetation and Ownership

The RSA contains over 7.6 million acres. Vegetation classifications were collected from Oregon State University's (OSU) Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) group of spatially explicit metrics for forest landscapes along the west coast. LEMMA exclusively focuses on mapping forest land, and as such, all "non-forest" vegetation classes are simplified in this vegetation class dataset. For this reason, Table 1 shows three classifications (non-forest, sparse, and open) that encompass a variety of different land uses other than forests. Additionally, there is a row that includes all acres that were excluded from additional analysis due to the various features listed in section 1.2. The total remaining amount of suitable forest land for management is 1,760,380 acres. This can be further broken down by productive forests by focusing only on mixed conifer and conifer stands, which equals 1,604,587 acres. Approximately 92% of suitable forest lands can be considered productive timberland for biomass procurement. By removing broadleaf acres from analysis there is a loss of 155,793 acres. Broadleaf acres are most concentrated around the city of Redding (see Figure 1). Juniper is also recognized as a source for potential feedstock through sage-steppe restoration activities, but due to its limited market accessibility at the moment, it is lumped into the conifer vegetation class.

Table 1: Total acres within the RSA summarized by vegetation classification as processed by LEMMA (OSU 2017)

		RSA	Suitable	Change
			Acres	
	Non-forest	2,803,690	2,525,876	277,814
	Exclusions	--	1,317,633	--
	Sparse	414,546	341,780	72,766
	Open	1,716,132	1,401,398	314,734
	Broadleaf, <10in	215,881	100,885	114,995
	Broadleaf, >10in	117,580	54,907	62,672
	Mixed, <10in	100,055	57,214	42,841
	Mixed, 10-20in	339,715	140,223	199,492
	Mixed, >20-30+	35,207	6,079	29,128
	Conifer, <10in	374,473	287,641	86,833
	Conifer, 10-20in	1,258,626	935,213	323,413
	Conifer, 20-30in	289,637	162,468	127,168
	Conifer, >30in	32,539	15,749	16,790
Total	In RSA	7,698,081	7,347,068	1,668,647
	Forested only	2,763,713	1,760,380	1,003,333
	Productive timberland	**2,430,252**	**1,604,587**	**825,665**

Table 2 illustrates that approximately 50% of the suitable lands are owned by the USDA Forest Service (USFS), and 44% of the land is owned by private landowners. The US Fish and Wildlife Service (USFWS) and the CA Department of Fish and Wildlife (CADFW) own the remaining 6% of suitable timberland for operations. As shown in Table 3, of the 50% land managed by the USFS, 17% is managed by the Shasta-Trinity National Forest (NF), 19% is managed by the Modoc NF, 6% is managed by the Klamath NF, and 23% is managed by the Lassen NF.

Table 2: Total productive timberland acres summarized by land ownership. Unsuitable lands are an aggregation of non-forest, open, sparse, and operation exclusions.

	Unsuitable	Broadleaf	Mixed Conifer	Conifer	Suitable Lands Total	
	Acres					
Local govt	1,889	222	29	273	524	
BIA	1,913	51	69	150	271	
BLM	3,539	54	41	4,819	4,914	
Bureau of Reclamation	7,125	455	1,080	1,341	2,876	
NPS	23,715	548	48	655	1,251	
Other Feds	13,838	111	280	608	998	
US FWS	115,953	2,473	3,587	46,280	52,340	3%
USFS	2,346,850	24,498	54,687	794,585	873,770	50%
Non profit	13,962	1,398	169	35	1,602	
CA Dept FW	618,059	13,299	9,212	29,263	51,774	3%
CAL FIRE	109,141	27	3	914	944	
CA Dept of Parks	16,966	494	398	1,242	2,133	
Other State	5,182	10	16	410	436	
Private	2,308,555	112,153	133,898	520,495	766,547	44%
Total	**5,586,688**	**155,793**	**203,516**	**1,401,071**	**1,760,380**	
		9%	12%	80%		

Table 3: Total productive timberland acres summarized by National Forest

	Unsuitable	Broadleaf	Mixed Conifer	Conifer	Suitable Lands Total	
	Acres					
Shasta Trinity	746,979	19,230	43,800	230,215	293,244	17%
Modoc	1,604,412	5,912	14,007	316,682	336,601	19%
Klamath	148,182	411	2,179	94,966	97,555	6%
Lassen	441,705	9,622	27,448	367,662	404,732	23%
Non-NFS	2,645,409	120,617	116,083	391,547	628,247	36%
Total	**5,586,688**	**155,793**	**203,516**	**1,401,071**	**1,760,380**	
		9%	12%	80%		

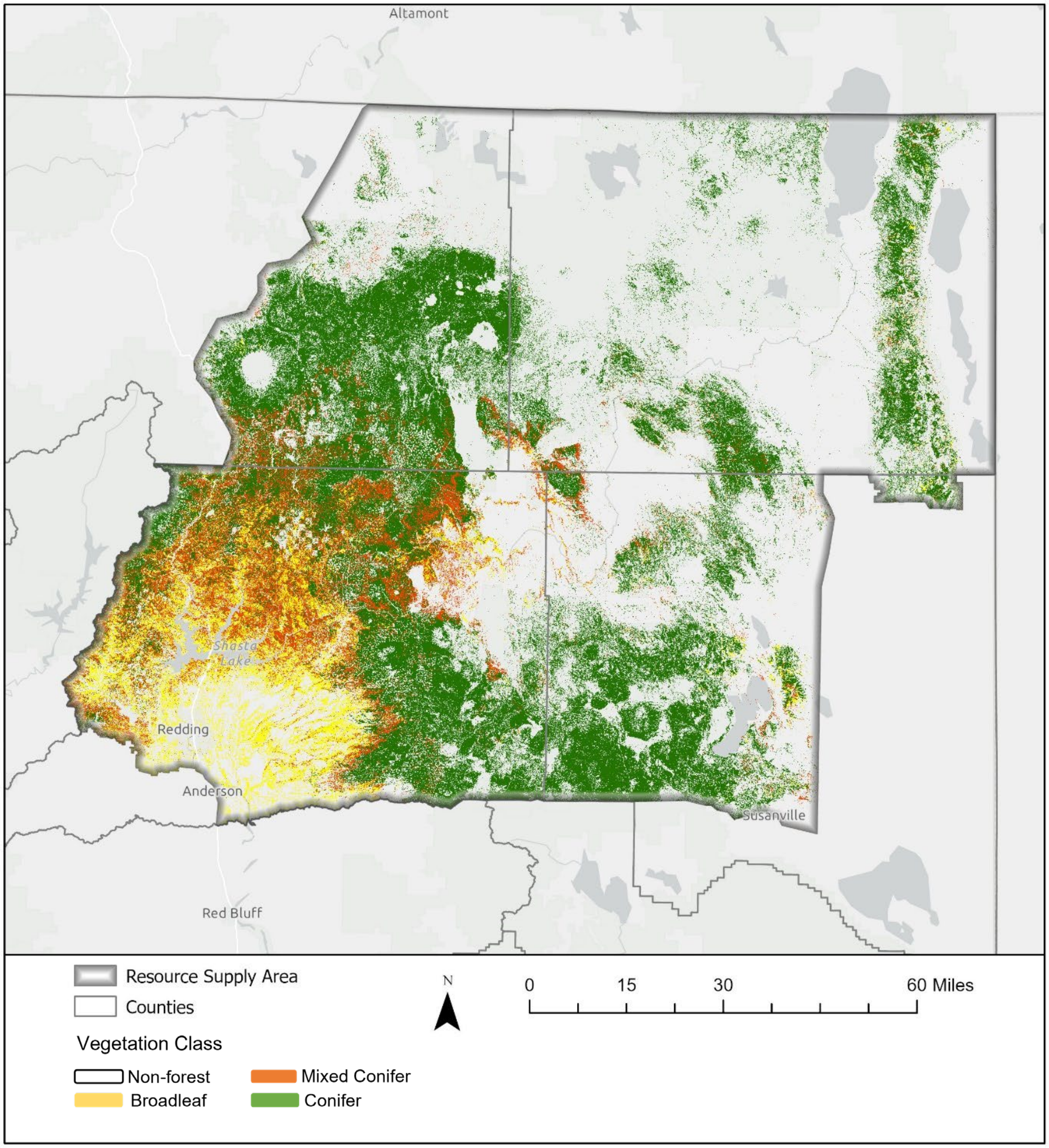


Figure 2: Forest type vegetation within the RSA

1.2.2 Wildfires

In the last decade 1,477,993 acres of land have burned within the RSA due to wildfire. 71% of the acres burned (1,056,046 ac) occurred after 2018. According to USFS Activity Tracking Systems (FACTS) database, 10 projects spanning over 600 acres originally planned for treatment on federal land have been lost to wildfire since 2018. It is hard to know how many planned projects on private land have been affected, however, 17 projects spanning over 224 acres have filed for "substantially damaged timberland" since 2017. This can illustrate how wildfires can impact years of work and money dedicated to preparing a harvest.

Burn scars are illustrated in Figure 3. 2021 burn scars are outlined in order to highlight the magnitude of acres burned within this one year, as well as to show areas of wildfire overlap within the last decade. The Dixie Fire is the largest wildfire which overlapped another fire in 2012, as shown in the southern boundary of the RSA.

Table 4: Ten year summary of wildfire acres burned within the RSA

	Acres
2012	214,284
2013	8,604
2014	95,305
2015	5,780
2016	3,251
2017	94,723
2018	404,113
2019	24,543
2020	258,201
2021	369,189
Total	**1,477,993**

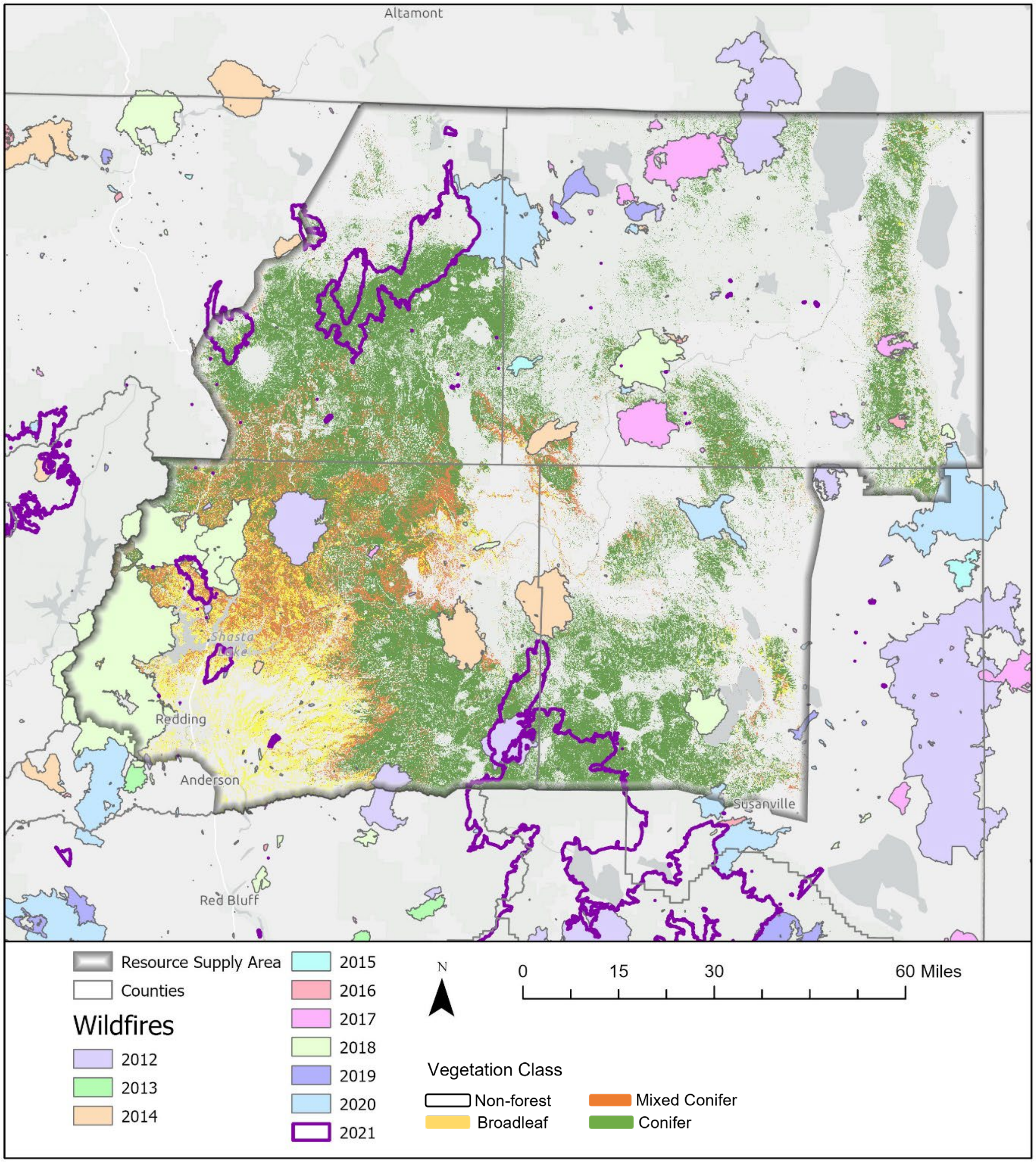


Figure 3: Ten year wildfire history within the RSA overlaid with forest type vegetation. 2021 wildfires are in outline to illustrate areas where burns overlapped

Of the 1,477,993 acres that burned, the analysis looked at burn severity of the largest fires identified through Monitoring Trends in Burn Severity (MTBS) and Rapid Assessment of Vegetation Condition after Wildfire (RAVG), both maintained by the US Geological Survey Center for Earth Resources Observation and Science (EROS) and the USFS Geospatial

Technology and Applications Center (GTAC). While MTBS is informed by RAVG, the two have different values used for their spatial datasets. This analysis considers increased greenness, unburned/low severity, and low severity as fire severity levels which are beneficial for the landscape.

Areas that burned at high severity are still common in a fire prone ecosystem (McIntyre, 2015), however, with increasing amounts of acres burning at higher fire severities than historically present, there is a general concern about future landscape conditions to regenerate as forest (Stephens, 2022). The region has experienced 144,785 acres of high severity fire where 99% of the acres burned occurred in 2021. This is consistent with findings on the increasing amount of high severity acres burned across the Western US (Hagmann et al, 2021). However, over 68% of the wildfires that have occurred in the last decade within the RSA can be considered beneficial. Only 12% of wildfires over the last decade were burned at high-severity.

It is important to note that wildfires did not exclusively occur in forested areas and therefore the following numbers should not be taken to directly account for damaged timberland and consequential tree mortality. Estimates on mortality from wildfires will be discussed in Section 2.1.4.

Table 5: Burn Severities of the largest wildfires over the last decade. Data collected from MTBS for 2012-2020 and RAVG for 2021. Increased Greenness was not included in RAVG's 2021 attributes. *The total number for "Unburned/low severity" is the sum of "Increased Greenness" and "Unburned/low severity" for 2012-2020 and "Unburned/low severity" for 2021.

	Acres		
	2012-2020	2021	Total
Increased Greenness	98,318	--*	--
Unburned/low severity	358,830	49,972	507,120*
Low severity	206,666	86,165	292,831
Moderate severity	169,603	72,469	242,073
High severity	884	143,900	144,785
Water	6,255	2,533	--
Total	**834,303**	**352,508**	**1,186,811**

These fires, however, have exacerbated issues within the region, especially as it relates to the forest product supply chain. As efforts to increase forest health, restoration, and resiliency projects are occurring throughout the region, the recently burned areas are being salvaged for harvest and processing. This has put considerable pressure on the supply chain. Sawmills have been overwhelmed with the potential supply of sawlogs (personal communication with industry experts). In 2021, Sierra Pacific Industries (SPI) stated they would need to prioritize their own burned sawlogs before allowing sawlogs not affiliated with their operations to be accepted at their facilities (Braxton Little, 2022). As SPI is the largest owner and operator of sawmills in the region, this has cascading effects throughout for forest operations (Braxton Little, 2022).

2. HOW MUCH BIOMASS IS BEING GENERATED IN THE RSA?

There are several ways to estimate nonmerchantable biomass for commercial products. This report will rely on timber operation records over the last 10 years in addition to an analysis on opportunistic volumes coming from recently burned areas. These feedstock sources will be further separated by potentially available and practically available. Potentially available biomass estimates are the maximum estimate that could be procured within the RSA based on treated acres. Practically available estimates take into account the myriad of constraints which may impact the ability for biomass to make it to market. For this report, practically available is a fraction of Potentially available estimates.

2.1 Potentially available

Several different categories of forest biomass exist to estimate biomass for new market development. These estimates can be categorized as coming from private, public, or “other” lands. The “other” category represents fuel reduction projects funded by CAL FIRE and led by Resource Conservation Districts (RCD), Fire Safe Councils (FSC), and other non-profits not occurring on public land, or do not require a Timber Harvest Plan. Primarily, the “other” category provides a place for fuel reduction projects subsidized through the CAL FIRE programs and only recorded through CALFIRE’s Management Activity Project Planning and Event Reporter (Cal MAPPER) database to be accounted for. Fuel reduction projects do not include projects which are funded by other entities such as the Department of Conservation, Wildlife Conservation Board, nor the Sierra Nevada Conservancy.

2.1.1 Timber Harvest Residuals within the RSA

Timber harvest residuals are generated as a byproduct of commercial timber harvest activities. These include tree limbs, tops, and sub-merchantable stems. Much of this material is rarely sent to a bioenergy facility unless economically viable. As such, this material is either piled for burning, decked at a landing, or lopped and scattered on-site.

Timber harvest levels were collected between the years 2012 and 2020 from the Board of Equalization (BOE) Timber Yield Tax and Harvest Value Schedules and recorded as thousand board foot (MBF) of sawlog cut per year by county. This data includes all projects which would bring merchantable timber to market including projects permitted under Timber Harvest Plans, Exemption Notices, and Timber Harvest projects occurring on public land. Further analysis on project contract levels and acreage per year are based on data from CAL FIRE Forest Practice GIS database for Timber Harvest Plans (THP), and the USFS FACTS Hazardous Fuels database. Nonindustrial Timber Management Plans were not included in analysis.

The BOE volume cut data was collected for the four counties within the RSA (Shasta, Modoc, Siskiyou and Lassen). A weighted treatment intensity factor was calculated in order to estimate the fraction of sawlog volume being generated within the RSA. While some other studies might use different methods to estimate fraction of volume produced within a RSA, this report sought to find a method that more directly corresponds to volume production based on county activity. For example, of all the projects conducted within Lassen County, 74% of them occurred within the RSA. In this regard, 100% of Modoc County's projects occur within the RSA, Shasta has 98% of projects in the RSA, and Siskiyou has 60%. Total weighted average for all treatments occurring within the RSA for these four counties is 76%.

Experts in the California biomass utilization sector estimate a 0.9 BDT recovery factor for timber harvest residuals for every MBF sawlog (TSS Consultants, 2020). Using this conversion factor, Table 5 shows that the region produces approximately 452,114 BDT, based on an average sawlog production of 502,349 MBF from 2012 to 2020. Using the treatment intensity adjustment of 76%, this equates to 343,607 BDT generated within the RSA. Percentages are displayed on the edges of the table – 90% of the biomass generated through timber harvest is associated with private landowners.

Table 6: BOE Timber Harvest Volume Cut between 2012 and 2020 in Lassen, Modoc, Shasta and Siskiyou Counties. A weighted treatment intensity by county percent was applied to total estimates in order to calculate the amount of MBF and corresponding BDT occurs within the RSA

Year	Vol (Public)	Vol (Pvt)	Total	Total	Within RSA (76%)	
	MBF			BDT		
2012	-	445,112	445,112	400,601	304,456.61	
2013	81,371	513,351	594,722	535,250	406,789.85	
2014	47,442	436,906	484,348	435,913	331,294.03	
2015	70,730	506,643	577,373	519,636	394,923.13	
2016	93,151	364,854	458,005	412,205	313,275.42	
2017	56,701	415,562	472,263	425,037	323,027.89	
2018	50,771	439,193	489,964	440,968	335,135.38	
2019	23,705	477,934	501,639	451,475	343,121.08	
2020	44,930	452,784	497,714	447,943	340,436.38	
2021	-	-	-	-	-	
Average	**52,089**	**450,260**	**502,349**	**452,114**	**343,607**	
BDT (Public)	46,880	-			35,628.84	10%
BDT (Private)	-	405,234			307,977.80	90%

To compliment BOE volume cut records, this report also investigated the amount of projects and acres being completed in the region using the CAL FIRE Timber Harvest Plan (THP) and the USFS FACTS Hazardous Fuels datasets. The USFS FACTS Timber Harvest data was also originally included for analysis, but further inspection found that nearly all projects listed in the Timber Harvest database were double counted in the Hazardous Fuels database. This research effort did not try to account for the double counting between both datasets, but instead selected the Hazardous Fuels data to best represent USFS harvest practices. Caution should be exercised in correlating the number of acres treated to the number of sawlogs or biomass feedstock produced for the region. It would be difficult to correlate these two numbers accurately due to varying forest compositions throughout the region.

In both the CAL FIRE and USFS datasets, many treatment types were not suitable for analysis. Selections were made for both datasets that best represent the type of treatments expected to produce biomass feedstock. They were then separated by their project status in order to isolate those which are completed, although projects which have been approved but not completed are briefly summarized in the following section as well.

Completed projects (2012-2021)

An average of 39,796 acres per year have been completed over the last decade through 802 contracts within the RSA. The highest acreage amount the region has completed was in 2018 with approximately 46,067 acres. 64% of the acres and 68% of the contracts completed were by private landowners. This equates to 381,785 MBF sawlog Scribner being produced within the RSA over the 9 year period, where the highest reported sawlog output being 451,988 MBF in 2013.

Table 7: Completed project count and acres occurring within the RSA under private THP and public Hazardous Fuels project types

Year	Net MBF Sawlog by Treatment Intensity	Completed Public Hazardous Fuels		Completed Private Timber Harvest Plans		Totals	
		Count	Acres	Count	Acres	Count	Acres
2012	338,285	287	14,929	289	23,141	576	38,070
2013	451,988	218	14,195	759	24,437	977	38,632
2014	368,104	309	19,031	348	14,025	657	33,057
2015	438,803	414	23,923	730	21,762	1,144	45,685
2016	348,083	313	12,673	384	32,603	697	45,275
2017	358,919	168	7,734	633	31,905	801	39,639
2018	372,372	169	12,049	876	34,018	1,045	46,067
2019	381,245	285	13,119	613	26,291	898	39,409
2020	378,262	143	9,714	283	22,615	426	32,330
2021	-	--	--	--	--	--	--
Average	**381,785**	**256**	**14,152**	**546**	**25,644**	**802**	**39,796**
			36%		64%		

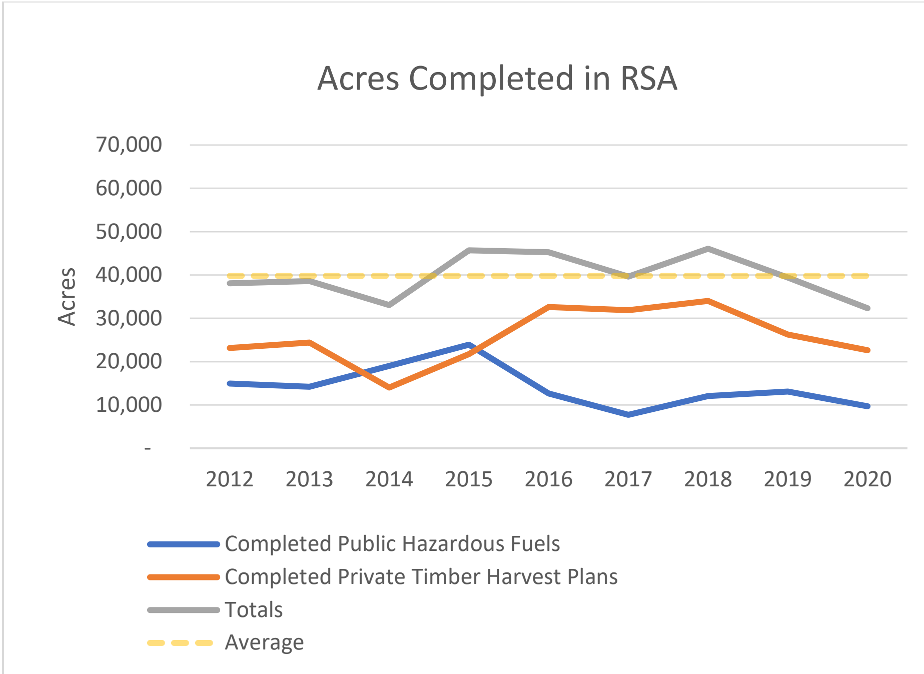


Figure 4: Completed acres within the RSA. Average acres completed = 39,796 acres per year

Active Projects (2014-2021)

Projects go through various stages of planning before they are completed. As such, the status of "active" projects—or those projects that have been approved but not completed—can be estimated in order to provide context on what type of projects are expected to enter the market. While these projects can represent recently permitted projects over the last few years, there are some projects which are about to surpass their max contract length allowed for Timber Harvest Plans (5 years; with a possible 2 year extension). For this reason, projects have been filtered to only include those within their max contract length (2014-2021). This information may be useful in understanding how many projects are active in the region as well as how many projects risk potential abandonment due to various unforeseen factors.

This data provides a unique perspective that isolates how many older projects have been planned and approved for operations but have not been completed within their permitted timeframe. It should be noted, however, that project completion forms can be submitted at any point after project completion for Timber Harvest Plans (personal communication with CAL FIRE). Therefore, many active projects may have already completed operations and are now waiting until the end of their contract to submit records. Due to this time lag complication, this report does not carry through biomass implications on active projects but rather relies on completed acre averages as the market capacity. Workforce capacity, limited infrastructure, and increasing occurrence of disturbance all are more likely constraints determining baseline biomass availability for the region.

Table 8: Active project count and acres occurring within the RSA under private THP and public Hazardous Fuels project types

	Active Public Hazardous Fuels		Active Private Timber Harvest Plans		Totals	
Year	Count	Acres	Count	Acres	Count	Acres
2012	--	--	--	--	--	--
2013	--	--	--	--	--	--
2014	33	2,616	448	17,995	481	20,611
2015	27	2,292	635	32,963	662	35,255
2016	127	9,299	585	24,605	712	33,904
2017	38	3,669	735	20,218	773	23,887
2018	187	8,185	821	32,526	1,008	40,710
2019	222	19,281	783	39,813	1,005	59,093
2020	296	18,118	856	35,829	1,152	53,948
2021	70	4,271	833	25,005	903	29,276
Average	133	9,066	695	29,136	828	38,201
Total	1,000	67,731	5,696	228,954	6,696	296,685

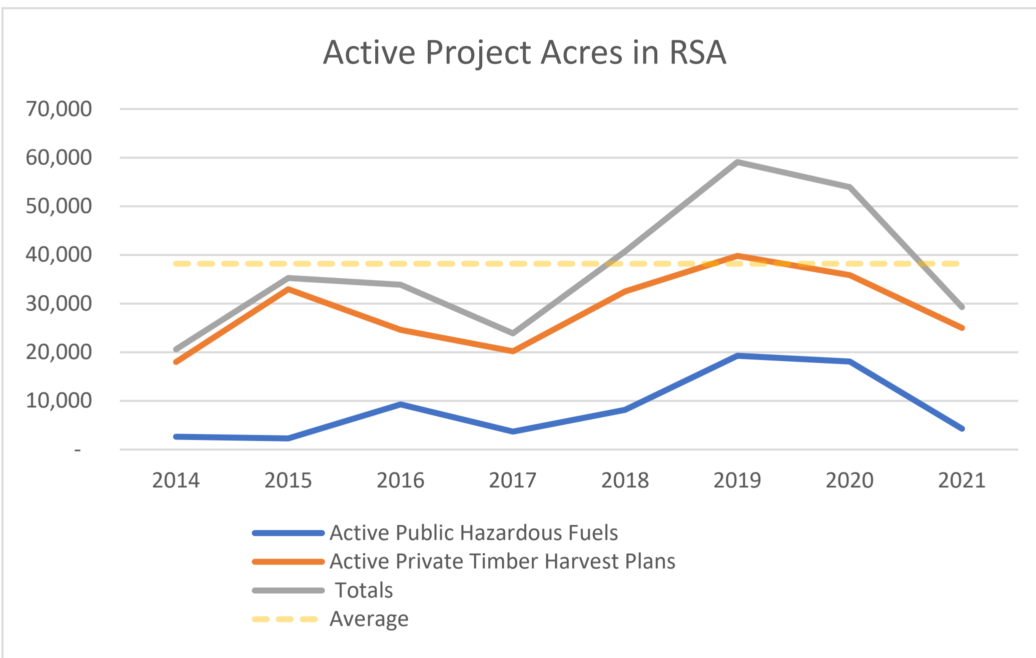


Figure 5: Active acres within the RSA. Average acres active = 38,201 acres per year

2.1.2 Pre-commercial thinning

In addition to timber harvest residuals, land managers can also employ precommercial thinning: a silvicultural treatment to support tree vigor and growth by increasing space between trees through the removal of less favorable trees or saplings. Because permits or tax documents must be filed only when timber or biomass is to be removed from site operations, this practice is not always recorded through the Board of Forestry (BOF) as material is lopped and scattered on-site. Rarely is there a viable market to pay for the biomass produced to warrant the removal of this material, thereby necessitating records (personal communication with operation experts, 2022). Nevertheless, timberland owners often use this management technique to improve stand conditions before a timber harvest. For this reason, it can be seen as a potentially available resource if given favorable economic conditions. This nuance will be translated appropriately in practically available estimates.

CAL FIRE THPs treatment types isolated commercial thinning, alterative prescriptions and clearcut acres as the most likely harvest prescriptions to leverage a pre-commercial thinning. USFS FACTS Hazardous Fuels database has a precommercial treatment type, and as such, was the only type included in analysis.

Precommercial thinning biomass removal rates are estimated to range between 3 BDT per acre to 9 BDT per acre based on forest treatment residue projections modeled with Forest Vegetation Simulator (FVS) under the California Biopower Impacts Project (Comnick and Rogers, 2018). When applying this to the average amount of harvested acres completed per year, approximately 119,387 to 358,163 BDT are estimated to be produced on an annual basis. This report will use the average in final estimates.

Table 9: Pre-commercial thinning potential biomass availability estimates. Low BDT estimates are 3 BDT per acre. High BDT estimates are 9 BDT per acre

TREATMENT TYPE	Acres	Low BDT	High BDT	Average BDT estimate
Pre-commercial thinning				
Public (USFS FACTS)	3,342	10,027	30,080	20,053
Private (THP)	9,278	27,834	83,503	55,669
Total	**12,620**	**37,861**	**113,583**	**75,722**

2.1.3 Fuel Reduction and Forest Health Projects

In addition to commercial harvests and pre-commercial thinning, there is a growing amount of fuel reduction projects being conducted throughout the region by private and public landowners as well as those administered by RCDs, FSCs and non-profits. These projects are not necessarily incorporated into the estimates of BDT from MBF, nor pre-commercial harvests, although they may employ similar silvicultural prescriptions to commercial and pre-commercial harvests. For this reason, biomass removal rates were adjusted to reflect more accurate estimates based on personal communication with operational experts in the region. BDT per acre is estimated to range from 9 to 14 BDT per acre. This is also consistent with other feedstock availability reports conducted in California. For projects occurring on private land, permits for fuel breaks and defensible space, and commercial thinning were analyzed. For public land, projects which completed fuel break, pre-commercial thinning, commercial thinning, sanitation cuts, and thinning for hazardous fuels were all analyzed.

Additionally, CAL FIRE separately tracks fuel break and fuel reduction projects not associated with THPs or the USFS FACTS database through an online viewer called the CAL FIRE CalMAPPER. This GIS application tracks fuel reduction projects under one of several CAL FIRE programs, including: California Vegetation Treatment Program (Cal VTP), California Forest Improvement Program (CFIP), Fire Plan, Forest Health, and the Vegetation Management Program (VMP). Some projects are double counted through the USFS FACTS database as well, but upon further inspection, these projects were related to broadcast burning, and therefore, were removed from analysis. Within these programs there are a variety of other treatment types that can be conducted, including fuel reduction. Projects permitted under "biomass utilization", "broadcast burn", or "reforestation" were removed from analysis. Ecological forestry, forestland stewardship, fuel break, fuel reduction, pest management, and right of way were all treatment types included in analysis. Data from THPs, USFS FACTS, and the Cal MAPPER were all incorporated into the analysis.

After clipping the Cal MAPPER data from 2012 to 2022 to the RSA, analysis found that the region had 107,394 acres completed or actively being completed under all the CAL FIRE programs. Of these acres, 84% (90,671) are from fuel break and fuel reduction projects. Fifty-five percent (55%) of all treatments included in analysis are conducted under the Fire Plan program, with 32% coming from the Forest Health program. Sixty-two percent (62%) of all completed and active projects have been recorded within the last two years (2020-2022).

The average 10-year project acreage for completed and active projects within the RSA is 9,755 acres per year, with 84% being fuel break and reduction projects. Because these types of projects have become increasingly more prioritized over the last decade, averaging the last 10 years would not be a fair estimate on future trends. There is a clear upward trend in completed and active acres being conducted in the region. On a 5-year average (2017-2022), acres increase to 14,574 acres per year, with 90% being fuel break and reduction projects. On a 3-year average (2019-2022), the region completed or was in the process of completing 19,086 acres per year, where 95% of them are associated with fuel reduction projects. Due to the political and public support to continue working on fuel reduction projects to reduce wildfire risk, this analysis assumes that the best estimate will be based on the 3-year averages.

Table 10: Annual project count and acres completed or active under the Cal MAPPER project viewer

		Completed		Active		Total		Fuel reductions only		
	Year	Count	Acres	Count	Acres	Count	Acres	Count	Acres	% of Total Acres
	2010	1	162			1	162			
	2011	4	733			4	733	3	76	
	2012	18	4,444			18	4,444	12	2,972	67%
	2013	4	2,711			4	2,711	4	2,711	100%
	2014	9	1,236			9	1,236	6	1,185	96%
	2015	16	4,355			16	4,355	12	1,791	41%
	2016	38	7,117			38	7,117	17	3,641	51%
	2017	35	4,718	3	540	38	5,259	26	2,882	55%
	2018	48	5,790	1	49	49	5,839	29	2,633	45%
	2019	18	1,980	8	919	26	2,899	16	1,757	61%
	2020	17	2,713	15	20,031	32	22,744	19	21,544	95%
	2021	17	4,369	21	2,209	38	6,579	23	5,822	89%
	2022	12	1,063	35	43,059	47	44,122	34	43,734	99%
2012-2022	10yr avg					29	9,755	18	8,243	84%
2017-2022	5yr avg					38	14,574	25	13,062	90%
2019-2022	**3yr avg**					**36**	**19,086**	**23**	**18,214**	**95%**

Table 11: Potentially available biomass estimates from only fuel break and fuel reduction treatments within Cal MAPPER

		Fuel Reduction			All Treatment Types		
		low	high	average	low	high	average
2012-2022	10yr avg	74,185	115,399	94,792	87,794	136,568	112,181
2017-2022	5yr avg	117,557	182,866	150,212	131,162	204,030	167,596
2019-2022	3yr avg	163,928	254,999	209,464	171,774	267,204	219,489

After combining all three datasets on fuel reduction and forest health projects, the estimated total biomass generated from these projects is 354,597 BDT per year.

Table 12: Annual Potentially available biomass summary for Fuel Reduction and Forest health projects

TREATMENT TYPE	Acres	Low BDT	High BDT	Average BDT Estimate
Fuel Reduction and Forest Health				
Public (USFS FACTS)	8,978	30,080	46,791	38,435
Private (THP)	1,147	83,503	129,894	106,699
Other (CalMAPPER)	18,214	163,928	254,999	209,464
Total	**28,339**	**277,511**	**431,684**	**354,597**

2.1.4 Standing dead and fire-killed trees

Tree mortality is a natural factor of forest succession and nutrient cycling. However, as tree mortality rates have risen due to the 2012-2017 drought, subsequent bark beetle infestation, and increasing occurrence of large, high severity fires, more operations throughout the Sierra Nevada are having to address this issue through hazardous tree removal, salvage, or sanitation cuts (The Beck Group, 2017). Utilizing as many dead trees as ecologically and economically as possible is a high priority due to the public safety concerns posed by dead trees to priority infrastructure like powerlines, roads and buildings, as well as the implications for wildfire risk, and the ability to reestablish productive forests after a disturbance event (The Beck Group, 2017).

2.1.4a Removal concurrent with harvests

When looking at the geospatial forest structure data from LEMMA, the highest concentrations of mortality were around Medicine Lake and the Lassen Volcanic National Park in 2017. Statistical summary found that there is approximately 2.79 BDT of standing dead biomass per acre on all forest types based on LEMMA's standing dead biomass volume estimates. One report conducted in the Southern Sierra estimated biomass availability from dead trees removed concurrently with harvests (CT Bioenegy, 2018). When applying the same methods to this analysis, we found the region could potentially expect 111,169 additional BDT. However, it is unclear how much of this number may already be incorporated in other calculations analyzed through this report.

Table 13: Potentially available average BDT estimate from standing dead concurrently removed with harvests

Year	Completed Public Hazardous Fuels	Completed Private Timber Harvest Plans	Totals	BDT Concurrent with Harvest
	Acres			
2012	14,929	23,141	38,070	106,348
2013	14,195	24,437	38,632	107,918
2014	19,031	14,025	33,057	92,343
2015	23,923	21,762	45,685	127,620
2016	12,673	32,603	45,275	126,476
2017	7,734	31,905	39,639	110,731
2018	12,049	34,018	46,067	128,687
2019	13,119	26,291	39,409	110,089
2020	9,714	22,615	32,330	90,313
2021	--	--	--	--
Average	**14,152**	**25,644**	**39,796**	**111,169**
BDT Concurrent with Harvests	39,533	71,637		

2.1.4b Fire-Killed Trees

Since 2017, a number of wildfires have occurred in these areas. As such, it can be assumed that additional mortality has occurred within these fire footprints which would have localized standing dead biomass to burn scars and magnified the overall mortality factor per acre. For these reasons, this report focuses on the amount of biomass that can be potentially salvaged within fire footprints from 2018-2021 based on burn severity data collected from the Monitoring Trends in Burn Severity (MTBS) dataset.

The analysis focuses on wildfires from 2018 to 2022 due to the rate of decay for fire-killed trees. Mason, Bruce and Girard (MBG) reported that deterioration rates for fire salvage are dependent on tree size and species (OFRI 2020), where all sizes and species lose 20% of their volume within the first 3 years. Interviews conducted with bioenergy facilities in the region state that they would prefer to have salvage logs chipped within 2 years, despite having logs that have been on their feedstock yard for at least 4 years (personal communication with bioenergy facility operator, 2022). CT Bioenergy applies a 3.4 to 11.2 year range of viability for beetle-killed tree mortality before felling the tree becomes a hazard (CT Bioenergy 2018). Mason Bruce and Girard state that dead trees can be safely harvested for approximately five years beyond a mortality event, which was confirmed with personal communication from CT Bioenergy (MBG 2019). Assuming that this report would be useful for another few years, only fires within the last 4 years were assessed.

2017 living biomass estimates were first summarized within wildfire footprints from 2018 to 2021. Because LEMMA forest structure maps only focus on forest types, it was assumed that there was no other biomass counted in this dataset that was not associated with potential forest-based biomass availability. There was a total of 48,668,354 green tones (GT) located within the burn scars before the incident start date. Next, burn severity was summarized by acre for each of these fires. Burn severity is calculated as a percent change in canopy cover classified from the relativized differenced normalized burn ratio (RdNBR) and separated in 4 classifications: low/unburned, low severity, moderate severity, and severe severity (Whitter et al. 2016). Finally, using estimates of tree mortality based on burn severity, a percent of stand mortality was estimated in the final formula as well. Tree mortality from burn severity was based on basal area percent killed where the mean percent killed for all four categories are 21%, 42%, 70%, and 95% for trees with DBH above 2.5cm, respectively (Whitter et al 2016).

Gross available mortality-based biomass estimates within the fire footprint was multiplied by both the percent of burn severity within the fire and percent of stand mortality within the burn severity class. Calculations found that 23,687,090 GT are available for salvage within these fire footprints right now. This equals approximately 22 GT per acre or 11 BDT per acre for removal throughout all fire footprints between 2018 to 2021. However, due to the stand structure of the forests, assumptions on tree mortality based on burn severity, and the "arbitrary" classification system employed by MTBS, these estimates may be off to a certain degree not calculated here.

The most considerable limitation to this dataset is the motivation for landowners to harvest fire-killed trees immediately after a wildfire to sell as sawlogs. Due to the deterioration rate of fire-killed trees, landowners can recovery anywhere from 37% to 100% of their forest stock within the first two years (OFDI 2020). This assumes sawlog markets have capacity to receive all of this material. This report does not try to discount for the amount of salvage harvest that will be conducted in the region after 2021, but rather suspects infrastructure capacity to already be impacted by current salvage rates. For this reason, all biomass included within the 2018-2021 fire footprints are included in the final estimates.

Within 100ft of roads

A 100 foot buffer around all road ways within each fire footprint was created in GIS in order to isolate hazardous tree removal operations based on a similar analysis conducted down in the Southern Sierra (CT Bioenergy 2018). Hazardous tree removal is being prioritized by many agencies in California due to the tree mortality crisis as well as the need to maintain safe ingress and egress routes in the event of a wildfire (The Beck Group, 2017). Due to safety protocol of felling hazard trees, this can sometimes lead to vegetation management up to 200ft away from roads due to slope. However, a 100 foot buffer around roads was used for conservative estimates.

Potentially available biomass applies the 11 BDT per acre estimate within 100 feet from the road way. Furthermore, this number was multiplied by percent of suitable forest land for tree recovery from fires. Analysis found that 38% of all fires within this time occurred on suitable forest land for operations. It was found that approximately 392,566 BDT could be available for removal from wildfires within the last 4 years. However, due to the economic constraints imposed on targeting these trees for biomass utilization, it is assumed that they will not be harvested immediately, but rather targeted on an annual basis as funds, infrastructure, and workforce capacity allow. For this reason, this total number is averaged on a 3 year, 5 year, and 7 year removal rate to find annual BDT estimates.

Table 14: Potentially available fire-killed mortality estimates 100ft from roads within fire footprints based on tree mortality from burn severity

	Public			Private			Suitable Total (BDT)
	Public acres	Salvage pot. (BDT)	Suitable (BDT)	Private acres	Salvage pot. (BDT)	Suitable (BDT)	
Fire-killed mortality within 100ft of roads within fire footprints							
100ft dist.	34,009	381,411	144,936	58,106	651,658	247,630	392,566
3yr avg	11,336	127,137	48,312	19,369	217,219	82,543	130,855
5yr avg	6,802	76,282	28,987	11,621	130,332	49,526	78,513
7yr avg	4,858	54,487	20,705	8,301	93,094	35,376	56,081

Within 101-1000ft of roads

Following the methodology used by CT Bioenergy (2018) to assess mortality-based recovery, a larger buffer out to 1000 feet was created in ArcGIS Pro along the roadways within the fire footprints. Furthermore, trees less than 20in DBH were excluded from analysis in order to prioritize those trees which offer the most value to operators. These two factors were assumed to potentially allow for some economically viable recovery (CT Bioenergy 2018). Furthermore, this analysis assumed that moderate and severe burn severities were the only types of fires which would have a significant impact on larger tree mortality. For this reason, the total amount of biomass above 20in DBH was multiplied by the fraction of moderate and severe burn severity occurrence (38%) within the 2018 to 2021 window. Finally, an additional 38% of the landscape burned was suitable for operations and included in the final BDT calculations. LEMMA (2017) rasters for living biomass using the component ratio method (CRM) and size class were combined within the buffer zone and calculated in Excel.

There is an estimated 3,811,695 BDT located within the 2018 to 2021 wildfire footprint that is above 20in DBH and 1000ft from all roads. Using the 38% moderate and severe burn severity fraction reduces the total BDT potential to 1,448,444 BDT. Using an additional suitability conversion, the total estimate BDT potential drops to 832,893 BDT. This number is averaged on an annual removal rate of 3 years to 7 years, where 3 years represents the high BDT recovery scenario and 7 years is the low.

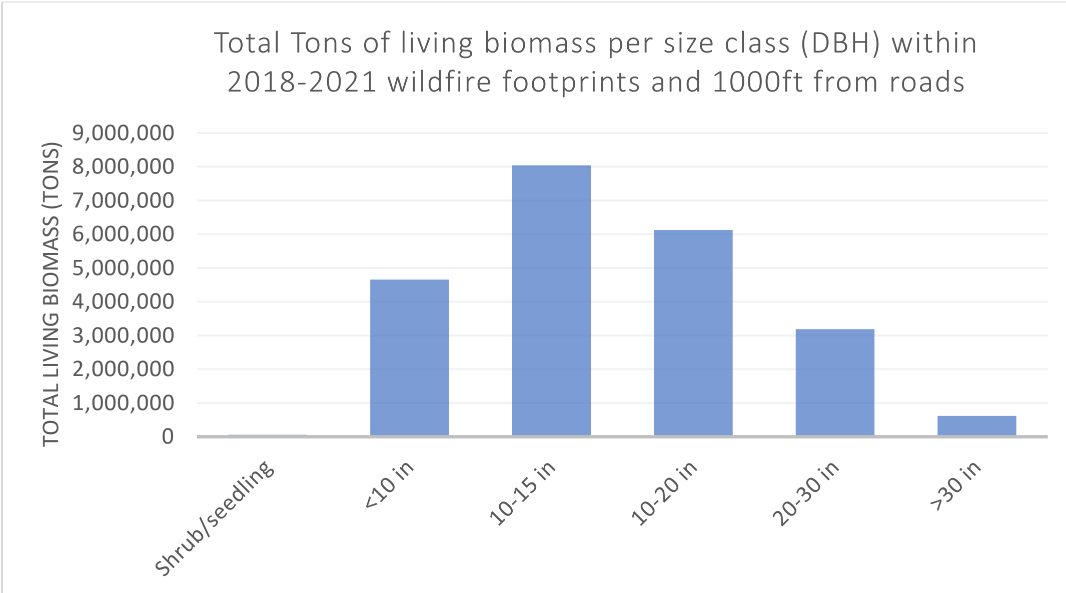


Figure 6: Size class distribution (DBH) by total living biomass (tons) located within 2018 to 2021 wildfire footprints and 1000ft from roads

After applying the 1000ft buffering, there was a significant amount of overlap between public and private roads. This resulted in approximately 40% unique private roads and 13% unique public roads available for management, with the remaining 46% of the 1000ft buffers available for collaboration between public and private ownership.

Table 15: Potentially Available biomass estimates from fire-killed mortality. Estimates focus on recoverable biomass from trees above 20in DBH and within 101-1000ft distance from private and public roads within 2018 to 2021 fire footprints

TREATMENT TYPE	Unique Public		Unique Private		Shared Responsibility		Suitable Total (BDT)
	Acres	Suitable (BDT)	Acres	Suitable (BDT)	Acres	Suitable (BDT)	
Fire-killed mortality within 101-1000ft of roads within fire footprints							
100ft (all DBH)	34,009	144,936	58,106	247,630	-	-	392,566
1000ft	64,226	-	193,245	-	220,985	-	
101-1000ft (>20inBDH)	30,217	33,025	135,139	154,114	220,985	253,188	440,327
Totals	**64,226**	**177,961**	**193,245**	**401,745**	**220,985**	**253,188**	**832,893**
3yr avg	21,409	59,320	64,415	133,915	73,662	84,396	277,631
5yr avg	12,845	35,592	38,649	80,349	44,197	50,638	166,579
7yr avg	9,175	25,423	27,606	57,392	31,569	36,170	118,985
		21%		48%		30%	

2.1.5 Potentially Available Biomass Summary

Table 14 provides a summary of all the option sources for forest-based nonmerchantable biomass procurement. On annual average, the private productive forestland has the potential to generate 671,857 BDT per year (59%) while the public has the potential to generate 198,229 BDT (18%). Fuel reduction and fuel break thinning associated with private, public, and CAL FIRE's CalMAPPER three-year average has the potential to generate 260,101 BDT (23%) with expectations for this to increase over the next decade or so. This results in approximately 1,130,187 BDT in sum being potentially available within the RSA. Feedstock ranges are included below the average estimate. These numbers can be high due to the range of biomass recovery factors that are reported for pre-commercial and fuel reduction harvests depending on treatment intensity. Fire-killed biomass especially has wide ranges due to the amount of biomass mobilized on 3yr, 5yr, or 7yr averages. Ultimately, given favorable economics and the right policy incentives, all fire-killed material could be removed today.

Standing dead biomass utilization and burn pile recovery are both opportunistic estimates for biomass procurement. This means that it may inflate the sustainable basis for a facility to build their operations on. For this reason, a "sustainable basis" and an "inflated" basis were both calculated to further contextualize the potential for long-term investments in new wood markets to be developed. The sustainable basis is 78% of the total potentially available estimates, while the opportunistic estimates are the remaining 22%. Due to the expressed interest in policy and funding currently being provided by both state and federal coffers, fuel reduction and forest health treatments were included in the sustainable basis category with expectations of this number rising in the next decade.

Table 16: Annual Potentially Available Forest-derived Biomass with the RSA

Annual Forest-based Biomass Potentially Available	Public average	Private average	other average	Totals	
Harvest residue	35,629	307,978	-	343,607	
Pre-commercial harvests	20,053	55,669	-	75,722	
Fuels reductions and forest health	38,435	106,699	209,464	354,597	
Standing dead	-	-	-	-	
Concurrent with harvests	39,533	71,637	-	111,169	
Fire salvage – 100ft of roads	28,987	49,526	-	78,513	
Fire salvage – 101-1000ft of roads	35,592	80,349	50,638	166,579	
Potentially Available	**198,229**	**671,857**	**260,101**	**1,130,187**	
Sustainable basis	**94,117** (±18,000)	**470,345** (±51,000)	**209,464** (±45,000)	**773,926**	78%
Inflated due to mortality and utilities	**64,579** (±30,000)	**129,875** (±61,000)	**50,638** (±24,000)	**245,092**	22%
	18%	59%	23%		

2.2 Practically available

Potentially available biomass estimates are the maximum estimate that could be procured within the RSA. However, the forest sector in general is prone to a variety of economic and environmental constraints which can impact the overall recovery of potential estimates, including: breakage and defects in logs, chip van accessibility, project size, NEPA delays, timber harvest plan costs, contractor availability, and unwillingness or inability for landowners to fund biomass removal (MBG 2019, CT Bioenergy 2018). Furthermore, due to the seasonal availability of projects sites due to snow or soil stability, potential feedstock estimates would have to be procured within the harvest season (April through November). This means that if a facility aims to procure all of the feedstock from in-woods sources, they would need to procure 100% of their material within this 7-month window (TSS Consultants 2021). Furthermore, a facility would also need a storage yard that could hold up to 5 months of feedstock to last through the winter. With climate change scenarios projecting less snow and drier conditions, in general, throughout the Sierra Nevada (Dettinger et al, 2018), it will be interesting to see how these considerations impact business planning.

Practically available biomass estimates are estimated by using a conversion factor to account for potential constraints to recovery. CT Bioenergy averages a 61% conversion factor across three studies, which includes a 65% conversion factor used by Shasta Sustainable Resource Management (formerly known as Wheelabrator), and a 45% conversion factor CT Bioenergy implies from a study on tree mortality recovery (Tubbesing 2020). TSS Consultants also employ a 60% conversion factor in their BioMAT study for mariposa Biomass Project (TSS Consultants 2015). This report applies a 60% average for all practically available feedstock sources.

Furthermore, some practically available conversion factors were customized for several feedstock sources after discussions with the internal team and the October 27th Task 3 draft release zoom meeting. The practically available estimates for pre-commercial thinning residue is given a 0% conversion factor. As discussed in Section 2.1.2, pre-commercial thinning is rarely mobilized out of the woods due to economic constraints. Similarly, public landowners often do not remove standing dead unless it is deemed hazardous. For this reason, the public share of the standing dead concurrently removed with harvest is also given a 0% conversion factor. However, given the presence of more outlets for this type of material, precommercial or mortality removed with harvests on public land may eventually become practically available given more favorable economics. As a reminder, economics is not taken into account in this analysis, but rather is looking at what harvests have been recorded over the last decade.

Table 17: Annual estimates for practically available forest-derived biomass from in-wood procurement sources

Annual Forest-based Biomass Practically Available	Public avg BDT	Private avg BDT	other avg BDT	Totals	
Harvest residue	21,377	184,787	-	206,164	
Pre-commercial harvests	-	-	-	-	
Fuels reductions and forest health	23,061	64,019	125,678	212,758	
Standing dead					
Concurrent with harvests	-	42,982	-	42,982	
Fire salvage – 100ft of roads	17,392	29,716	-	47,108	
Fire salvage – 101-1000ft of roads	21,355	48,209	30,383	99,947	
Practically Available	**83,186**	**369,713**	**156,061**	**608,960**	
Sustainable basis	**44,438** (±5,000)	**248,806** (±14,000)	**125,678** (±27,000)	**418,922**	76%
Inflated due to mortality	**38,748** (±18,000)	**77,925** (±37,000)	**30,383** (±14,000)	**147,055**	24%
	14%	61%	26%		

2.2.1 Utility Vegetation Management

Utility vegetation management estimates are difficult to quantify through public datasets. Distribution line data is not easily available, although transmission line data is maintained by the California Energy Commission. However, most work being prioritized and overseen by the California Natural Resource Agency's Office of Electrical Infrastructure Safety (EIS) is being targeted for distribution lines.

The RSA is served by Investor Owned Utility (IOU) Pacific Gas and Electric (PGE) and Publicly Owned Utility (POU) Pacific Corporation (PacificCorp) who both own their own distribution infrastructure. Since 2009 the California Public Utilities Commission issued several decisions related to fire-safety regulations. One of these products is a fire-threat map to prioritize utility vegetation management. The RSA is completely within the elevated fire threat and has some portions of extreme fire threat within the region as well (CPUC 2021).

Distribution lines can be managed through several different objectives ranging from pole clearings to wildfire mitigation measures. PGE states that for every 55 million trees they inspect, they remove approximately 1.6 million trees (PGE Power-wise Tree Guide, n.d). This would lead to a 2% removal factor along distribution lines. While a 50ft buffer (PGE Fact Sheet, n.d) around electricity distribution line data could be applied for analysis, this dataset is not publicly available due to national security reasons, and therefore was not included in this report.

Through interviews with operating facilities within the RSA, there could be as little as 12,000 BDT which is delivered to these facilities per year. However, due to the nature of utility vegetation management these numbers cannot be consistently relied upon and therefore can inflate practically available estimates for a new wood utilization market.

Utility vegetation management often targets disturbance events first before focusing on "green" hazard trees (personal communication with utility vegetation expert). Without a major disturbance event, or any other project occurring within range of a biomass utilization facility, estimates from this procurement source would effectively be zero. To complicate matters, reporting on vegetation management is inconsistent as well, and therefore cannot be estimated accurately through state or federal harvest documents.

Furthermore, what is cut is not always removed. In one account, utility vegetation managers scattered cut hazard trees after the Dixie Fire rather than hauling it to a facility (personal communication with facility operator). This leads to a more complicated projection for utility management as operations don't necessarily enter the market even if there was capacity for the market to accept it.

2.2.2 Sawmill Residues

In addition to forest biomass procured from forest operations ("in-woods"), there is also suitable feedstock bio-processing facilities can use from sawmills after processing lumber. Conversion factors for how much biomass is produced per thousand board foot (MBF) of lumber were created in 2020, based on 2016 industry data (Marcille 2020). Based on this data, the conversion factor for coarse, sawdust, shaving and bark (BDT) generated from one MBF of lumber is approximately 78%.

However, in order to use this conversion factor, our MBF sawlog data needed to be converted to MBF lumber. Marcille (2020) found that for every MBF sawlog produced, 1.67 MBF lumber was generated per year based on 2016 data. For example, 100 MBF of sawlog would equal 167 MBF lumber and generate ~130 BDT of sawmill residue.

When applying the treatment intensity weighted fraction per county operating within the RSA (76%), a more realistic number is estimated for the amount of lumber generated. After calculation, the total estimated amount of sawmill residue generated is approximately 519,175 BDT per year. This is consistent with similar calculations conducted for each facility serving the RSA (see Section 3.1).

Table 18: 8 year averages (2012-2020) per county from BOE volume cut data with lumber estimates and sawmill residue based on a 78% BDT to MBF lumber conversion factor

	Vol (Public)	Vol (Pvt)	Total	Lumber (x1.67)	Produced within RSA (76%)	Sawmill Residue (78%)
Counties	MBF log Scribner			MBF lumber		BDT
Lassen	7,103	55,374	62,477	102,462	75,822	59,141
Modoc	6,768	39,407	46,175	75,727	75,727	59,067
Shasta	10,604	192,641	203,245	333,322	326,656	254,792
Siskiyou	27,614	162,837	190,452	312,341	187,404	146,175
Totals	**52,089**	**450,260**	**502,349**	**823,852**	**665,609**	**519,175**
	10%	90%			Public (BDT)	53,834
					Private (BDT)	465,342

2.3 Forest-derived Practically Available Biomass Estimate Summary

Practically available estimates are summarized in Table 17. Including both utility vegetation management estimates and sawmill residues into the practically available estimates from various in-wood procurement sources, the grand total biomass available on the market is approximately 1,140,135 BDT per year. 82% of this can be produced on a sustainable basis, while the other 18% can be considered inflated due to mortality and utility vegetation management. Even still, the largest variability in estimates are in the inflated numbers as there is no guarantee that they would be available on a yearly basis, but rather must be negotiated through spot market availability.

While these estimates show how much biomass could be practically procured from within the RSA, it does not take into account how much is currently being utilized by existing facilities. Section 3 will be taking these estimates and finding net availability of practically available biomass based on existing infrastructure.

Table 19: Annual estimates for practically available forest-derived biomass from in-wood, sawmill residue, and utility vegetation management procurement sources

Annual Forest-based Biomass Practically Available	Public avg BDT	Private avg BDT	other avg BDT	Totals	
Harvest residue	21,377	184,787	-	206,164	
Pre-commercial harvests	-	-	-	-	
Fuels reductions and forest health	23,061	64,019	125,678	212,758	
Standing dead					
Concurrent with harvests	-	42,982	-	42,982	
Fire salvage - 100ft of roads	17,392	29,716	-	47,108	
Fire salvage - 101-1000ft of roads	21,355	48,209	30,383	99,947	
Practically Available	**83,186**	**369,713**	**156,061**	**608,960**	
Utility vegetation management	-	-	12,000	12,000	
Sawmill residues	53,834	465,342	-	519,175	
GRAND TOTALS	**137,020**	**835,054**	**168,061**	**1,140,135**	
Sustainable basis	**98,272** (±5,000)	**714,147** (±14,000)	**125,678** (±27,000)	**938,098**	82%
Inflated due to mortality and utilities	**38,748** (±18,000)	**120,907** (±37,000)	**42,383** (±14,000)	**202,037**	18%
	12%	73%	15%		

3. HOW MUCH BIOMASS IS BEING UTILIZED IN THE RSA

This section will review how much practically available biomass is currently being utilized within the RSA on an annual basis. The total practically available estimates found in Section 2 will be subtracted by the total amount of biomass being utilized in order to find how much net availability there is for new woody market development. This can also be referred to as "economically viable". Note, there is no competition analysis included in this report. While there are opportunities for facilities to outbid each other within shared procurement zones, this analysis looks at how much biomass currently has no market available for removal.

Furthermore, all facilities operating within the RSA participate in the Biomass Renewable Auction Mechanism (BioRAM) program established in 2015 through Gov Brown's tree mortality Emergency Order. This program offers highly favorable economics for bioenergy facilities to procure at least 80% of their feedstock from high hazard zones (HHZ) as defined by CAL FIRE. This program is set to expire by 2025. If this occurs, much of the utilization capacity for practically available estimates from in-wood sources may substantially drop. Without the subsidy to prioritize HHZ material, facilities may shift to lower-priced feedstock sources coming from the agricultural sector. While this analysis focuses on what the current market capacity for the region is to utilize nonmerchantable biomass, there is no sensitivity analysis on what would happen if BioRAM expired in 2025. Data was collected from UC Agriculture and Natural Resource (UCANR) Extension.

3.1 Current biomass end-users and feedstock requirements

There are currently six (6) major biomass utilization facilities and seven (7) sawmills operating within or around the RSA. While sawmill and biomass facilities are reliant upon each other in many ways when creating an efficient and effective supply chain, this report mainly focuses on biomass utilization facilities. However, sawmills are briefly included in discussion in order to better understand sawmill residue estimates. Furthermore, forest-derived feedstock is only a part of the feedstock mix that a biomass utilization facility can procure from. Agricultural and urban wood waste are also both procurement sources, but are not estimated here. It is expected that there is considerable interest in further supporting forest-derived feedstock procurement, although agricultural residues are also becoming more important for advanced technology solutions to meet California's climate goals (Baker et al, 2020).

Data was provided by the UCANR team and includes many attributes, but some values needed for analysis were incomplete. Furthermore, interviews conducted throughout the region required updating some entries. For this reason, calculations, literature reviews, and interviews helped compliment the inputs to this report's existing infrastructure analysis. For feedstock mix, when no information was available, analysis assumed a similar feedstock mix to facilities of a similar size within the region.

One of the assumptions used in calculations was the amount of feedstock each facility procures within the RSA[1]. Due to the profit-dependent range of procurement zones, some facilities have the potential to procure a fraction of their feedstock outside of the RSA. Therefore, a simple 50mi linear radius was generated for each biomass utilization facility and overlaid with the RSA boundary to estimate the percent of each facility's procurement within the RSA. All areas in each facility's "woodbasket" that were outside of the RSA were removed from analysis. Note, all operational facilities are participating in the BioRAM subsidy program, and as such, have the ability to procure feedstock much further than a 50mi radius. This analysis attempted to simply calculations as much as possible with the use of a 50mi linear radius.

It is assumed that the *minimum* amount each facility would be able to procure their in-woods feedstock is equal to the fraction of their 50mi radius located within the RSA (see Table 19). For example, if a facility procures 100,000 BDT per year, but 20% of their "woodbasket" was located outside of the RSA, we assumed that the facility would procure atleast 80,000 BDT from within the RSA. This can be seen as a limitation, however. Due to the high productivity of operations within the RSA, much more biomass could feasibly be procured from this region. That is why we suggest it is the *minimum* amount each facility would procure.

Furthermore, feedstock mix was also included in order to understand how much sawmill residue versus in-woods material each facility required. In-woods and sawmill residue numbers are generalized for the entire RSA. These assumptions support a simple understanding of fiber flow within the region. Actual numbers are highly dependent on the year and general market conditions. In sum, there is approximately 783,505 BDT currently being utilized within the RSA.

Table 20: Operational biomass utilization facilities serving the RSA. Forest-derived feedstock estimates only. All facilities are participating in the BioRAM subsidy program.

Name	Type	MW nameplate	procurement within RSA	
Burney Forest Power	Bioenergy	31	100%	
Honey Lake Power	Bioenergy	31	14%	
Roseburg Forest Products Biomass Power	Bioenergy	15	43%	
Shasta Sustainable Resource Management	Bioenergy	55	70%	
Sierra Pacific Anderson Biomass Power II	Bioenergy	30	100%	
Sierra Pacific Burney Biomass Power	Bioenergy	20	100%	
Total		**182**	**783,505 BDT**	
Procured from sawmill residuals			402,529 BDT	51%
Procured from in-woods			381,497 BDT	49%

[1] Feedstock volume calculations were based on nameplate megawatt (MW) capacity, with a capacity factor of 85% when no information was available. 1 BDT was assumed to equal 1 MWh, and there are 8,760 hours in a year.

Operational sawmills are also summarized in Table 20. However, because sawmills have significantly large ranges for sawlog procurement, it is assumed that all sawmills would be able to serve the RSA region and beyond. Therefore, the treatment intensity weight used in estimating timber harvest residual (76%) was also applied to estimating the amount of sawmill residue produced within the RSA as well. MMBF lumber tallies are either sourced from publicly available resources or calculated using the MMBF sawlog cut volume estimates collected from BOE and multiplied by the 2016 sawlog to lumber ratio of 1.67 (Marcillle 2020). As shown in Table 21, total sawmill residue being generated within the RSA is approximately 520,923 BDT.

Table 21: Operational sawmills serving the RSA based on treatment intensity weights

Sawmills	Type
Roseburg Forest Products Veneer Mill	Peeler Mill
Shasta Green Sawmill	Small Log Mill
Sierra Pacific (Anderson Division)	Sawmill
Sierra Pacific (Burney Division)	Small Log Mill
Sierra Pacific (Redding Division)	Large Log Mill
Timber Products Company (Yreka)	Peeler Mill
Collins Chester Sawmill	Sawmill
TOTALS	
MMBF lumber tally	**878,750**
BDT from sawmill residue	**685,425**
Adjusted BDT within RSA	**520,923**

3.2 Net biomass feedstock available without competition

Table 22 summarizes the final net availability of nonmerchantable biomass feedstock located within the RSA. There is a grand total of 409,646 BDT available for new wood utilization markets based on current and existing capacity within the region to operate. It is important to note that current in-woods biomass utilization is under the sustainable procurement source amount. However, the reality of providing an outlet to inflated sources on an ad-hoc basis suggests that there is varying availability in both the sustainable and inflated sources. Furthermore, due to sawmill residues being the lowest cost procurement source for many biomass utilization facilities, the estimated 144,282 BDT net availability may be a high estimate. As such, caution is advised, and any amount of sawmill residue would need to be negotiated on a contractual basis with the sawmill for existing or new facility development.

Due to the linear 50mi radius economic constraint applied to operating facilities, this net availability also suggests that locating more biomass facilities within an economically viable distance from residue sources may be able to fill the unutilized gap in the supply chain.

Table 22: Net Availability of nonmerchantable biomass (BDT) within the RSA. Forest-derived feedstock estimates only

Procurement Source	Practically available feedstock Totals	Biomass Utilized	Net available
In-woods	620,960	356,117	264,843
Sustainable	418,922		
Inflated	159,055		
Sawmill residue	519,175	374,893	144,282
GRAND TOTALS	**1,140,135**	**730,489**	**409,646**

4. HOW MUCH BIOMASS WILL BE GENERATED BASED ON DESIRED TREATMENT LEVELS IN THE RSA?

The goal for this section is to estimate the amount of biomass that may be removed in the future due to new levels of policy and funding support for fuel reduction. This analysis will leverage terrestrial condition assessment (TCA) prioritization mapping for the region and provide a general understanding on how to make the most impact through targeted treatment. Analysis for this section will be completed by the end of 2023.

4.1 Assessing interest in expanding treatment within the RSA

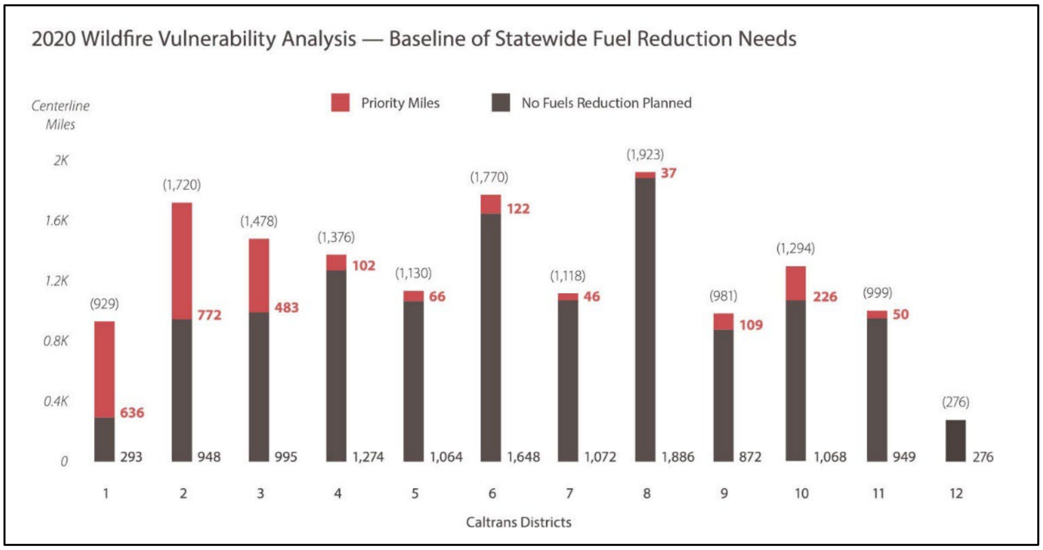
There is a significant amount of interest in expanding fuel reduction and forest health treatments throughout the State. This region is no different and has a variety of landowners who are working on expanding operation capacity and activity over the next decade.

In a seminal agreement signed in 2021, the State of California and the USDA Forest Service (USFS) entered into a shared stewardship memorandum of understanding (MOU) with the goal of treating one million acres per year starting 2025. There are many other actions included in the MOU, but they are all in support of achieving the treated area targets. A simple analysis was conducted for the RSA to look at how many more acres the region would need to treat in order to accomplish its proportional share of the MOU goal. The proportional share of the MOU was based on the fraction of forested acres located within the RSA. With a general baseline of 44,000 treated acres per year as per Section 3 of this report, the region may expect to see an additional 10,000 acres treated per year, for a total of 54,000 treated acres per year. However, be aware that this does not include metrics of community and ecological resilience. Depending on the results of the TCA to be completed, these numbers may differ substantially.

While this may not seem like much, this increase in treatments will require magnifying capacity throughout a supply chain which already contains a sizable surplus of unutilized biomass. There are a variety of actors and landowners in the region who are preparing to increase their operations within the region.

The **USDA Forest Service (USFS) and Bureau of Land Management (BLM)** owns roughly 53% of the forested land within the RSA. The Modoc, Lassen, Shasta-Trinity and Siskiyou NFs have some proportion of land located within the RSA. Interviews were conducted with several of these NFs in order to understand how they envision land stewardship over the next decade. There is uniform interest in removing more biomass, however workforce capacity, NEPA constraints, and the general biomass market make it very difficult to include in bid packages. The Modoc NF particularly has strong interest in expanding their treatment efforts, knowing that at least doubling and probably quadrupling their efforts will be needed to address the scale of the wildfire risk.

The **California Department of Transportation (Caltrans)** prepared a wildfire vulnerability analysis in 2019 and 2020 to confirm how much of the state highway network is vulnerable to wildfire ("Roadside Fire Fuels Reduction", n.d.). The RSA is currently located within Caltrans District 2 which was reported to have 772 priority centerline miles that are vulnerable to wildfire and need fuel reduction. This is the highest number of miles that need management throughout all Caltrans districts and represents 45% of all centerline miles located within District 2. It is not clear how many of these centerline miles are located within the RSA, but future analysis may be able to specify these numbers. Caltrans has established a vegetation and wildfire executive steering committee in 2021 to support the need to implement these priority acres and tie in other goals as established by the California Wildfire and Forest Resilience Task Force (WFRTF).



The **Pacific Gas & Electric Company (PG&E)** is currently improving their vegetation management operations with the goal to reduce ignition from infrastructure failure as well as mitigate wildfire risk from impacting energy distribution lines. Their yearly reporting on activities shows where they are prioritizing their efforts as well as 3yr and 10yr goals. Currently they have been investing considerable time to modeling and inspecting risk, and have surpassed their goals for vegetation management (PGE, 2022). This will continue into the future and be heavily influenced by disturbance events which pose a risk to their infrastructure as well as preventative maintenance to ensure system operations.

4.2 Building the terrestrial condition assessment to inform priority treatments

The MCA project group originally intended to use 300M datasets to determine biomass estimates for this market assessment. However, the California Resources Agency, Department of Conservation, and USGS 3DEP recently invested in a large, comprehensive acquisition of quality L1 lidar data in our region, which was collected in 2022. This led the market impact analysis included in this report to be based on a BDT recovery factor per acre. Yet, because the terrestrial condition assessment has been delayed, the MCA objective to identify priority fuel reduction and thinning acres has also been delayed.

Together with existing QL2 lidar data, the region has a unique opportunity to leverage these lidar data to conduct a precision inventory of biomass estimation to meaningfully inform forest-level project bid packages as well as the Market Capacity Assessment. The 2022 lidar data are currently being processed and quality controlled, and our partnership will coordinate with

University of Washington and 34 North to request permission access to conduct our forest structure and biomass estimation. As the DOC and USGS release the final lidar data, we will immediately process these products to produce a forest structure condition assessment and update the biomass assessment, as needed. **The estimated timeframe to complete the terrestrial condition assessment is slated for the end of 2023.**

LiDAR data provides a direct measurement of the earth's surface as well as the objects on the earth's surface such as forests. We will use existing methods to analyze the lidar and available FIA inventory information to estimate biomass by structure class and report these data at a 30m resolution. Lidar can be analyzed to directly measure canopy height and canopy cover by height strata. In addition, lidar data can be modeled to segment overstory trees and estimate crown size, canopy density, crown volume, and basal area. These precision data can provide the necessary inputs for conducting biomass estimations for market assessments.

Due to this improvement in spatial analysis, the MCA may be updated to include additional sources which are more difficult to quantify due to a lack of records. Some sources which would require substantial mapping analysis include:

- Biomass generated from the PG&E transmission strategy
- Biomass generated from Caltrans vegetation management strategy
- Biomass generated from additional harvest projections including small landowners or non-industrial timber management plans (NITMP)

5. LIMITATIONS AND CONSIDERATIONS

It is expected that this document will help inform and support ongoing efforts to expand market availability for biomass utilization in order to address the region's community and ecological resilience goals. However, this report may not be suitable as a substitute for feedstock availability assessments required by new biomass utilization business plans. There are a number of aspects that this report fails to address that would be important for a new facility to understand. Rather, this report is most useful to inform efforts to initiate a quasi-public institutional arrangement to aggregate feedstock and lower risk for feedstock procurement contracts. The following are a few limitations to consider:

- **No economic considerations**. This report's goal is to look at the current fiber flow within the region given the current market conditions. As such it does not take into account the amount of biomass that could be available given more favorable economics. There is a reasonable assumption that siting new biomass outlets would provide an increase in biomass availability due to the reduction of haul distances and subsequent haul costs. However, this type of analysis requires a different methodology that was not within the scope of the project and is more appropriate on a case-by-case basis. Additionally, economic considerations to biomass availability have already been completed for all BioRAM facilities through the High Hazard Fuels Availability Study (MB&G, The Beck Group, 2019). Some economic research and analysis will be included in Tasks 4, 5, and 6 of the OPR project.
- **Market competition for biomass.** Competing demand for biomass was not fully analyzed in this report. Many reports (including this one) have shown that there is little concern regarding the total quantity of biomass supply throughout the state. Nevertheless, the location of the end-user, economics of removal, and access to the material are aspects of market competition that are particularly difficult to quantify for a region as a whole. The dynamics of an ever-changing landscape coupled with the strong relationships between various actors along the supply chain create forecasting competitive prices difficult. Instead, this report uses a simple "net-availability" approach to define how much biomass is produced on an annual basis but not utilized by end-users. However, while this number is quantifiable, the location of the excess biomass is much more difficult to identify and not within the scope of this report.
- **Estimates on how much will be procured in the future has not been completed.** With the exception of standing dead salvage estimates, research focused mostly on the 10-year recorded history of harvest activity. The numbers contained in the report identify the expected availability per year, but there may be more made available over the next decade due to political and funding support. Similarly, this report does not included biomass from PGE distribution lines, Caltrans roadside vegetation clearing, or improved access to small private landowners. With the acquisition of QL2 Lidar data, the team will be better equipped to estimate future biomass and support better forecasting.
- **Workforce capacity and housing availability.** Due to the report's scope to focus only on current market capacity, it would be interesting to compare an analysis on workforce

capacity to the findings in this report to see if the results on market capacity for biomass utilization are congruent. It could also illuminate the biggest constraint to expanding market capacity.

Anecdotally, workforce capacity (especially hauling) is regarded as one of the largest constraints to reach state and regional goals for community and ecological resilience. While economics is also regarded as a critical lever to biomass utilization, the results found in this report may be inferred as a workforce constraint as much as it is an economic constraint. In other words, if the economics were more favorable, there would be more people willing to work in the sector. However, as stakeholder meetings revealed, housing availability and associated city amenities are limited in these rural regions. This discourages a potentially willing workforce from accepting positions in regions with a strong promise for biomass utilization opportunities, thus linking market capacity back to workforce constraints rather than economics.

- **BioRAM program may end in 2025.** Over the next few years BioRAM—one of the most effective programs to support forest-based biomass utilization—may end. Unless the legislature approves an extension, the loss of this program may redirect a considerable amount of demand for forest-based biomass from participating facilities. This could simultaneously reduce competition demand for forest-based biomass resources as well as potentially strand more biomass out in the woods due to the loss of a subsidized program which targets high hazard fuels. It is hard to know how this will impact the market, but if the program is not continued it will certainly have some impact

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