BIOMASS FEEDSTOCK SUPPLY AVAILABILITY AND COST ANALYSIS FOR THE CENTRAL SIERRA REGION OF CALIFORNIA

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SIERRA BUSINESS COUNCIL

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INTRODUCTION

The Sierra Business Council (SBC) is working closely with the Governor's Office of Planning and Research and the Mariposa Resource Conservation District to implement the Woody Feedstock Aggregation Pilot Program within the Central Sierra Region of California. The pilot program will be an opportunity for significant innovation in the natural resources manufacturing industry and forestry management sector in California by spearheading a regional approach with a Joint Powers Authority (JPA) or other similar entity between Alpine, Amador, Tuolumne, Calaveras and Mariposa counties. The project will encourage development of small enterprises where innovative forestry businesses can develop and operate.

The project and associated deliverables as proposed will address how forest restoration, climate adaptation, and stakeholder engagement can arise from delivering biomass to businesses, all while promoting community fire resilience and enhancing public safety.

SBC has retained TSS Consultants (TSS) to conduct several tasks in support of this project. This report provides findings from the feedstock supply availability and cost analysis conducted by TSS to confirm availability and cost of woody feedstocks within the feedstock sourcing area (FSA). Note that the FSA includes all five subject counties: Alpine, Amador, Tuolumne, Calaveras, and Mariposa.

ANALYSIS OBJECTIVES

Summarized below are the tasks that TSS implemented in support of this analysis.

Task 1a. Conduct a biomass feedstock market supply analysis to determine current urban wood and forest-sourced feedstock supply availability within the Central Sierra Study Area (CSSA). CSSA is defined as that region which includes Alpine, Amador, Tuolumne, Calaveras and Mariposa counties. GIS analysis will be utilized to confirm vegetation and forestland ownership types within the FSA.

Task 1b. Review current urban wood waste management and forest management activities within the CSSA to forecast the amount of feedstock supply potentially and practically available. Confirm forest feedstock supply by land ownership category (e.g., state, private, federal).

Task 1c. Develop a current competition analysis focused on current market demand for biomass feedstock sourced from within the CSSA.

Task 1d. Identify future feedstock supply sources and risks (including competition from potential biomass utilization facilities).

Task 1e. Utilizing findings from tasks 1a through 1d, prepare a biomass feedstock supply availability and cost analysis report (in executive summary format). A 5-year feedstock pricing forecast (2025-2029) will be provided utilizing base case and worst

case scenarios. TSS will provide observations regarding feedstock sourcing supply chain development and optimized feedstock blend considering current market conditions.

FEEDSTOCK SOURCING AREA

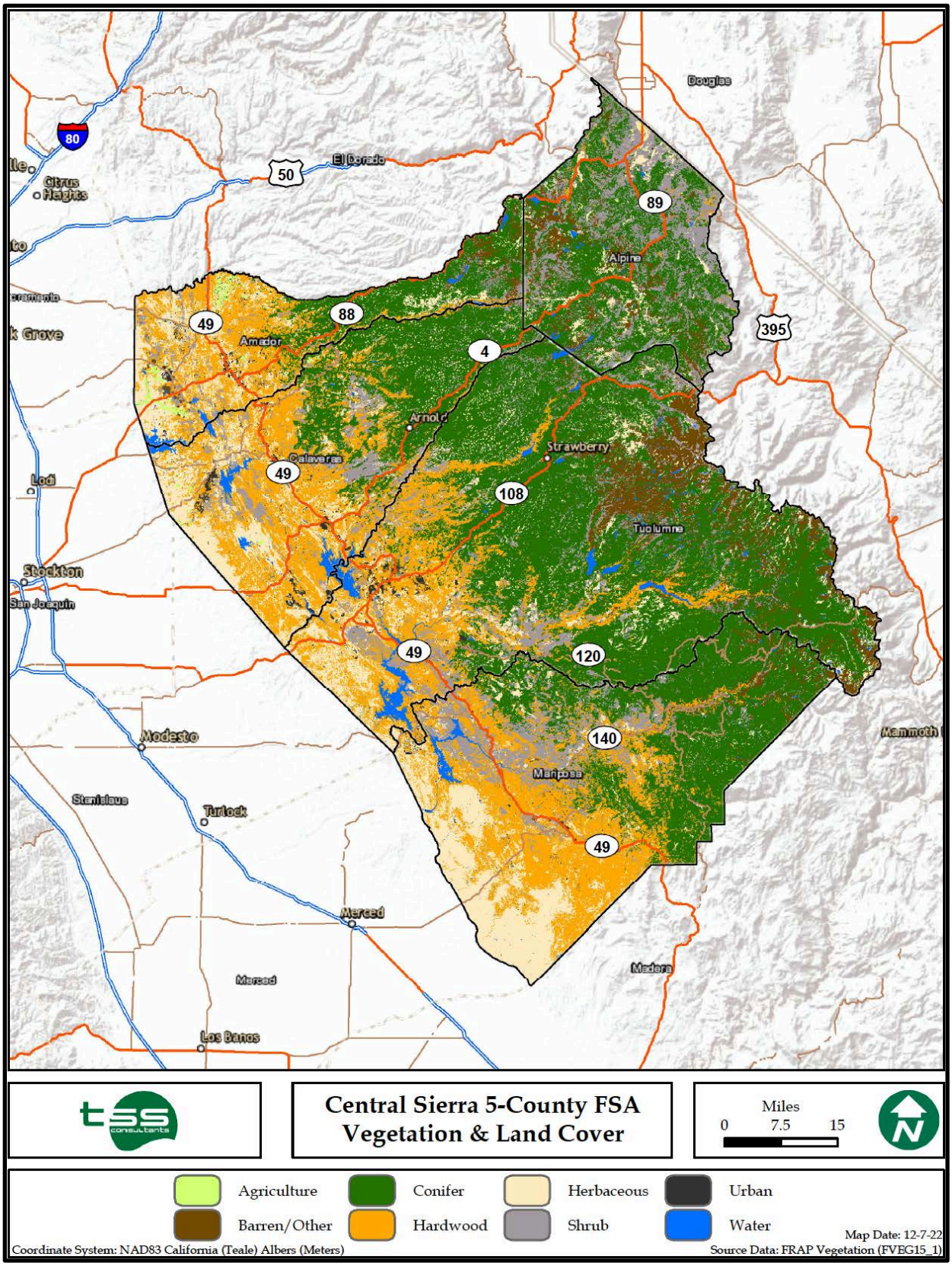
The feedstock sourcing area is defined as the Central Sierra region including Alpine, Amador, Tuolumne, Calaveras and Mariposa counties. This is a large region that includes just over 3.9 million acres (see Figure 1).

Vegetation and Land Cover

The FSA includes portions of the Central Sierra Nevada Range and the San Joaquin Valley. Using geographic information system (GIS) data maintained by Cal Fire,[1] TSS conducted an analysis of vegetation cover and land use. Figure 2 is a map highlighting vegetation and land cover by type within the FSA.

[1] Cal Fire, Fire and Resource Assessment Program.

Figure 1. Vegetation and Land Cover Types Within the FSA



Outlined in Table 1 is a summary of vegetation and cover acreage by type.

Table 1. Vegetation and Land Cover Acreage Within the FSA

Vegetation and Land Cover	Five-County FSA	
	Acres	Percent
Agriculture	14,027	<1%
Barren/Other	231,877	6%
Conifer	1,558,803	40%
Hardwood	908,590	23%
Herbaceous	576,211	15%
Shrub	514,268	13%
Urban	39,425	1%
Water	74,395	2%
Total	**3,917,596**	100%

Forestland

Note that the FSA includes approximately 3,917,596 acres total of which the most significant vegetation cover type is conifer dominated forestland at 1,558,803 acres (making up about 40% of the FSA). Forestland has historically provided sustainable volumes of sawtimber and woody biomass for commercial enterprises located within and tributary to the FSA. The commercial agriculture sector is very well developed in the San Joaquin Valley. Orchards, row crops, and livestock operations are active in this region. Ready access to commercial orchard removals was a primary reason for development of several biomass power plants[2] tributary to this region.

Woodland

The second most significant vegetation cover type is hardwood dominated woodland. At 908,590 acres, woodland makes up 23% of the FSA. Some woodland acreage is included in fuel breaks and is actively managed in support of defensible communities. TSS experience in the region confirms that some woodland acreage is managed as rangeland for commercial livestock operations.

Urban Land Cover

Volumes of tree trimmings and construction/demolition wood (aka urban wood) are generated within communities. The FSA includes communities that produce tree trimmings and urban wood, including Jackson, San Andreas, Mariposa, and Sonora. A total of about 39,425 acres falls within the urban land cover designation, making up about 1% of the FSA.

Wildfire

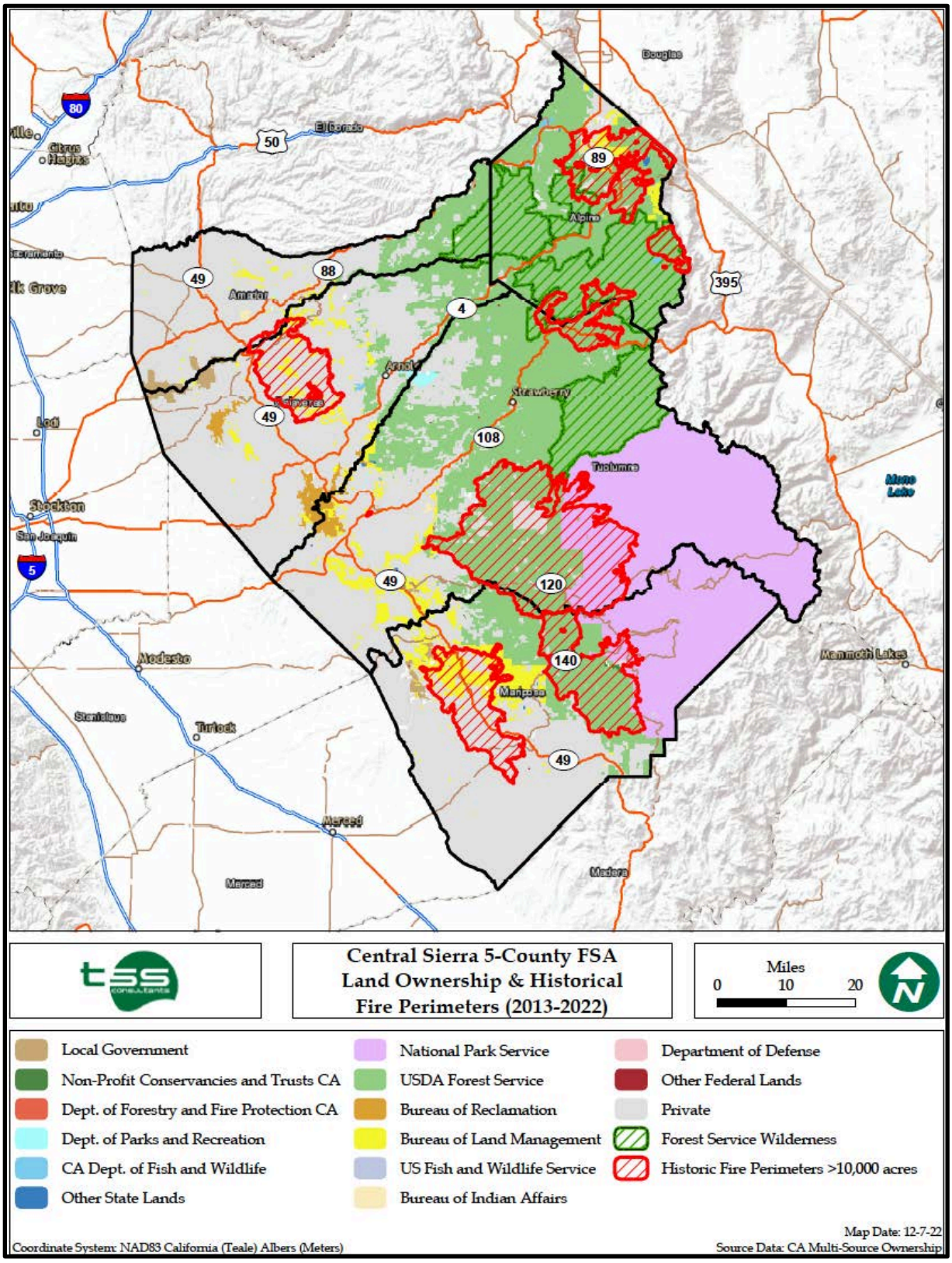
Wildfire activity in the last decade has been extreme, with over 625,000 acres within the FSA impacted (see Table 2). The response from state and federal policy makers has been to significantly

[2] DTE Stockton, Tracy Biomass.

increase targeted funding to support more proactive vegetation management in the coming years, which should increase the volume of forest material removed.

Figure 2 is a map highlighting recent wildfire events within the FSA.

Figure 2. Wildfire History Within the FSA



Summarized in Table 2 are the wildfires shown in Figure 2. Note that only fires over 10,000 acres are shown.

Table 2. Historic Wildfires Within the FSA 2013-2022

Wildfire Name	Year	Acres Impacted
Rim	2013	256,176
Butte	2015	70,847
Washington	2015	17,915
Detwiler	2017	81,826
Donnell	2018	36,461
Ferguson	2018	96,831
Slink	2020	12,783
Tamarack	2021	52,269
	Total	**625,108**
	Average Acres/Year	**62,511**

Clearly there is significant wildfire activity within the FSA. While there will likely be an opportunity to conduct post-fire restoration activities (as a result of ongoing wildfire events) that will likely generate forest biomass, there is also the risk of these wildfire events damaging the productive capacity of forestland to grow wood fiber within the FSA.

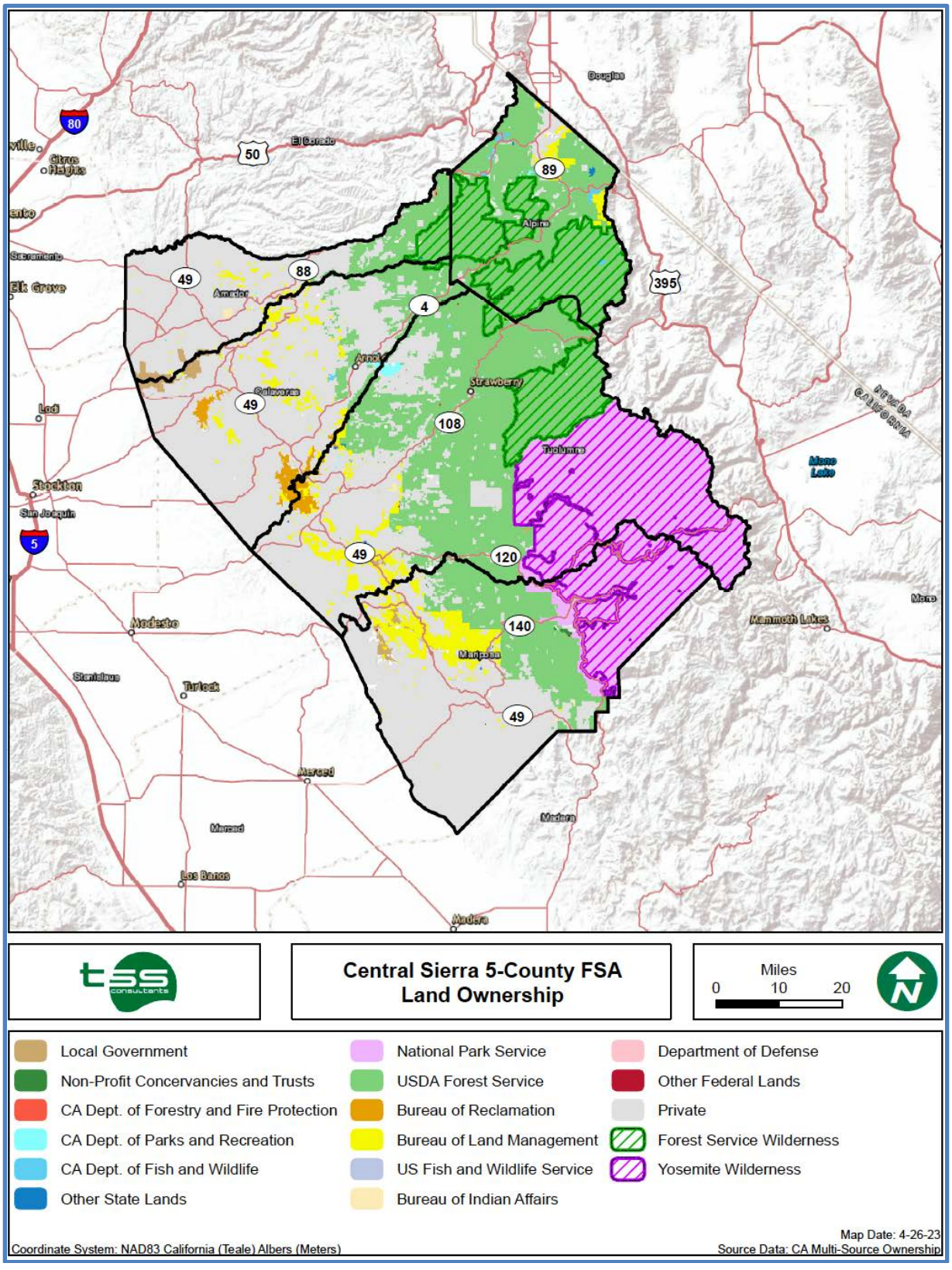
Land Ownership

Land ownership is critical to understand feedstock availability within a region, as management objectives of the landowner will drive feedstock availability. Land ownership within the FSA includes forestland managed by various public agencies (e.g., USDA Forest Service, Bureau of Land Management, National Park Service) as well as private landowners (industrial and non-industrial). Sawlog and forest feedstock supply (such as processed timber harvest residuals) availability is very dependent upon forest resource management activities. Each forestland ownership has specific goals and objectives. Public land management agencies such as the USDA Forest Service and the Bureau of Land Management are mandated by public policy to manage for various attributes, including recreation, wildlife habitat, ecosystem services, and natural resource outputs. Forest resource outputs, such as sawlogs, recovery of forest thinning material, and timber harvest residuals as forest feedstocks, are not a priority.

Private forest ownership, made up of small non-industrial ownership (typically family owned) and industrial (e.g., Sierra Pacific Industries) make up most of the private forestland ownership within the FSA. Non-industrial forest owners are typically families managing various resources, including the production of sawlogs as a long-term revenue source. Industrial forest owners are focused on active forestland management, including sawtimber output and fuels reduction activities (to protect timber assets).

TSS utilized GIS shape files from the State of California database to conduct land ownership analysis. Figure 3 incorporates this data to highlight land ownership within the FSA.

Figure 3. Land Ownership Within the FSA



FOREST FEEDSTOCK SUPPLY

This analysis focused on timber harvest residuals, forest fuels reduction activities (including post-fire restoration) and sawmill residuals as forest resources potentially available as biomass feedstock within the FSA.

Forest Ownership

Table 3 summarizes forestland and woodland ownership within the FSA.

Table 3. Forestland and Woodland Acreage by Ownership Within the FSA

Ownership	Forestland Acreage	Percent of Forest Acreage Within the FSA
Bureau of Indian Affairs	2,982	<1%
Bureau of Land Management	82,511	4%
Bureau of Reclamation	9,984	<1%
CA Dept. of Fish and Wildlife	3,895	<1%
CA Dept. of Forestry and Fire Protection	252	<1%
CA Dept. of Parks and Recreation	6,930	<1%
Dept. of Defense	1,184	<1%
Local Government	10,212	<1%
National Park Service*	58,586	3%
Non-Profit Conservancies and Trusts	1,510	<1%
Other State Lands	984	<1%
USDA Forest Service*	708,291	38%
Private	976,772	52%
Total	**1,864,093**	**100%**

*****Wilderness acreage considered forestland and woodland has been subtracted and is not included in Table 3.

Table 3 confirms that forestland (conifer and hardwood dominated acreage) ownership within the FSA is primarily made up of private land at 52% and USDA Forest Service (USFS) at 38% of total. Note that several federal and state agencies (California Department of Fish and Wildlife, California Department of Parks and Recreation) are managing forestland for recreation and/or wildlife habitat and produce relatively little forest biomass feedstock. However, National Park Service (NPS) is the exception. In recent years, Yosemite National Park has partnered with the Mariposa County Resource Conservation District[3] to treat hundreds of acres of overstocked forest stands within the park, primarily along roads.

Sierra Pacific Industries (SPI) accounts for ownership of approximately 200,000 acres of industrial private forestland within the FSA, predominantly in Amador, Calaveras and Tuolumne counties.

[3] Per discussions with Melinda Barrett, Executive Director, Mariposa County Resource Conservation District.

This ownership is divided into two districts known as Martell (including Amador and northern Calaveras County) and Sonora (including southern Calaveras and all of Tuolumne County). SPI has no timberland in Alpine County or Mariposa County.

Timber Harvest Residuals

Timber harvest residuals in the form of limbs and tops are generated on a regular basis as a byproduct of commercial timber harvest activities. Once collected and processed, these residuals are an excellent, relatively cost effective feedstock. Forestland managers interviewed in the course of this investigation confirmed that removal of these residuals is a preferred method for disposal as opposed to piling and burning. Within the FSA, these residuals are currently either piled and burned onsite or chipped and scattered onsite. Note that the window for pile burning can be narrow and the liability of pile fires escaping containment can be significant. Many forestland managers have stopped burning residual piles due to liability issues and impacts to air quality. In addition, liability insurance premiums have skyrocketed in recent years due to insurance carriers' concerns regarding potential liability of burning (e.g., timber harvest residuals or prescribed fire).[4]

As a byproduct of commercial timber harvests, the availability of these residuals rises and falls with timber harvests within the FSA. TSS reviewed California Department of Tax and Fee Administration (CDTFA) records to confirm timber harvest trends for the last five years (that data is available), 2017 through 2021. Note that CDTFA records track commercial timber harvests by county and ownership type (private and public). Table 4 provides historic private timber harvest sawlog volumes from the five counties with commercial timber harvests located within the FSA. Note that harvest estimates are presented in thousand board feet[5] measure (MBF).

Table 4. 2017 to 2021 Private Timber Harvests by County

County	2017 (MBF/Yr)	2018 (MBF/Yr)	2019 (MBF/Yr)	2020 (MBF/Yr)	2021 (MBF/Yr)	5 Yr Avg (MBF/Yr)
Alpine	0	0	0	5	2,259	**453**
Amador	7,167	7,578	5,078	15,443	21,147	**11,283**
Calaveras	52,933	38,096	7,326	42,516	16,002	**31,375**
Mariposa	6,923	9,517	6,490	2,339	1,997	**5,453**
Tuolumne	42,311	31,061	22,863	58,454	42,026	**39,343**
Totals	**109,334**	**86,252**	**41,757**	**118,757**	**83,431**	**87,906**

Based upon TSS' experience working with logging and chipping contractors in this region, the recovery factor for biomass feedstock processed from timber harvest residuals is approximately 0.9 bone dry tons[6] of woody biomass (treetops and limbs) that could be produced from each MBF of timber harvested. Using the 0.9 BDT per MBF recovery factor and the 87,906 MBF/year (five-year average) harvest estimate, there are 79,115 BDT/year of timber harvest residuals from private forest lands potentially available within the FSA. Not all timber harvest residuals are recoverable, as

[4] Per discussions with private sector field foresters.
[5] Thousand board feet (MBF) is a common unit of measure used in the timber industry to express relative volume of sawtimber. One board foot measure is approximately equal to a board that measures 12" by 12" and 1" thick.
[6] One bone dry ton = 2,000 dry pounds.

topography and road systems will impact economic collection and transport. TSS' knowledge of topography and road systems within the FSA confirmed that approximately 65% of forestland is on topography that will accommodate economical collection and transport of forest biomass. Using the 65% figure results in a practically available timber harvest residual estimate from private lands of 51,425 BDT/year.

Public timber harvests conducted within the FSA are predominantly managed by the USDA Forest Service. Table 5 provides historic public timber harvest sawlog volumes from the five counties located within the FSA.

Table 5. 2017 to 2021 Public Timber Harvests by County

County	2017 (MBF/Yr)	2018 (MBF/Yr)	2019 (MBF/Yr)	2020 (MBF/Yr)	2021 (MBF/Yr)	5 Yr Avg (MBF/Yr)
Alpine	0	0	0	0	0	**0**
Amador	2,055	5,215	0	4,275	1,187	**2,546**
Calaveras	0	0	819	5,758	4,120	**2,139**
Mariposa	2,596	1,397	3,502	1,254	0	**1,750**
Tuolumne	18,525	19,306	16,612	12,545	9,990	**15,396**
Totals	**23,176**	**25,918**	**20,933**	**23,832**	**15,297**	**21,831**

Using the same timber harvest residuals calculation methodology as noted above, TSS estimates approximately 19,648 BDT/year is potentially available from public lands within the FSA. Adjusting for topography (approximately 65% of the landscape will allow recovery and transport of timber harvest residuals), there is about 12,771 BDT/year of timber harvest residuals from public lands practically available.

Note that public timber harvest volumes are approximately 25% of private timber harvest volumes. As discussed earlier in this report, public agencies such as the USFS do not prioritize active forest management with timber outputs but rather focus on a range of land management objectives including (but not limited to) wildlife habitat improvement and recreation. In addition, public land management agencies are subject to federal appropriations to fund timber management activities. Federal appropriations are set each year by congress and can be inconsistent. USFS annual timber harvest levels rise and fall each year. Some years the timber harvest levels are relatively high (e.g., 2017 and 2018) as federal agencies conduct post-fire restoration following wildfire events.

The cost to process (chip or grind) and load timber harvest residuals into chip trucks in the forest ranges from $50 to $65/BDT.[7] The cost to transport timber harvest residuals ranges from $130 to $150/hour.[8] Assuming an 80-mile one-way transport distance (4.5 hours roundtrip including loading and unloading time) and transport cost of $140/hour, the total roundtrip transport cost is $630. Assuming 14 BDT of timber harvest residual volume in the truck, the roundtrip transport cost is $45/BDT. The total cost to process, load, and transport (80-mile haul distance at $140/hour and $57.50/BDT to process and load) comes to $102.50/BDT.

[7] Per discussions with logging contractors and foresters.
[8] Ibid.

Forest Fuels Reduction Residuals

Due to high fire danger conditions and overstocked forests, there are concerted efforts across all forest ownerships to proactively reduce hazardous forest fuels in support of fire resilient forest ecosystems. Forest managers are conducting forest thinning activities to achieve fuels treatment and stocking control (reduce the number of trees per acre as forest stands age over time and tree size increases). In California, the state has allocated $1 billion over five years to address hazardous forest fuels across all ownership types with a focus on private forestlands. This investment is primarily allocated through grants administered by state agencies (e.g., Cal Fire, California Department of Conservation) and will increase the opportunities for Fire Safe Councils, Resource Conservation Districts, and National Forests to administer forest fuels reduction projects at landscape scale. Federal funding through the Natural Resources Conservation Service (NRCS) is available and targets non-industrial private forestland. In addition, the Bipartisan Infrastructure Law (signed into law November 2021) has significant carve outs for fuels reduction including $514 million for hazardous fuels management and $500 million for community wildfire defense grants (targeting at-risk communities nationwide).[9] Lastly, the recently passed Inflation Reduction Act (signed into law August 2022) includes $2 billion to fund hazardous fuels reduction on federal lands and $450 million for fuels reduction on non-federal lands.[10]

TSS interviewed both private and federal land managers to secure information regarding current forest management and fuels reduction activities within the FSA. These discussions confirmed a strong interest to increase acres treated across the FSA with an emphasis on creating fire resilient landscapes which support fire defensible communities. Mitigating wildfire behavior is clearly driving vegetation management within the FSA. With the USFS managing 47% (see Table 3) of forestland within the FSA, there is a clear emphasis on treating federally-managed lands.

Shared Stewardship Agreement

In August 2020, the state of California and the USFS signed the Shared Stewardship Agreement[11] which sets out a coordinated strategy to increase the pace and scale of forest fuels treatment activities across the state. Ultimately, as laid out in the agreement, the state hopes to facilitate treatment of 500,000 acres/year of fuels treatment on private and state lands, with the USFS completing 500,000 acres/year of fuels treatment on federal lands, all by 2025. Considering that 4.4 million acres in California were impacted by wildfire in 2020 and approximately 2.6 million acres impacted in 2021, the timing of this agreement is critical and when fully implemented, will help make available forest biomass and sawlogs (including within the FSA).

Forest Thinning Projects

The FSA contains the entirety of the Stanislaus National Forest and portions of three other National Forests: Eldorado, Sierra, and Humboldt-Toiyabe. Interviews with USFS forest managers on these forests confirm significant interest in and planning for forest restoration and fuels thinning projects over the next five years.

[9] Per January 4, 2022, Council of Western State Foresters briefing paper.
[10] Per August 12, 2022, Society of American Foresters forest policy update.
[11] https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf

Large landscape partnerships have been established throughout the five-county FSA to help increase the pace and scale of restoration on National Forest lands. Master Stewardship Agreements (MSA) and Good Neighbor Authority (GNA) agreements are allowing counties and non-governmental organizations (NGOs) to greatly increase the amount of acres slated for treatment within the next three to five years. On the Eldorado and Stanislaus National Forest, the Upper Mokelumne River Watershed Authority has over 100,000 acres of National Forest in its forest projects plan to be treated under its MSA. Tuolumne County has partnered with the Stanislaus NF through a MSA to treat approximately 120,000 acres of the SERAL[12] project. Amador, Calaveras, and Alpine counties all have entered into their own GNA agreements with National Forests inside their jurisdictional boundaries and will be ramping up their collaborative efforts to mitigate hazardous fuels.

The recent passage of the Bipartisan Infrastructure Bill (as noted earlier) has directed significant funding toward the USDA's Wildfire Crisis Strategy (WCS). Under this program, two Priority Landscapes within the FSA have been identified: the Stanislaus Landscape, totaling 245,000 acres of the Stanislaus National Forest in Tuolumne County, and the Sierra Front Landscape, which includes 40,000 acres of Humboldt-Toiyabe National Forest in Alpine County. Funding is in place to execute a wide range of forest thinning and timber harvest projects over the next five years in these forests.

For the purposes of this feedstock supply review, TSS assumes that the USFS will increase forest thinning activities across the FSA to 10,450 acres/year over the next five years. During the previous five years, the USFS averaged approximately 4,300 acres/year of fuels reduction treatments. Forest fuels removed on federal lands are typically 5 to 8 BDT/acre. Assuming 7 BDT/acre, the potentially available forest fuels reduction residuals on national forests within the FSA totals about 73,150 BDT/year.

Public Forestlands Overview

The FSA includes four National Forests.

Stanislaus National Forest

Spanning almost 900,000 acres from the Mokelumne River south to the Merced River watershed, the Stanislaus NF will be providing the majority of woody biomass coming from public lands within the FSA. Along with significant federal funding as one of the top ten Priority Landscapes under the USDA's Wildfire Crisis Strategy, this national forest benefits from proximity to forest products manufacturing enterprises and having well established public-private partnerships that are performing large-scale landscape restoration projects across the forest.

Humboldt-Toiyabe National Forest

Timber harvest and forest restoration projects are expected to increase over the next five years on portions of approximately 40,000 acres of Humboldt-Toiyabe NF located within Alpine County. This area lies within another of the USDA Priority Landscapes known as the Sierra Front. Due to its location on the eastside of the Sierra crest and proximity to a newly established forest products

[12] SERAL = Social and Ecological Resilience Across the Landscape.

facility in Carson City, Nevada,[13] it is likely that much of the harvested timber and residuals will be processed there. In addition, western Alpine County contains portions of both the Eldorado NF and Stanislaus NF, which have experienced significant mortality of high elevation true fir species. Tree mortality removal, post-fire restoration and fuel break installation projects in these areas will produce forest residuals that would more likely be utilized by facilities located along the western slope of the FSA.

Eldorado National Forest

Approximately 79,000 acres of the Eldorado NF land base lies within Amador County. While the majority of fuels treatments and timber harvest programs planned by this forest will fall outside county lines (including the ongoing Caldor Fire recovery), Highway 88 serves as a major thoroughfare for harvested timber and residuals headed west and brings truck traffic through the Amador County seat of Jackson. Local collaborative groups have ramped up their forest restoration projects along the Highway 88 corridor through Master Stewardship Agreements. Large landscape efforts such as the above-mentioned Forest Projects Plan will cross boundaries from Eldorado to Stanislaus and should result in increasing quantities of forest residual production from the Amador Ranger District over the next five to ten years.

Sierra National Forest

The current plan of work for timber harvesting and forest restoration within the Sierra NF are primarily focused south of Mariposa County (and outside this study's FSA) in areas that have recently experienced significant wildfire impacts, such as the Creek Fire footprint. Other active projects are located in areas with a strong collaborative presence like the Dinkey Creek area. However, with effective local partners like the Mariposa County RCD managing projects and nearly 200,000 acres of NF within Mariposa County, there is considerable opportunity for fuels treatment projects and woody biomass residual removal if the Sierra NF management team prioritizes more thinning and harvesting within the northern portion of its jurisdiction.

Private Forestlands

Like federally managed lands, there are ongoing forest fuels reduction projects on private lands within the FSA. Based on interviews with foresters, logging contractors, land managers and TSS knowledge of the FSA, about 5,000 acres/year are currently being treated. Fuels reduction on private lands typically results in 10 to 15 BDT/acre removed (as private land managers are usually more aggressive when treating forest fuels). Assuming 12 BDT/acre, the potentially available forest fuels reduction residuals on private lands total 60,000 BDT/year. Adding national forest and private land thinning residuals results in approximately 133,150 BDT/year of potentially available forest fuels reduction residuals.

Fuels reduction efforts within the FSA on private industrial forestlands are expected to continue at their current pace for the near term, although land managers for Sierra Pacific Industries have pointed out that fuelbreak creation will begin to diminish as they will eventually cover their entire ownership (likely by 2030). Fuels reduction efforts on federal lands are forecast to increase due to a dramatic increase in funding available to the national forests and a significant backlog of untreated

[13] Tahoe Forest Products.

acres across federal lands within the FSA. Planning documents for the Stanislaus NF, for example, show 35,500 acres planned for fuels reduction over the next five years.

As with timber harvest residuals, not every acre treated will accommodate forest biomass removal. Using the 65% accessible metric (as used for the timber harvest residuals calculation), approximately 86,548 BDT/year of forest fuels reduction feedstock is considered practically available.

The cost to collect, process, and load forest fuels reduction residuals into chip trucks in the forest ranges from $65 to $75/BDT.[14] The cost to transport forest fuels reduction residuals is similar to the cost to transport timber harvest residuals and ranges from $130 to $150/hour.[15] Assuming an 80-mile one-way transport distance (4.5 hours roundtrip including loading and unloading time) and transport cost of $140/hour, the total roundtrip transport cost is $630. Assuming 14 BDT of forest fuels reduction residual volume in the truck, the roundtrip transport cost is $45/BDT. The total cost to collect, process, load, and transport (80-mile haul distance at $140/hour and $70/BDT to collect, process, and load) comes to $115/BDT.

As with timber harvest residuals, forestland managers, power utilities, and state and federal agencies are willing/able to offset a portion of these costs. Biomass power plants in Central and Northern California are currently paying between $45 and $70/BDT for forest fuels reduction residuals (delivered to the facility).

Post-Fire Restoration

The USFS is significantly increasing reforestation targets nationwide (including Region 5 – California). Increased funding levels appropriated by Congress are focused on reforestation efforts with a goal to replant 1.5 million acres in California. The 2021 Replant Law provides increased funding to support replanting efforts as currently funded by the Reforestation Trust Fund (created by Congress in 1980). The Trust Fund had a $30 million/year cap that the Replant Act now supersedes, with up to $123 million/year for reforestation activities on national forestland. The Replant Law also directs the USFS to develop a 10-year plan to address the backlog of acres needing restoration by 2031.

Discussions with Region 5 staff[16] confirmed additional funding due to the Replant Law is available within California at around $10.5 million/year (triple the amount of past years). Region 5 staff is asking for another $10.5 million/year. In addition, partner organizations (e.g., American Forests) contribute funding to support reforestation efforts. With all of this increased funding support, Region 5 is planning to conduct site preparation (including biomass removal) on approximately 15,000 to 30,000 acres/year. As Region 5 implements site preparation activities (prior to tree planting), some forest biomass removal is likely. This will add additional forest biomass into the marketplace. USFS staff are still in the planning phase of this reforestation effort.

[14] Per discussions with logging contractors and foresters.
[15] Ibid.
[16] Ramiro Rojas, Deputy Regional Silviculturist.

Sawmill Residuals

Currently there are two commercial-scale sawmills operating within the FSA. Both are owned and managed by Sierra Pacific Industries.

Sierra Pacific Industries – Standard
SPI operates a large sawmill complex at Standard, producing primarily dimension lumber. Discussions with area foresters confirm that the Standard mill is currently utilizing about 72 million board feet of logs (72 MMBF), producing about 95 million board feet (lumber tally measure) of lumber per year. This mill is currently operating on a two shift/day production basis.

Sierra Pacific Industries – Chinese Camp
The SPI Chinese Camp mill is a small log sawmill primarily producing fencing. Discussions with area foresters confirm that the Chinese Camp mill is currently utilizing about 40 million board feet of logs (40 MMBF), producing about 73 million board feet (lumber tally measure) of lumber per year. This mill is currently operating on a two shift/day production basis.

An estimate of sawmill residuals produced within the FSA is summarized in Table 6. Note that TSS utilized a sawmill calculation methodology developed by the Forest Resources Association[17] in 2010 to estimate residual volumes.

Table 6. Sawmill Residuals Produced Within the FSA

Sawmill	Chips (BDT/YR)	Shavings (BDT/YR)	Bark (BDT/YR)	Sawdust (BDT/YR)	Hog Fuel (BDT/YR)	Total (BDT/YR)
SPI Standard	41,818	8,078	19,008	14,256	3,802	**86,962**
SPI Chinese Camp	32,208	6,222	14,640	10,980	2,928	**66,978**
Totals	**74,026**	**14,300**	**33,648**	**25,236**	**6,730**	**153,940**

Discussions with foresters and fiber managers confirmed that commercial markets for sawmill residuals are quite dynamic. For example, much of the sawmill residual volume is being sold to biomass power plants as High Hazard Zone (HHZ) compliant fuel. Much of the bark produced is utilized as landscape cover. Table 7 summarizes current sawmill residuals pricing (delivered to end-users) within the FSA .

Table 7. Current Sawmill Residuals Market – Delivered Pricing

Sawmill Residual Type	Low Range ($/BDT)	High Range ($/BDT)
Chips	$50	$65
Shavings	$45	$65
Bark	$35	$55
Sawdust	$35	$55
Hog Fuel	$35	$55

[17] https://www.forestresources.org/

Summary of Forest Feedstock Availability

Posted in Table 8 is a summary of forest feedstock availability by type within the FSA.

Table 8. Forest Feedstock Supply Availability Within the FSA

	Timber Harvest Residuals (BDT/Year)	Forest Fuels Reduction Residuals (BDT/Year)	Sawmill Residuals (BDT/YR)	Totals (BDT/Year)
Potentially Available	98,764	133,150	153,940	**385,854**
Practically Available	**64,196**	**86,548**	**153,940**	**304,684**

URBAN WOOD WASTE FEEDSTOCK SUPPLY

This analysis focused on two types of potential urban wood waste feedstocks currently available within the FSA: 1) construction/demolition and 2) tree trimmings.

Wood waste produced within urban communities in the form of construction and demolition wood, and tree trimmings, is an excellent and cost effective feedstock source. Typically low in moisture content (<25% moisture) and available year-round, urban wood is increasingly available due to several California legislative mandates.

- Assembly Bill 1594 – Signed into law in 2014, this legislation eliminates the waste diversion credit for landfills to use organics (including wood waste, tree trimmings) as alternative daily cover (ADC) effective 2020. Federal law requires landfills to be covered at the end of each workday to prevent odors, vermin and insects. While landfills have traditionally utilized soil as ADC, many states allow the use of alternative materials (including organics such as wood waste) for cover. Commencing in 2020, landfills are utilizing other techniques to cover landfills (such as tarps) on a daily basis.
- Senate Bill 1383 – Signed into law in 2016, this legislation seeks to mitigate short-lived climate pollutants (e.g., methane) by diverting organic wastes (including wood) away from landfills. It mandates a 50% reduction in organic waste disposal from 2014 levels by 2020 and a 75% reduction by 2025.

Due to these legislative mandates and an increased level of interest to extend the service life of landfills, investment in urban wood waste sorting and processing operations has increased, resulting in more urban wood waste being available for value-added use.

Urban Wood Waste

Urban wood waste generated by a community or region is directly proportional to population. The higher the population within a given area, the more urban wood waste is produced. TSS utilized 2021 data from the US Census Bureau (most recent data available) to estimate current population for

every county within the FSA. Within the FSA there is an estimated population of approximately 161,672 residents.

Solid waste characterization studies are conducted sporadically throughout the U.S. A particularly comprehensive study was conducted in 2016 by the Oregon Department of Environmental Quality (ODEQ). Using the 2016 ODEQ solid waste characterization study[18] and a 2018 ODEQ solid waste generation report,[19] TSS utilized the findings to calculate urban wood generated within the FSA. As noted in the 2018 waste generation report, approximately 7.4 pounds of waste are produced daily per person. The 2016 characterization study found an estimated 10.6% of the solid waste stream generated as clean wood (paint free, no treated wood). Using this waste generation estimate, it was calculated that approximately 17,358 BDT/year of urban wood are potentially available within the FSA.

Approximately 65% of this volume is recoverable as clean wood waste feedstock, resulting in 11,283 BDT/year of urban wood waste feedstock as practically available. Table 9 summarizes urban wood waste produced within the FSA on an annual basis by county.

Table 9. Urban Wood Feedstock Produced Within the FSA

County	2021 Population Within FSA	Potentially Available Urban Wood Waste Feedstock (BDT/Year)	Practically Available Urban Wood Waste Feedstock (BDT/Year)
Alpine	1,235	133	**86**
Amador	41,259	4,430	**2,879**
Calaveras	46,221	4,963	**3,226**
Mariposa	17,147	1,841	**1,197**
Tuolumne	55,810	5,992	**3,895**
Totals	**161,672**	**17,358**	**11,283**

Note that sparsely populated counties, such as Alpine and Mariposa, produce relatively little urban wood and as such are not likely be a consistent feedstock source. Also, urban wood waste sorting and processing require significant capital investment in equipment. Many rural counties (like the five that make up the FSA) are not actively producing urban wood.

Tree Trimming Material

As with urban wood waste, tree trimming material volume produced within a community or region is proportional to population. Based on the 2016 ODEQ waste characterization study,[20] it is estimated that approximately 89 dry pounds of tree trimmings potentially suitable as feedstock are generated annually per person. Employing the data and methodology above yields about 7,194 BDT/year of tree trimming material as potentially available. TSS experience confirms that approximately 80% of this volume is recoverable as feedstock, resulting in 5,756 BDT/year of tree

[18] https://www.oregon.gov/deq/mm/pages/waste-composition-study.aspx
[19] 2018 Oregon Material Recovery and Waste Generation Rates Report, Oregon Department of Environmental Quality.
[20] https://www.oregon.gov/deq/mm/pages/waste-composition-study.aspx

trimming material feedstock as practically available. Table 10 summarizes tree trimming material produced within the FSA on an annual basis by county.

Table 10. Tree Trimming Feedstock Produced Within the FSA

County	2021 Population Within FSA	Potentially Available Tree Trimming Feedstock (BDT/Year)	Practically Available Tree Trimming Feedstock (BDT/Year)
Alpine	1,235	55	**44**
Amador	41,259	1,836	**1,469**
Calaveras	46,221	2,057	**1,645**
Mariposa	17,147	763	**610**
Tuolumne	55,810	2,484	**1,987**
Totals	**161,672**	**7,194**	**5,756**

Note that TSS has found that rural communities adjacent to woodland and forestland typically use firewood as a primary source of home heat. Tree trimmings produced in these rural counties typically are used as firewood. Tree trimmings from the FSA will not be a consistent feedstock source.

Summary of Urban Wood Waste and Tree Trimming Feedstock Availability

Noted in Table 11 is a summary of urban wood waste and tree trimming feedstock availability within the FSA.

Table 11. Urban Wood Feedstock Supply Availability Within the FSA

	Urban Wood Feedstock (BDT/Year)	Tree Trimming Feedstock (BDT/Year)	Totals (BDT/Year)
Potentially Available	17,358	7,194	**24,552**
Practically Available	**11,283**	**5,756**	**17,038**

WOOD FEEDSTOCK SUPPLY AVAILABILITY

This woody biomass supply analysis includes a forecast of woody feedstock fiber supply availability within the FSA. Table 12 summarizes TSS findings regarding potentially and practically available wood feedstock supply availability.

Table 12. Potentially and Practically Available Feedstock Supply

	Timber Harvest Residual Feedstock (BDT/YR)	Forest Fuels Reduction Residuals (BDT/YR)	Sawmill Residuals (BDT/YR)	Urban Wood (BDT/YR)	Tree Trimmings (BDT/YR)	Totals (BDT/YR)
Potentially Available	98,764	133,150	153,940	17,358	7,194	**410,406**
Practically Available	**64,196**	**86,548**	**153,940**	**11,283**	**5,756**	**321,722**

Table 12 confirms practical availability of approximately 321,722 BDT/year of biomass feedstock within the FSA.

Seasonal Availability of Feedstocks

Table 13 summarizes seasonal availability of feedstocks (by type) produced within the FSA.

Table 13. Seasonal Availability of Feedstocks

Feedstock Type	Availability	Comments
Urban Wood and Tree Trimmings	Year Round	Communities produce construction/demolition wood and tree trimmings on a year-round basis. Some slowdown over the Thanksgiving and Christmas/New Year holiday period.
Timber Harvest Residuals	April through November	Timber harvest residuals are typically available when commercial timber harvests are being conducted. Wet weather will cause operations to pause.
Forest Fuels Reduction	April through November	Forest fuels reduction activities are conducted as weather permits. Like timber harvest residuals, wet weather will cause operations to pause.

CURRENT FEEDSTOCK COMPETITION

Competition for biomass feedstock produced within the FSA comes primarily from existing biomass power plants, compost/soil amendment/landscape products, firewood, and animal bedding markets.

Biomass Power Plants Sourcing Feedstock from the FSA

Figure 4 highlights the location of facilities sourcing biomass fuels generated within the FSA.

Figure 4. Facilities Sourcing Biomass Feedstock Within the FSA

Note that there are four biomass power facilities that have historically sourced biomass feedstock generated within the FSA. Summarized below are details for each of these facilities and related market sectors (e.g., firewood, landscape cover) currently sourcing biomass from the FSA. Several of the biomass power plants have BioRAM[21] power purchase agreements.

BioRAM Power Plants

There are two power plants with BioRAM power purchase agreements (Pacific Ultrapower Chinese Station and Rio Bravo Rocklin) sourcing forest feedstocks from the FSA. Both have fuel usage requirements that stipulate 60% forest biomass sourced from High Hazard Zones[22] and 80% forest biomass sourced from sustainable forest management (SFM) operations. Note that if the BioRAM facilities are not able to secure 60% HHZ and 80% SFM compliant fuel in a given month, the BioRAM power purchase agreement (PPA) allows for a fuel blend that includes predominantly urban and agricultural fuels.

[21] Bioenergy Renewable Auction Mechanism.
[22] As designated by Cal Fire.

Pacific Ultrapower Chinese Station

The Pacific Ultrapower Chinese Station (PUCS) facility is rated at 22 MW of net power production capacity and utilizes a first generation Energy Products of Idaho bubbling fluidized bed combustion boiler. The facility first entered commercial service in 1986. Located strategically in the Central Sierra Nevada foothills, this facility has access to forest feedstocks, agricultural byproducts, and urban wood waste (mostly sourced from the SF Bay Area). Annual fuel usage is estimated to be 175,000 BDT/year. PUCS is currently operating under a BioRAM PPA with Southern California Edison.

Rio Bravo Fresno

Rio Bravo Fresno (RBF) has a 24 MW net generation capacity with an annual fuel usage of 192,000 BDT.[23] The plant utilizes a Combustion Engineering circulating fluidized bed combustor. It is located near the community of Malaga, just south of Fresno, California. RBF began commercial operation in 1988 and initially contracted to sell all of its capacity and output under a 30-year Pacific Gas & Electric power purchase agreement with a 2019 termination date. A BioRAM PPA with Southern California Edison became effective in 2017 and was terminated in September 2022.

State Senate Bill 901 stipulates that BioRAM PPAs will not be extended if the facility is located in a severe non-attainment airshed. The RBF facility is located within a non-attainment airshed, which resulted in the curtailment of the BioRAM PPA. Recent discussions with former RBF staff confirmed that a new three-year PPA (not BioRAM) has been secured, effective October 2022. With this new PPA, RBF feedstock procurement efforts are focused on low-cost urban wood and agricultural residuals (orchard removals, nutshell) sourced locally.

Rio Bravo Rocklin

The sister plant of Rio Bravo Fresno, Rio Bravo Rocklin (RBR) has a 24 MW net generation capacity with an annual fuel usage of 192,000 BDT. The plant utilizes a Combustion Engineering circulating fluidized bed combustor (very similar to the Rio Bravo Fresno facility). It is located just north of Sacramento, California, with ready access to urban, agricultural, and forest feedstocks. RBR began commercial operation in 1988 and initially contracted to sell all of its capacity and output under a 30-year Pacific Gas & Electric power purchase agreement with a 2019 termination date. RBR is now operating under a BioRAM PPA with Southern California Edison that became effective 2017.

Sierra Pacific Standard

The Sierra Pacific Industries (SPI) Standard facility is able to source biomass fuel in the form of forest products manufacturing residuals (e.g., sawdust, bark) generated by sawmill operations collocated on site. Now that sawmill residuals qualifying as High Hazard Fuel are in strong demand, the Standard facility has increased purchases of urban wood waste and agricultural byproducts as substitute fuel (in place of sawmill residuals) for onsite power generation and

[23] Estimate provided by Hector Lara, former Fuel Manager, Rio Bravo Fresno.

process steam. With access to lower priced urban and agricultural fuel, Standard is able to sell the high-value HHZ fuel to facilities such as Pacific Ultrapower Chinese Station.

Commercial Firewood

Firewood operations are using bole wood and branch wood timber harvest residuals and tree removal operations as raw material. However, as regional air districts have become concerned about particulate matter (and other air pollutants) produced from firewood combustion, the market demand for firewood has dropped significantly. The San Joaquin Valley Air Pollution Control District regularly implements "Spare the Air Alerts" requiring homeowners to curtail the use of firewood. Due to air emissions abatement regulations, most new homes constructed within the eight counties that are within the Air District's jurisdiction cannot be equipped with wood burning appliances or fireplaces that utilize firewood.

Landscape Cover and Soil Amendment

Compost operations typically source tree trimmings and green waste material as raw material. This is especially the case now that the state (CalRecycle is lead agency) is implementing provisions of Senate Bill 1383. Much of the compost produced is used as landscape cover along state highways (Cal Trans is a major consumer) and as soil amendment for commercial agricultural operations. In addition, sawmill residuals (bark and chips), once processed, are regularly sold into the landscape cover markets.

Livestock Bedding

Sawmill residuals, such as shavings, have become a favored livestock bedding material. The FSA is home to numerous ranches with livestock operations that utilize shavings as livestock bedding.

Current Feedstock Competition Within the FSA

Table 14 provides an overview of the commercial-scale facilities currently utilizing biomass feedstocks produced within the FSA.

Table 14. Facilities Currently Sourcing Biomass Feedstock from the FSA

Facility	MW (Net)	Total Feedstock Consumption (BDT/Yr)	Feedstock Sourcing (BDT/Yr) from the FSA				
			Timber Harvest Residual Feedstock (BDT/YR)	Forest Fuels Reduction Residuals (BDT/YR)	Sawmill Residuals (BDT/YR)	Urban Wood and Tree Trimmings (BDT/YR)	Totals (BDT/YR)
Pacific Ultrapower Chinese Station	22	175,000	25,000	61,500	40,000	2,000	128,500
Rio Bravo Fresno	24	192,000				2,000	2,000
Rio Bravo Rocklin	24	192,000	5,000	5,000			10,000
Sierra Pacific Standard	7	56,000			40,000		40,000
Firewood	N/A	N/A	3,000			2,000	5,000
Landscape Cover/Soil Amendment	N/A	N/A			59,940		59,940
Livestock Bedding	N/A	N/A			14,000		14,000
Totals		**615,000**	**33,000**	**66,500**	**153,940**	**6,000**	**259,440**

Note that cull logs produced within the FSA provide supplementary wood fiber to the Pacific Ultrapower facility. In addition, the American Wood Fibers facility at Jamestown processes logs (mostly cull logs) for production of animal bedding. Logs are not included in this feedstock supply analysis.

CURRENT FEEDSTOCK SUPPLY AVAILABILITY

The feedstock supply availability findings regarding potential, practical, and economic wood fuel supply are summarized in Table 15.

Table 15. Potential, Practical and Economic Feedstock Availability

Availability	Timber Harvest Residual Feedstock (BDT/YR)	Forest Fuels Reduction Residuals (BDT/YR)	Sawmill Residuals (BDT/YR)	Urban Wood and Tree Trimmings (BDT/YR)	Totals (BDT/YR)
Potentially Available	98,764	133,150	153,940	24,552	**410,406**
Practically Available	64,196	86,548	153,940	17,039	**321,722**
Current Competition	33,000	66,500	153,940	6,000	**259,440**
Economically Available	**31,196**	**20,048**	**0**	**11,039**	**62,282**

As noted in Table 15, approximately 62,282 BDT/year of woody feedstocks are economically available within the FSA.

FUTURE SUPPLY SOURCES AND RISKS

There are a number of future feedstock supply sources and risks associated with the FSA.

Additional Sources

Summarized below are factors that will cause the feedstock supply available within the FSA to increase in the coming years.

Post-Fire Restoration

As demonstrated in recent years, California is consistently impacted by wildfire events (see Figure 2 and Table 2). Over the past decade, the FSA has averaged 62,511 acres/year impacted by wildfire.[24] This is not likely to change. TSS anticipates that wildfires will occur in the near term within and tributary to the FSA. Forest feedstock from post-fire restoration activities will produce significant volumes of wood waste (damaged trees removed in preparation for tree planting operations). Some of this potential feedstock will be available at discounted cost due to post-fire restoration cost-share funding provided by state (California Office of Emergency Services) and federal (Federal Emergency Management Agency, US Forest Service, Bureau of Land Management) agencies. Note that wildfire events are episodic and unpredictable. Accurately forecasting wildfire activity within the FSA is not possible.

Risks

Potential feedstock supply chain risks are summarized below.

[24] Historic wildfires over 10,000 acres in size, 2013 to 2022.

Potential Competition – Idle Facilities

There are three idle biomass power plants that could be repurposed and source feedstock from the FSA. Two are now owned and managed by Clean Energy Systems and a third, Otoka Energy, is currently for sale.

Clean Energy Systems

Headquartered in Rancho Cordova, California, Clean Energy Systems (CES) has been actively engaged in development of proprietary oxy-combustion technologies since 1996. Founded by aerospace engineers, CES developed a low emissions power generation system (oxy-fuel combustor) and registered 25 patents by 2008. A unique feature of the CES technology is the ability to separate and capture CO2. CES has a pilot plant collocated with a solar PV facility just north of Bakersfield (known as the Kimberlina facility). In 2011, CES purchased the Placerita Power Plant near Santa Clarita in northern Los Angeles County which allowed CES to deploy equipment in a variety of configurations using existing infrastructure (power interconnect and gas pipeline interconnect).

In 2020, CES purchased both the Mendota and Delano biomass power plant sites from Covanta Energy. In 2021, a press release announced that CES seeks to develop a biomass carbon removal and storage (BiCRS) power generation facility with carbon capture and sequestration technology. The Delano site is now targeted to be the location for initial siting of the BiCRS technology, followed by a facility at Mendota.[25] Both the Mendota and Delano sites are located adjacent to geologic formations that facilitate development of injection wells for long-term storage of CO2. CES is currently in the process of securing environmental permitting for the Delano and Mendota operations. CES hopes to bring the Delano facility into commercial service in 2026.

In July 2022, CES announced the planned purchase of the Madera Biomass (MB) facility. MB is an idle 25 MW biomass power plant located at Madera. Current owner is Community Renewable Energy Services. The purchase is forecast to close Q1 or Q2 2023.

Otoka Energy Inc

Otoka Energy Inc, the current owner of the Buena Vista Biomass Power (BVBP) plant, has been actively offering the 18 MW (net capacity) facility for sale since 2017. Located near Ione (see Figure 5 map), BVBP was first constructed in 1987 as a lignite (low-grade coal) fired co-generation facility which provided steam to the adjacent wax extraction facility and combusted processed lignite mined in the area. The facility was re-permitted in 1997 to combust wood waste and subsequently closed in 1999 due to a number of factors, including deregulation of the California electric power generation sector. In 2001, the plant was refurbished, including upgrades to the boiler and fuel handling system to operate using 100 percent woody biomass fuel. Due to the downturn in the power generation market and lack of focus on a renewable portfolio standard, the project was not returned to commercial operation. Otoka purchased the facility in 2010 and commenced refurbishment activities. A PPA with Sacramento Municipal Utility District (SMUD) was negotiated and became effective in 2013. Experiencing operational challenges, the facility was not able to meet SMUD PPA commitments to reliably deliver power. The PPA was terminated in 2016 and the facility has been idle ever since. TSS is aware of several firms that have shown interest in purchasing this facility but failed to come to mutually beneficial terms with Otoka.

[25] Per discussions with Clean Energy Systems staff.

Potential Competition – Greenfield Facilities in Development

There are eight greenfield facilities in early development phases that may compete for feedstock produced within the FSA.

Aemetis

Aemetis is an advanced biofuels and biochemical production company. Headquartered in Cupertino, California, Aemetis has two commercial-scale production facilities: ethanol production facility at Modesto, California (65 M gallons/year production capacity) and a chemical and ethanol production facility in India (50 M gallons/year production capacity). For the last several years, Aemetis has been developing a biomass to ethanol facility at Riverbank, California. Annual feedstock usage is forecast at 200,000 BDT/year with orchard removal material and forest residuals as the primary feedstocks.

Bioenergy Market Adjusting Tariff

In September 2012, the California legislature passed Senate Bill 1122. This bill allocates 250 MW of the state's Renewable Portfolio Standard for small-scale bioenergy projects. Scaled at five MW generation capacity or less, these projects fall under the Bioenergy Market Adjustment Tariff (BioMAT) program. Forest based projects have an allocation of 50 MW and like the BioRAM projects, must utilize 80% of annual fuel usage from sustainable forest management operations. The remaining 20% of annual fuel can be sourced from clean urban wood (e.g., pallets, tree trimmings) or agricultural byproducts (e.g., shell, pits, orchard removals).

Currently, there are nine BioMAT projects in California being considered or in the project development phase. Three of the BioMAT projects (if successful in securing a PPA, attracting project financing and commencing commercial operation) that would source forest feedstocks from the FSA include:

- North Fork Community Power (2 MW project at North Fork)
- Mariposa Biomass (2 MW facility at Mariposa)
- Blue Mountain Electric Company (3 MW facility at Wilseyville)

Together, these three facilities will utilize approximately 56,000 BDT of forest-sourced material on an annual basis. However, there are major challenges ahead for the BioMAT projects, including the successful deployment of such small-scale projects, negotiation of a PPA, project financing, addressing interconnection costs, and securing community acceptance.

Golden State Natural Resources

At this time, it appears that the Rural County Representatives of California (RCRC) is developing a commercial-scale fuel pellet facility at Keystone. RCRC has created a non-profit entity known as Golden State Natural Resources as the sponsor. During a November 3, 2020 presentation by Greg Norton, then President and CEO of RCRC, to the Tuolumne County Alliance for Resources and Environment,[26] Mr. Norton announced that Golden State Resources plans to move forward with development of an industrial fuel pellet production facility at Keystone (see Figure 5 map). Apparently, RCRC has a 20-year Master Stewardship Agreement with the USFS to conduct forest

[26] https://tucare.com/

restoration and fuels treatment projects. RCRC expects these projects to produce a significant volume of forest biomass (logs and chips) that will be utilized as feedstock for the Keystone facility. In addition, this facility is expected to source sawmill residuals as feedstock (likely from SPI Standard and Chinese Camp mills).

Discussions with RCRC staff[27] confirmed that plans are moving forward to develop the Keystone facility with the intent to enter commercial operations in 2024. The 59-acre Keystone site (49 usable acres) has been purchased and environmental permitting is underway. Fuel pellets will be railed to Port of Richmond for export to Pacific Rim utilities. Collocated on the Keystone site will be a 10 MW biomass power plant that will provide process steam and power. Feedstock demand for the fuel pellet operation will be approximately 300,000 BDT/year with a focus on forest feedstocks. Some agricultural feedstocks (orchard removals) will also be utilized. The power plant will utilize about 80,000 BDT/year with some fuel sourced from urban wood waste processing facilities. Plans are to source feedstock from a 60 to 100-mile radius of Keystone.

RCRC is seeking other siting opportunities in California including Nubieber in northeastern California.[28] RCRC expects that the 20-year MSA will anchor feedstock sourcing options throughout California.

Tuolumne Biomass, LLC

A former gravel pit operation at Jamestown, California, is being developed as a small log utilization facility. Located on 17 acres, the Tuolumne Biomass, LLC operation would procure small logs for processing into a variety of value-added commodities including posts, poles, firewood, and biomass fuel (for sale to the Ultrapower Chinese Station facility). This facility is currently in the environmental permitting phase and would likely be a net producer of biomass fuel. It is now planning to begin log procurement in Q3 2023 and commence commercial operations in the first half of 2024.

Tuolumne Bioenergy, Inc

Tuolumne Bioenergy, Inc plans to install a commercial-scale fuel pellet production facility on three acres in an industrial park in Sonora. Scaled to produce 30,000 tons/year of residential grade fuel pellets, this facility will require approximately 44,000 BDT/year of forest residuals as feedstock. A market analysis has been completed that confirms a local market for fuel pellets produced at Sonora. Plans are to bring this facility into commercial operations in 2024.

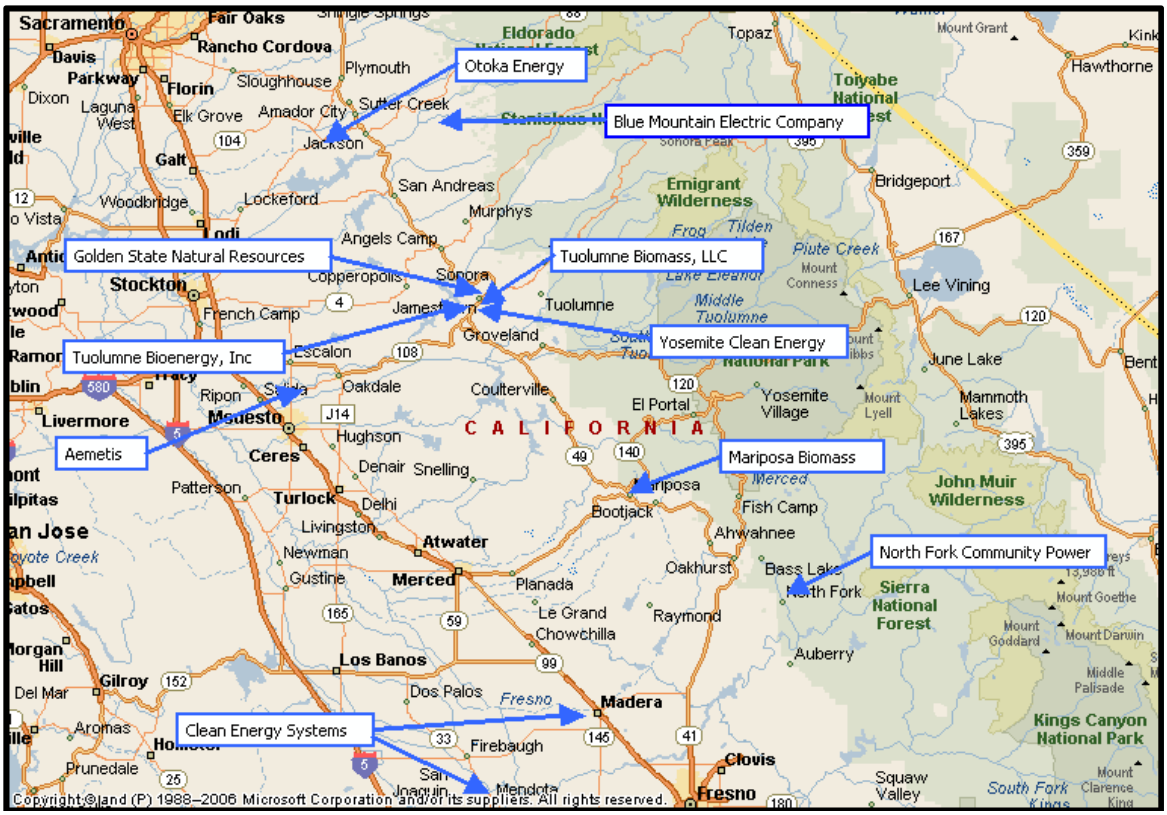
Yosemite Clean Energy, LLC

Yosemite Clean Energy (YCE) is considering development of a forest biomass to green hydrogen production facility near Jamestown. YCE has received significant grant funding ($1 million) from the California Department of Conservation. Plans are to develop a commercial-scale facility at Oroville, followed closely by development of the Jamestown site. Targeted feedstocks include orchard wood and forest residuals. The plan is to procure approximately 90,000 BDT/year with commercial operations commencing Q1 2026.

[27] 11/15/21 phone conference with Terrance Rodgers, Economic Development Officer, RCRC.
[28] Nubieber site is currently in escrow with GSNR as the purchaser.

Figure 5 highlights the locations of the idle biomass power plants and planned greenfield facilities that, if developed, could source feedstock from the FSA.

Figure 5. Potential Feedstock Supply Competition



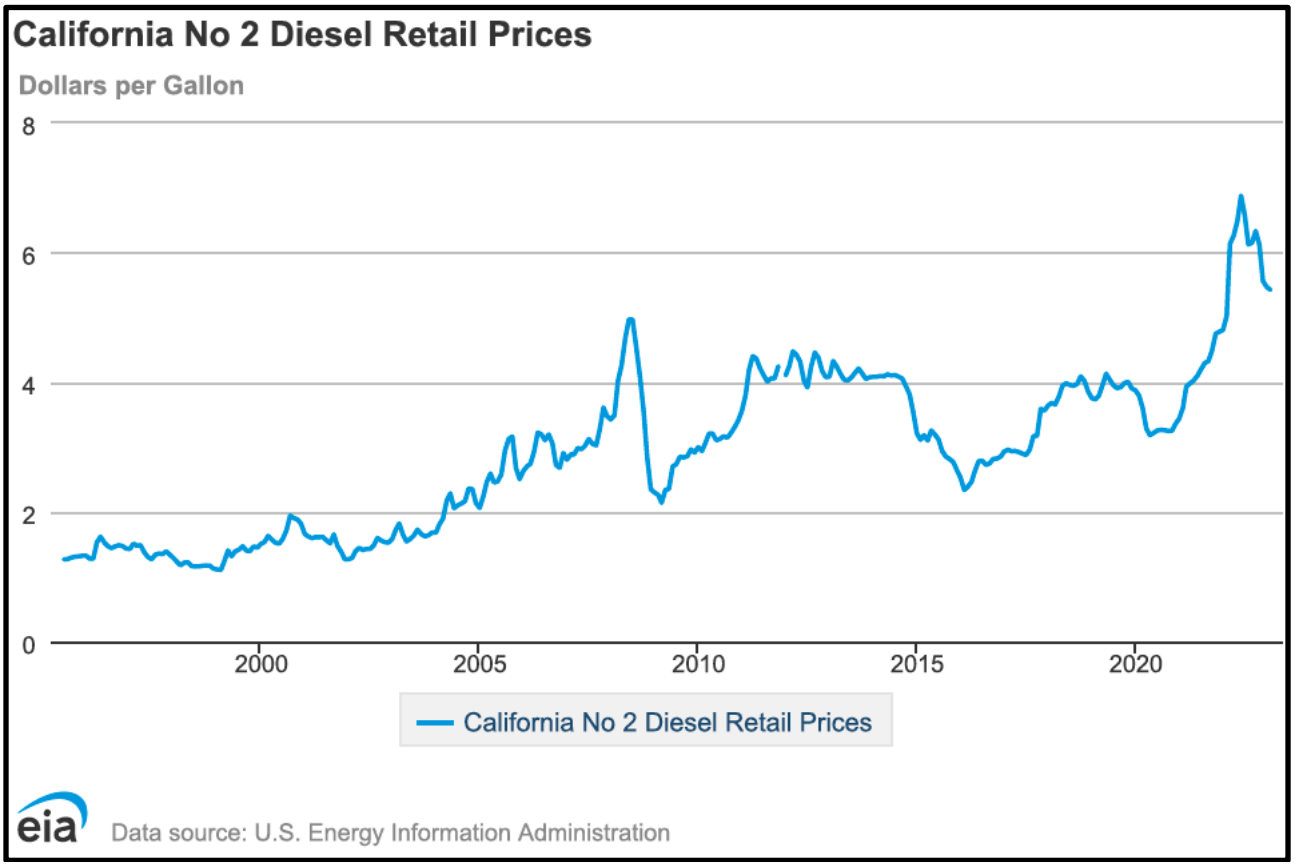
Diesel Fuel

The cost of transporting biomass feedstocks (chips and/or small logs) represents the single most significant expense when procuring biomass. Variables such as diesel fuel cost (currently at $5.42/gallon), workers compensation expense, and maintaining a workforce (locating qualified drivers) are all factors that significantly impact the cost to transport bulk commodities such as wood fiber. Interviews with commercial transport companies indicate the current cost to transport woody biomass feedstocks is between $130 and $150/hour.

At this time, diesel fuel costs are the most significant variable impacting transport costs. In recent months, diesel fuel price escalation has had a major impact on biomass fuel prices throughout the U.S. Figure 6 shows the change in California diesel fuel retail prices (monthly) from 1995 through February 2023.[29]

[29] Energy Information Administration, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emd_epd2d_pte_sca_dpg&f=m

Figure 6. California Diesel Prices 1995 through February 2023



Based on TSS' experience, forest-sourced biomass fiber requires approximately 2.6 gallons of diesel to collect, process, and transport a BDT of chipped biomass fiber with an average round trip haul distance of 100 miles. Therefore, a $1.00/gallon increase in diesel fuel equates to about a $2.58/BDT (assuming 40% moisture content) increase in the cost to produce and transport processed timber harvest residual chips.

CURRENT WOOD FEEDSTOCK PRICING

A wood feedstock market survey was conducted to secure indicative current market pricing for woody feedstocks delivered to commercial-scale operations (e.g., biomass power plants within and tributary to the FSA) sourcing wood fiber produced within the FSA. Findings from the market survey are summarized in Table 16.

Table 16. Current Delivered Prices for Wood Feedstock Produced Within the FSA

Feedstock Type	Low Range ($/BDT)	High Range ($/BDT)
Timber Harvest Residuals	$40	$60
Forest Fuels Reduction Residuals	$45	$65
Sawmill Residuals – Sawdust and Hog Fuel	$40	$50
Urban Wood and Tree Trimmings	$14	$24

FIVE-YEAR FEEDSTOCK PRICING FORECAST

Feedstock pricing forecasts were conducted assuming feedstock demand amounting to 24,000 BDT/year for a community-scale bioenergy facility with 3 MW of generation capacity located within the FSA. Both base case and worst case five-year delivered feedstock pricing scenarios were considered.

Feedstock Supply Pricing Forecast Base Case

Summarized in Table 17 is the 2025 biomass feedstock blend for the base case scenario.

Table 17. 2025 Feedstock Supply and Delivered Pricing Base Case

Feedstock Type	Volume/Year (BDT)	$/BDT
Timber Harvest Residuals	15,000	$50.00
Fuels Reduction Residuals	9,000	$60.00
Total	**24,000**	
Blended Feedstock Delivered Pricing		**$53.75**

Assumptions used to generate the 2025-2029 feedstock market price base case estimate are as follows.

- All feedstock pricing reflects delivery of 3” minus material.
- Feedstock usage is 24,000 BDT/year.
- Transportation costs average $140/hour.
- Forest-sourced material (timber harvest residuals and fuels reduction residuals) collection, processing, and transport costs are subsidized by state and federal funding.
- Delivered feedstock prices will escalate at 1.5% per year (commencing in 2026) to reflect increased diesel and labor costs over time.

Feedstock Supply Pricing Forecast Worst Case

Summarized in Table 18 is the 2025 biomass feedstock blend for the worst case scenario.

Table 18. 2025 Feedstock Supply and Delivered Pricing Worst Case

Feedstock Type	Volume/Year (BDT)	$/BDT
Timber Harvest Residuals	15,000	$57.50
Fuels Reduction Residuals	9,000	$69.00
Total	**24,000**	
Blended Feedstock Delivered Pricing		**$61.81**

Assumptions used to generate the 2025 feedstock market price worst case estimate are as follows.

- All feedstock pricing reflects delivery of 3" minus material.
- Feedstock usage is 24,000 BDT/year.
- Transport costs average $150/hour.
- 2025 delivered feedstock worst case pricing is 15% higher than 2025 base case.
- Forest-sourced feedstock material (timber harvest residuals and forest fuels reduction residuals) collection, processing and transport costs are subsidized with state and federal funding.
- Feedstock prices increase 10% commencing in 2026 to reflect feedstock market impact of competing facilities (e.g., Yosemite Clean Energy, Tuolumne Bioenergy, Tuolumne Biomass) commencing commercial operations.
- Delivered feedstock prices escalate at 3% per year commencing in 2027 to reflect increased diesel and labor costs over time.

Five-Year Feedstock Price Forecast Base Case and Worst Case

Summarized in Table 19 is the five-year base case and worst case price forecast for feedstock delivered to a facility located within the FSA.

Table 19. 2025 to 2029 Feedstock Price Forecast Base and Worst Case

Year	2025 ($/BDT)	2026 ($/BDT)	2027 ($/BDT)	2028 ($/BDT)	2029 ($/BDT)
Base Case	$53.75	$54.56	$55.37	$56.21	$57.05
Worst Case	$61.81	$67.99	$70.03	$72.13	$74.30

OBSERVATIONS

Summarized below are TSS observations from this feedstock supply availability assessment.

Dynamic Marketplace

The FSA is located in a mature woody feedstock utilization marketplace with a variety of factors impacting feedstock supply and demand. The existing biomass power plant infrastructure has been able to successfully negotiate BioRAM PPAs. While these PPAs have five-year terms, they have already been extended once and in most cases will likely be extended again.

Seasonal Availability

As noted in Table 13, feedstock availability can be seasonal. Some feedstock (urban wood and tree trimmings) are available year round; however, agricultural byproducts and forest feedstocks are seasonal.

Potential Feedstock Competition

There are 11 facilities in development that could source forest and/or urban wood feedstocks from the FSA. It is likely that not all of these facilities will be successfully deployed, but the fact that 11 are in consideration confirms there is a high level of interest in the marketplace to develop value-added utilization enterprises.

SUPPLY CHAIN DEVELOPMENT RECOMMENDATIONS

Outlined below are recommendations in support of feedstock supply chain development.

Feedstock Transport Logistics

One of the most significant feedstock sourcing cost centers is transportation. Transporting feedstock from its source to the utilization facility is typically the most costly single step. There may be an opportunity to work with feedstock suppliers to assure that they are optimizing feedstock transport by maximizing feedstock tonnage onboard truck. Delivering dry feedstock (e.g., letting forest feedstock dry in the forest before transporting) will assure maximum BDT/load transport, thus optimizing economies of transport.

Forest Feedstocks

As noted in the Forest Feedstocks section of this report, there is a significant and compelling issue regarding catastrophic wildfire within California (and the Inland West). State and federal legislatures are seeking out ways to proactively address the buildup of forest fuels. The state legislature has already committed significant funding, and recent federal legislation (Bipartisan Infrastructure Law and Inflation Reduction Law) includes significant fiscal appropriations to support forest restoration and fuels reduction. In addition to funding forest thinning, there will be funding to restore fire-impacted forests. This could be an opportunity to develop additional forest feedstock supply chain infrastructure to support increased investment in forest restoration.

Longer Term Service Contracts

As state and federal agencies increase funding support for fuels reduction and post-fire restoration activities, there will be a concomitant need to support expansion of existing contractors and development of new contractors available to deploy equipment and staff to treat and restore forestland within the FSA. A significant barrier for these contractors is the capital investment required to purchase equipment. In order to secure capital from the private financial sector, contractors will need to demonstrate a steady stream of work. TSS recommends that the USFS consider utilizing long-term service contracts that can be used by contractors to demonstrate to financial institutions that there is enough work to sustain contractor's need for cash flow to service debt.