Happy Camp, California Biomass Supply & Feasibility Study

Completed for:

The RISE Collaborative &

Happy Camp Community Action, Inc.

Completed by:

THE BECK GROUP

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CHAPTER 1 – EXECUTIVE SUMMARY

1.1 INTRODUCTION

Happy Camp Community Action, Inc. (HCCA) is a 501(c)(3) non-profit organization located in Happy Camp, California and is the fiscal sponsor of RISE Collaborative (RISE). HCCA/RISE, through funding provided by a California Office of Emergency Services JumpStart grant, sponsored this biomass supply, biomass technology screening, and biomass feasibility study in support of using a biomass-based business sited in Happy Camp to meet HCCA/RISE's objectives of protecting people, property, infrastructure, and way of life. HCCA/RISE retained the services of The Beck Group (BECK), a Portland, Oregon-based forest products planning and consulting firm, to complete the biomass supply, biomass technology screening, and feasibility studies. This report documents all study methodologies, analyses, results, conclusions, and recommendations.

1.2 BIOMASS SUPPLY STUDY

Figure 1.1 illustrates the Happy Camp Region and the surrounding national forests. For the purposes of this study, the supply area considered was the area defined by a 15-mile radius circle centered on Happy Camp, California: the Happy Camp Supply Area, or HCSA.

Figure 1.1—Happy Camp Region Map

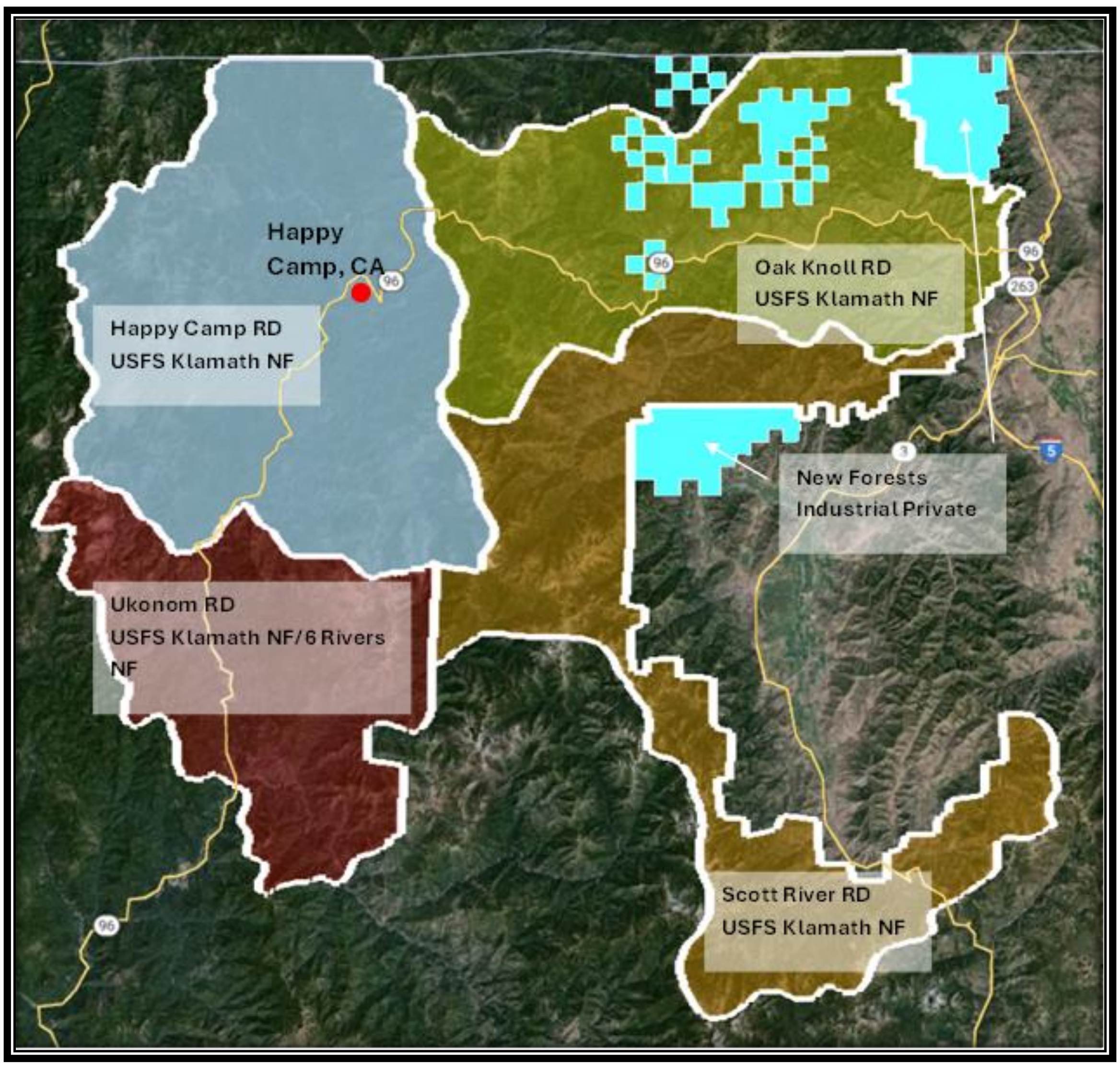


Table 1.1 illustrates the results of the supply study. As the data show, there is a total of nearly 24.9 million board feet (or about 110,000 bone dry tons) of various types of biomass produced annually within a 15-mile radius of Happy Camp. Of the sawtimber volume, most is sold to various sawmills and veneer mills in Northern California. However, 3.0 MMBF (*million board feet*) are oversized logs that have weak markets because only a few mills can utilize them and they are distant from Happy Camp. An estimated 2.4 MMBF of sawtimber could be generated per year should there be a focus on removing hazard trees from road rights-of-way. The topwood volume is produced as a by-product of sawtimber, and is currently largely unutilized. Logging slash includes the limbs and unusable portions of harvested trees; it is also a by-product of sawtimber harvest. The thinning volume in the table is an estimate of what is produced by thinning 2,000 acres per year.

Table 1.1—Estimated Annual Supply of Biomass Near Happy Camp, California

Source Type	MMBF per Year	BDT per Year	Available Portion (BDT/year)
Baseline Sawtimber	19.6	68,600	10,500
Hazard Tree Removal Sawtimber	2.4	8,500	8,500
Logging Slash	n/a	9,300	6,000
Topwood	2.9	10,300	10,300
Thinning	n/a	13,000	13,000
Total	**24.9**	**109,700**	**48,300**

The various types of biomass listed in the table all have differing costs to produce and deliver to a manufacturing facility. The estimated delivered cost ranges from a low of $35 per bone dry ton for sawtimber to a high of $180 per bone dry ton for small diameter trees (see Table 2.8 in the body of the report for more details). Despite this wide range in cost, the costs are consistent with those observed in other regions and are at levels that allow a forest products manufacturing business or businesses to operate profitably.

The key conclusion that can be drawn from the biomass supply analysis are that there is enough currently unutilized biomass produced near Happy Camp to support a forest products manufacturing business (or businesses). The cost of the biomass is such that a carefully selected forest products manufacturing business can operate viably. And finally, a forest products business can be established with almost no increase in current harvesting levels. Rather, the business would allow for increased utilization of trees that are already being harvested. See Chapter 2 for additional details on the supply analysis.

1.3 TECHNOLOGY SCREENING

Regarding the types of forest products manufacturing businesses, BECK completed a screening of 15 different technologies. A small-scale, specialty sawmill and a pilot-scale wood wool cement large wall element business were identified as the business types most viable for Happy Camp. Both businesses could operate at the former sawmill site in Happy Camp.

The concept for the sawmill is for it to be small in scale and produce specialty products. It would only have about 1% of the production capacity of the industrial-scale mills operating in Northern California. To avoid competing with those mills it will focus on producing specialty lumber products, especially large timbers from the larger diameter logs that are available in the Happy Camp area. Sawmilling technology is well developed and the markets for lumber products are well understood. Thus, the key to success largely revolves around strong management of the business.

The concept for wood wool cement-large wall element operation is that it would produce material that forms the walls for residential structures. Other parts of the structures would still use conventional materials. The benefits of wood wool cement construction are that the buildings are much more fire-resistant than conventional stick-built homes. This is an important consideration in towns throughout the Western US such as Happy Camp where wildfire, and its potential to damage or destroy homes is a significant risk. Additionally, the buildings have superior energy performance because the material is highly insulative, which means the buildings are easy to heat or cool. Yet another advantage of this material is that since it forms the entire wall of a building (as opposed to the studs, insulation, sheathing, vapor barriers, and siding that are all used to form the walls in conventional, stick-built framing), this monolithic design means that the walls can be constructed very rapidly. This reduces the time and labor associated with home construction.

However, a major hurdle for this concept is that the wood wool cement-large wall element product is new to the United States. Thus, it is not currently approved for use in building codes. The material, however, has been used structurally in European buildings for decades. Given these circumstances, a pilot-scale facility is the approach considered here because it minimizes capital investment during the period of gaining building code approval. Also, the small scale is appropriate for Happy Camp where there are few homes built each year.

There are several keys to success for this business. First, the market must support construction of about 20 homes per year. This will likely require participation by the Karuk Tribe and/or looking beyond just the Happy Camp area as the market. The second is pursuing a two-pronged business development approach of gaining broadly accepted building code approval (which will take several years) and a short-term approach of using a performance-based approach on a project-by-project basis to prove code equivalence in each jurisdiction. See Chapter 3 for additional details.

1.4 FEASIBILITY ANALYSIS

Table 1.2 summarizes key elements of the feasibility analysis completed for the sawmill and wood wool cement concepts analyzed in this study. As the results indicate, both businesses have relatively modest initial capital investments and generate positive annual cash flows. Both also provide a modest number of full-time jobs, which is meaningful in a small community such as Happy Camp. See Chapter 4 for additional details about the feasibility analysis.

Table 1.2—Summary of Key Feasibility Indicators about Each Biomass Utilization Business

Source Type	Small-Scale Specialty Sawmill	Wood Wool Cement-Large Wall Element Pilot-Scale Plant
Capital Investment (dollars)	$1,300,000	$320,000
Annual Revenue (dollars)	$2,229,000	$696,600
Annual Expense Excluding Depreciation (dollars)	$1,936,000	$560,529
Net Annual Cash Flow (dollars)	$293,000	$168,071
Simple Payback Period (years; CapEx divided by Cash Flow))	4.44	1.90
Direct Full-time Jobs (number of people employed)	5	4

1.5 RECOMMENDED NEXT STEPS

Both forest products manufacturing businesses analyzed are judged to be technically and economically feasible. However, there are a variety of technical and economic uncertainties remaining after the high-level analysis completed during this phase of planning. Therefore, it is recommended that HCAA/RISE complete additional analysis and business planning to further the potential for developing these businesses. Key areas for further work include:

- The Karuk Tribe's ancestral homelands are centered in and around Happy Camp. The Karuk Tribe can be a key partner in the development of both businesses. Continued and deepened engagement with the Karuk Tribe is recommended in any subsequent planning work.
- The analysis was largely based on increasing the utilization of the currently available biomass supply in Happy Camp. The financial analysis suggests that both businesses can viably operate at the scale of the currently available material. However, both businesses could also grow in scale to match increased harvest levels and potentially increased market demand for the products produced. Increasing the scale of either business would improve financial performance. However, increasing timber harvest would need support from local citizens and the US Forest Service, which is the dominant landowner in the region. Therefore, it is recommended that the US Forest Service and the various key stakeholders such as the Mid-Klamath Watershed Council and the Western Klamath Restoration Partnership be engaged as potential project partners in any subsequent planning work.
- There are a variety of uncertainties in the feasibility analyses for both businesses. These should be evaluated more deeply and rigorously in an upcoming phase of planning and due diligence, including:
    - Engaging with the US Forest Service and other stakeholders more deeply to assure the annual biomass supplies identified in this study are assuredly available should a business(es) be developed.
    - Engaging an engineering firm or firms to more precisely estimate capital costs including equipment purchase, site development, building construction, etc.
    - In association with the engineering firms' work, refining key operating assumptions such as the amount of labor, raw material to finished product yields, power costs, productivity rates, site development-related costs and partners, permitting and regulatory issues, etc.
    - Identifying entrepreneurs willing to develop and operate one or both of these businesses.
    - Specific to wood wool cement, the medium and long terms will require that large wall elements gain acceptance into building codes. Absent this, WWC would be limited to the project-by-project approach. This acceptance will include need for testing the materials' strength, fire resistance, seismic performance, etc. Much of this type of work can be completed with the assistance of universities working in cooperation with industry associations that certify material quality compliance.
- Critical to the success of any new business is the presence of an entrepreneur willing to invest in and operate the business. Several such people have already expressed interest. These people, and any others yet to step forward, should be engaged in any subsequent planning work.
- There are a variety of local, State, and Federal grant funding programs that can support further planning and development of these businesses. See recommendations in Chapter 4 for specific programs that can support further planning and research.

CHAPTER 2 – HAPPY CAMP SUPPLY STUDY

Three key processes are involved in this study, including: 1) Estimating the supply and cost of biomass in the Happy Camp, California area; 2) Screening biomass utilization technologies to identify which are most appropriate for Happy Camp; and 3) Completing a feasibility analysis for a preferred technology (or technologies). This chapter provides an assessment of the supply and cost of biomass in the Happy Camp region.

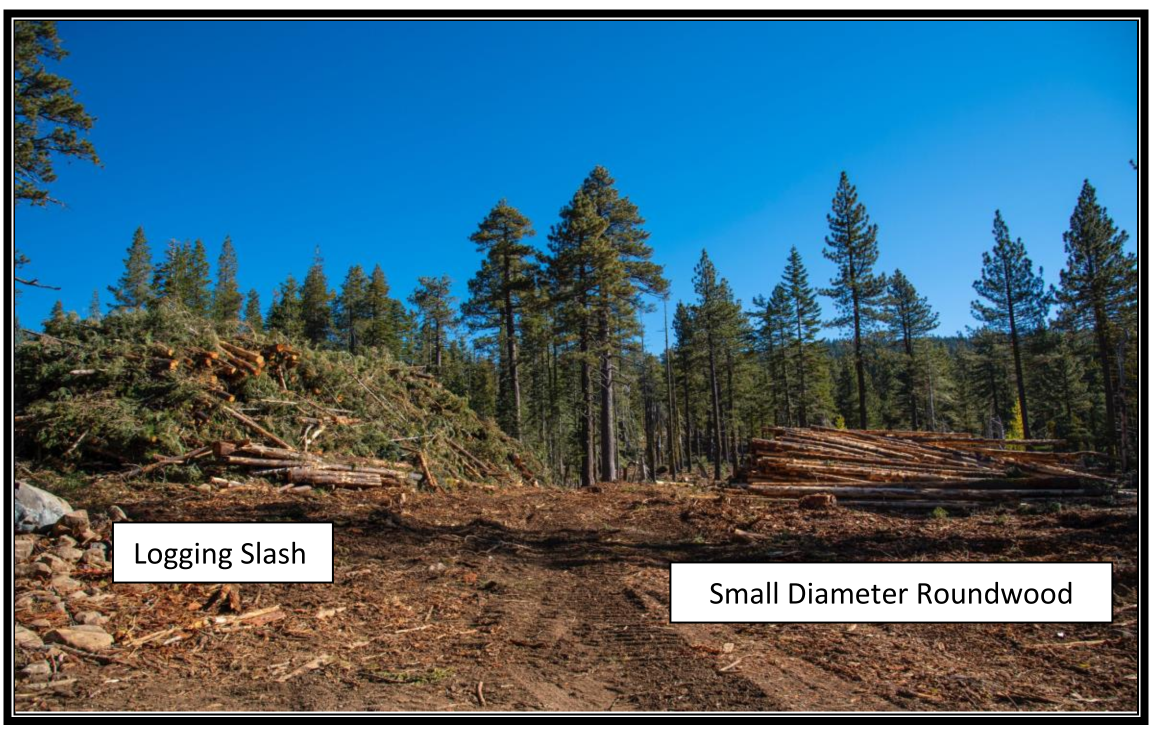
2.1 DEFINING BIOMASS FOR THE PURPOSES OF THIS STUDY

The terms "biomass" or "woody biomass" are often used to refer to a variety of materials. Therefore, it is useful to begin by defining it for the purposes of this study. Biomass includes materials that can be sourced directly from the forest, plus other materials that are the by-products of other processes. Thus, biomass can include forestry residues such as logging slash and topwood. It also includes whole tree stems, which are commonly referred to either as sawlogs[1] (large logs used to produce lumber or veneer), or "small diameter roundwood" (logs too small for lumber or veneer manufacturing). These sources are the main focus of this analysis.

Biomass also includes mill residuals such as bark, sawdust, wood chips, and planer shavings, which are the by-products of wood milling operations. Other biomass sources of even lesser importance in the Happy Camp context include urban wood waste and agricultural/orchard waste. These are not given further consideration in this study.

Figure 2.1 provides an illustration of logging slash and small diameter roundwood. Note that for the most commonly used types of logging equipment configurations in the Happy Camp region, both the logging slash and small diameter roundwood accumulate at a centralized location in the harvest unit, known as a *landing*. Landings are accessible to trucks and other equipment so that the material can be transported to market.

Figure 2.1—Illustration of Forest-Derived Biomass Including Logging Slash & Small Diameter Roundwood



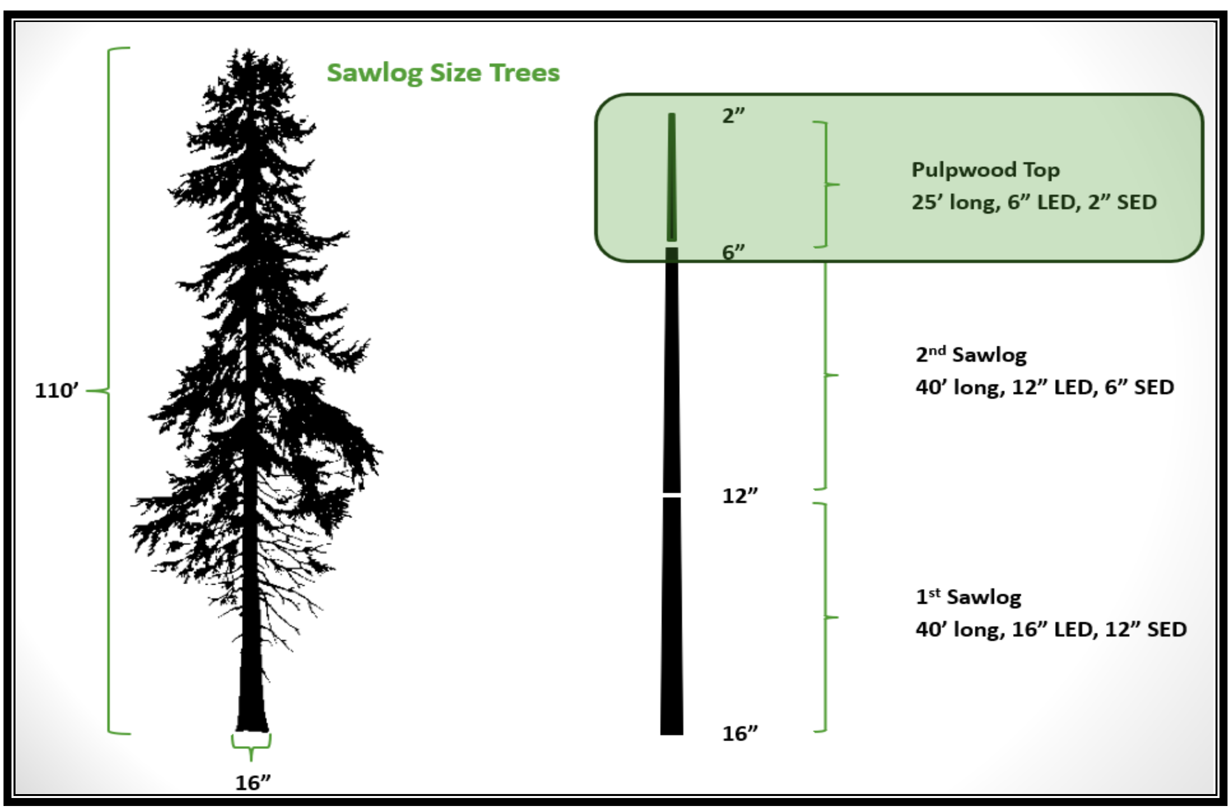
[1] Throughout this report the term "sawlog" is used to describe a log that is "merchantable" for producing either lumber or veneer.

Logging slash is any portion of a harvested tree stem that cannot be utilized in milling. It includes things like limbs, tops, and portions of the stem that are too crooked, rotted, or otherwise defective to be utilized. The limb portion of logging slash contains large amounts of bark, needles, and once piled contaminants such as dirt and rocks. This largely limits the use of logging slash to boiler fuel after it has been ground or chipped. If no options exist for utilizing logging slash, it is either lopped and scattered back across the harvest unit, or open-pile burned.

Topwood is a subcategory of logging slash. It is the smallest diameter portion of a larger diameter tree that has been harvested for sawlog utilization as shown in **Figure 2.2**. All trees taper from the base to the top as shown in the figure; the tree is 16" in diameter at the base, 110' tall, and tapers to a thin leader at the tip. Such a tree will yield two sawlogs, each approximately 40' long. The remaining topwood portion of the tree will be about 25' long, about 6" in diameter at the large end and about 2" in diameter at the small end. Importantly for the utilization of the topwood portion of trees, the logger must process and sort the tops from the slash. This most commonly happens when the whole stem is transported (from where the tree was felled) to a landing. At the landing, a piece of equipment called a *processor* removes the limbs and cuts the logs to length. If there is no market for the topwood portion, it will not be delimbed and cut to length, but rather be thrown into the slash pile. If a market is present, however, the topwood portion will be delimbed, cut to length, and set aside into a deck of topwood logs. Note however that a logger will likely charge a purchaser a fee for the extra cost associated with delimbing and sorting the topwood that would otherwise be thrown into a slash pile. This issue is further discussed in Section 2.5.2.

Logging operations typically assign little to no cost to the topwood material, since it is a by-product of harvesting the sawlogs. This is a key distinction between topwood and other small diameter roundwood described in the next paragraphs. It means that topwood is generally a much cheaper source of biomass than other small diameter roundwood.

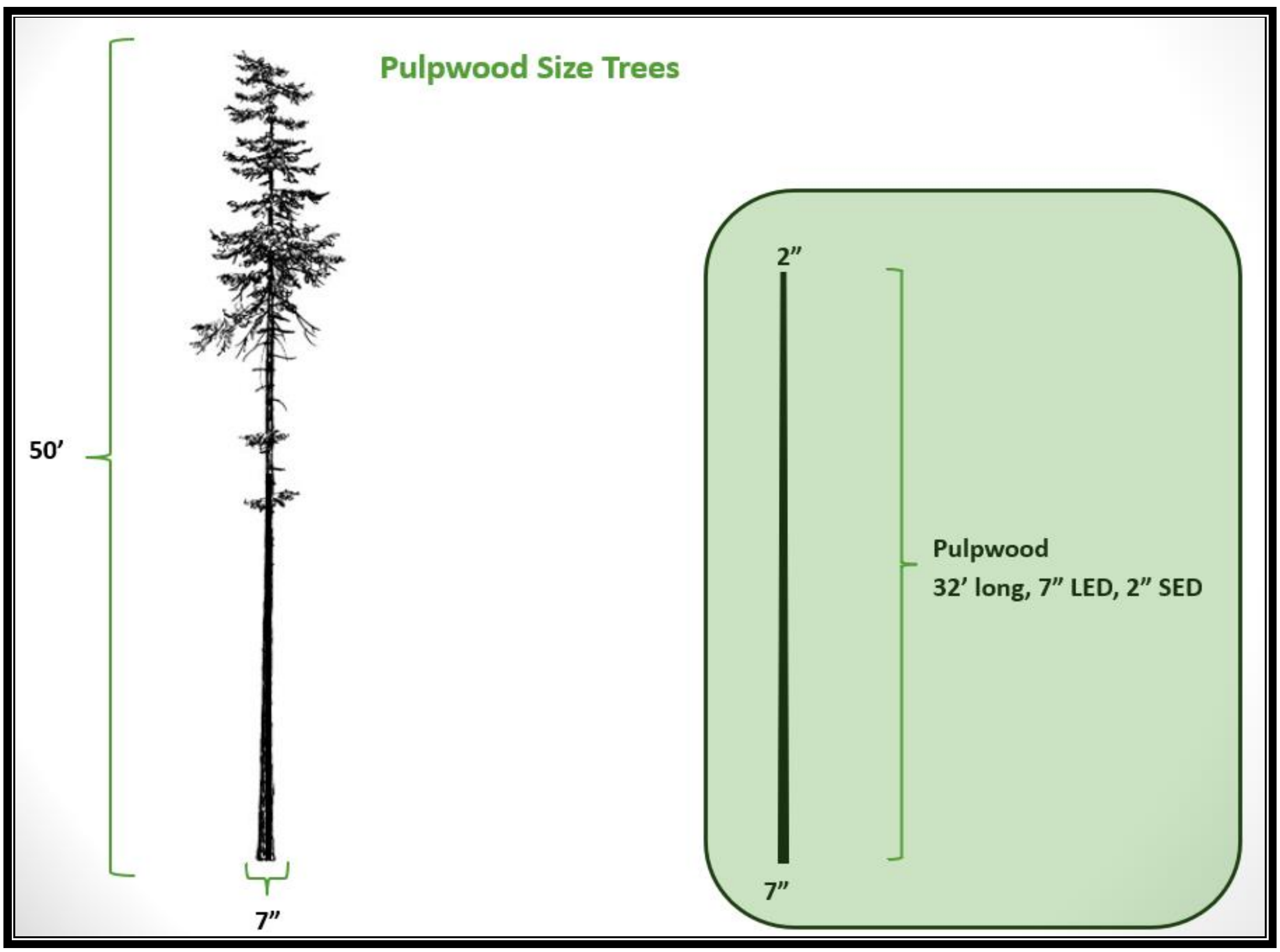
Figure 2.2—Illustration of How a Sawlog Size Tree Is Utilized (sawlogs & topwood)



Another source of small diameter roundwood consists of trees where no portion of the stem is large enough to be utilized as a sawlog as shown in **Figure 2.3**. In many regions of North America, trees of this size are referred to as pulpwood because they are most utilized for making pulp and/or paper. As the example pulpwood tree in the figure shows, it is 7” in diameter at the base and 50’ tall. Such a stem will yield a pulpwood log about 32’ long, 7” in diameter at the large end and 2” in diameter at the small end. However, unlike topwood (which arrives at a landing area by virtue of being attached to a larger log), all logging costs are assigned to the pulpwood. This makes it a costlier biomass raw material than topwood. Unfortunately, most forest health and wildfire mitigation treatments are specifically designed to reduce the density of stands of pulpwood-size trees. Thus, the small trees harvested from such treatments are among the costliest biomass sources.

Similarly, mill residuals and agricultural/orchard residues are also often considered by-products of other processes, and therefore do not always have to bear the full cost of their accumulation and preparation. While those biomass supply sources are not an important supply consideration for this study, their cost is important when considering which utilization options are most feasible for a business in Happy Camp. This is because some technologies, for example pellet manufacturing, can utilize both small diameter roundwood and mill residuals. However, a business that relies solely on small diameter roundwood as the raw material for pellet manufacturing will have a much higher raw material cost than a similar operation that relies on mill residuals as its raw material source.

Figure 2.3—Illustration of a Pulpwood Size Tree Stem

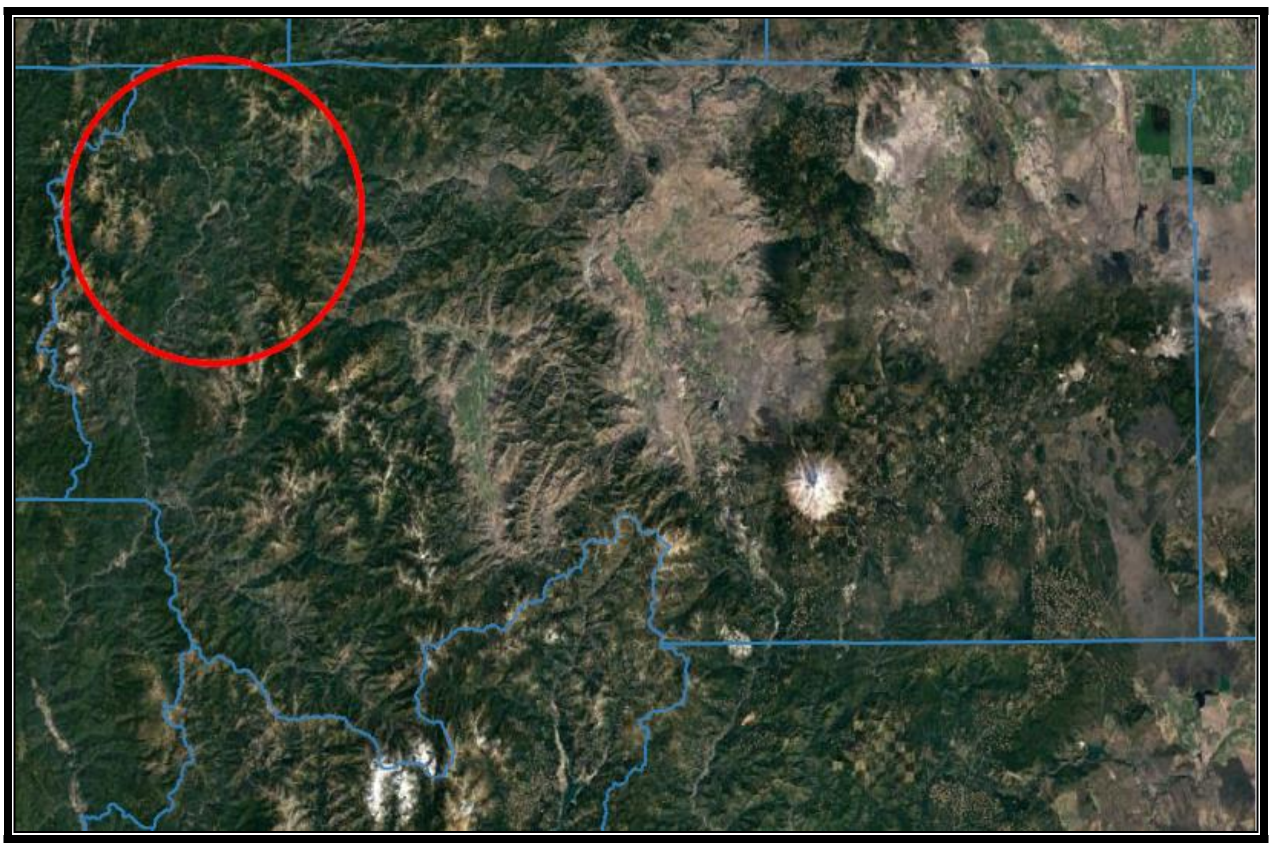


2.2 DEFINING THE HAPPY CAMP SUPPLY AREA (HCSA)

Raw materials for biomass facilities and other types of wood products manufacturing operations are typically sourced as closely as possible to the manufacturing plant. This strategy is especially common for biomass because most manufacturing processes do not convert it to a high-value material, meaning that transportation (and logging) costs must be kept low for a biomass conversion facility to optimize financial performance. Thus, most biomass facilities have a well-defined core procurement area within a certain distance of their locations. However, when conducting a supply study, a facility's core procurement area often does not match up nicely to administrative units such as counties, national forests, National Forest Ranger Districts, etc. Those types of administrative units are important because information about standing timber inventory, harvests, employment, etc. is often organized by administrative unit.

This situation applies in the case of Happy Camp. Therefore, BECK has elected to treat the 15-mile radius shown in **Figure 2.4** as the supply area for the study. However, most of the data about standing timber inventory, ownership, and historical timber harvest refer to all of Siskiyou County. As will be further described in the following sections, adjustments were made as appropriate to make the information specific to the supply area that comprises a smaller portion of Siskiyou County.

Figure 2.4—15-Mile Radius Supply Circle Centered on Happy Camp, California



2.3 CHARACTERISTICS OF THE TIMBERLAND IN THE HCSA

BECK gathered data from the U.S. Forest Service's Forest Inventory and Analysis database. The database is derived from a program started in the 1920s when permanently marked plots were established across the forests of the United States. The plots are located on all landownerships and there is one plot for every 6,000 acres of land. Once every 10 years, a forester revisits each plot and takes measurements of the trees located on the plot including number of trees, size of trees, species present, type of landowner, etc. When the data from a large area such as a county or multiple counties are aggregated, one can interpret the information as being representative of the average forest conditions in that area over the preceding decade.

The analysis is limited to land classified as *timberland*. In reference to FIA data, this term means land capable of growing at least 20 cubic feet of wood fiber per acre per year and that has not been removed from timber production by administrative ruling or practical reality. In other words, timberland is wooded land that has not been classified as protected Wilderness, roadless, a national park, etc.

Table 2.1 illustrates that Siskiyou County contains more than 2.2 million acres of timberland. Siskiyou County's area is just over 4 million acres. Thus, timberland accounts for about 55% of all land in Siskiyou County. The table also shows that about 70% of this timberland (1.5 million acres) is owned by national forests, and 30% (0.66 million acres) is private.

Table 2.1—Timberland Ownership in Siskiyou County

County	Ownership Type				Total
	National Forest	Other Federal	State & Local	Private	
All of Siskiyou County	**1,545,055**	**1,447**	**4,361**	**659,551**	**2,210,414**
% of Total	**70%**	**0%**	**0%**	**30%**	**100%**

Table 2.2 provides similar information to the preceding table but is specific to the 15-mile radius circle around Happy Camp. As the data show, there are nearly 300 thousand acres of timberland in the supply area. Of that total, 99.9% is national forest; nearly all the timberland in the 15-mile supply area is in Siskiyou County. As will be described in Section 2.7, the predominance of national forest lands in the supply area indicate the need for any biomass utilization facility in the Happy Camp area to develop strong partnerships with National Forest management staff in the region.

Table 2.2—Timberland Ownership within 15-Mile Radius of Happy Camp

County/State	National Forest	Other Federal	State & Local	Private	Total	% of Total
Del Norte County, CA	6,580	0	0	0	6,580	2.3%
Siskiyou County, CA	274,727	0	0	186	274,913	97.0%
Josephine County, OR	1,929	0	0	0	1,929	0.7%
Total Acres	283,285	0	0	186	283,471	100.0%
% of Total	99.9%	0.0%	0.0%	0.1%	100.0%	

Table 2.3 provides an estimate of the total standing tree volume on timberland in Siskiyou County. As the data show, there are more than 180 million *bone dry tons*[2] of standing timber in Siskiyou County. Of that total, nearly 80% (144 million bone dry tons) is found on national forest lands. Given the 2.2 million acres of timberland in Siskiyou County, one can infer that on average there are 82 bone dry tons of standing timber per acre in Siskiyou County. For perspective, this is the equivalent of about 6.5 truckloads of material per acre.

Table 2.3—Standing Timber Volume on Timberland in Siskiyou County (Bone Dry Tons)

	National Forest	Other Federal	State & local	Private	Total
Siskiyou	143,935,078	104,292	585,559	36,763,833	181,388,762
% of Total	79%	0%	0%	20%	100%

Table 2.4 provides a summary of the species composition of the standing timber in the HCSA. As the data show, Douglas-fir and true firs account for nearly 85% of the total standing volume. This translates into more than 3 million bone dry tons of standing timber among those two species. Importantly, as previously described, about 10% of the FIA permanent plots are revisited each year. Therefore, as dramatic changes such as wildfire, insect or disease mortality affect a large landscape, the impacts of those changes may not be fully reflected in the FIA data for several years. For example, there were several large and recent wildfires that affected the Happy Camp area. Thus, the standing volumes expressed in Table 2.3 and Table 2.4 should be treated with caution as they might overstate actual current standing volumes.

Table 2.4—Standing Timber Volume in the HCSA by Species (BDT in millions)

	Douglas-fir	Ponderosa pine	True fir	Sugar pine	Incense cedar	Other softwood	Tan oak	Other hardwood	Total
% of Total	64%	2%	20%	3%	2%	1%	2%	6%	100%
Tons	2.37	0.07	0.76	0.13	0.06	0.02	0.08	0.21	3.72

2.4 HISTORICAL TIMBER HARVEST IN SUPPLY AREA

Table 2.5 provides a summary of historical timber harvest levels in Siskiyou County as reported by the University of Montana's Bureau of Business and Economic Research, which tracks timber harvests for the Western U.S. As the data in the preceding table illustrate, the average annual timber harvest in Siskiyou County was 210 million board feet during the years 2002 to 2022. Within the HCSA, the estimated annual historical harvest has averaged about 19 million board feet.

Based on prior experience and knowledge, BECK estimates that on average, every thousand board feet of timber harvested equals 3.5 bone dry tons of material. Thus, the average annual timber harvest in Siskiyou County is about 737,000 bone dry tons (210 MMBF[3] x 3.5BDT/MBF). Recall that portions of Siskiyou County are quite

[2] Bone Dry Ton (BDT): a unit of measurement common to the forest products industry. It is an amount of wood weighing 2,000 pounds at zero percent moisture content. In practice, wood always contains a certain percentage of moisture as part of its weight. Thus, BDT are only a calculated volume as determined by weighing a small sample from a load of biomass at the time it is received. The sample is then oven-dried and reweighed frequently until it no longer loses weight. That steady-state weight is then considered its bone dry weight. The beginning and final weights are then used to calculate the percent of the total as-received weight that was moisture and what portion was bone dry wood fiber. For example, in a truckload weighing 25 tons, if half the weight of the sample was water the truckload would have a bone dry weight of 12.5 BDT.

[3] MBF = 1,000 board feet (log scale) and MMBF = 1 million board feet (log scale)

distant from Happy Camp. Therefore, it might be useful to think of Siskiyou County as the “universe” of supply upon which a new biomass conversion facility can draw. However, the practical and cost-effective supply for a facility at Happy Camp will be smaller. In the remainder of the analysis, BECK estimates the portion of the supply that is practically and cost-effectively available to a facility in Happy Camp.

Recall from Tables 2.3 and 2.4 that there are an estimated 181.4 million bone dry tons of standing timber in Siskiyou County. This means that the average harvest over the last 20 years has removed about 0.4%, or less than half of one percent of the standing volume per year. As a simple way to provide perspective on the harvest relative to standing volume, this means that it would take nearly 250 years to harvest all the standing timber in Siskiyou County at the current harvest rate (100% divided by 0.4%).

Table 2.5—Historical Timber Harvest Levels in Siskiyou County (2002 to 2022 MBF/Year)

Year	Private & Tribal	State	Forest Service	Other Public	Total
2002	160,962	0	36,828	2	197,792
2003	187,025	0	69,212	0	256,237
2004	199,753	0	64,206	0	263,959
2005	158,923	0	68,760	4	227,687
2006	151,384	0	42,476	2	193,862
2007	184,280	0	69,841	0	254,121
2008	124,984	0	37,939	133	163,056
2009	108,735	0	26,098	42	134,875
2010	167,392	0	52,418	10	219,820
2011	141,889	0	88,533	12	230,434
2012	116,340	0	50,085	0	166,425
2013	128,006	0	61,614	108	189,728
2014	151,632	0	52,098	0	203,730
2015	200,767	0	62,120	0	262,887
2016	133,969	0	86,853	0	220,822
2017	170,268	0	64,089	0	234,357
2018	180,756	0	66,954	0	247,709
2019	163,973	0	46,669	0	210,642
2020	136,201	0	31,251	0	167,452
2021	166,424	0	36,564	0	202,988
2022	126,246	0	47,336	0	173,581
Annual Average	**155,234**	**0**	**55,331**	**15**	**210,579**

CHAPTER 2 – HAPPY CAMP SUPPLY STUDY

The Klamath National Forest (KNF) is a key element of the biomass supply for the Happy Camp biomass utilization project. This is because much of the HCSA falls within boundaries of the Klamath National Forest including the Happy Camp, Oak Knoll, and Scott River Ranger Districts. Additionally, the Ukonom Ranger District, which is technically part of the Klamath National Forest, is managed by the Six Rivers National Forest. **Figure 2.5** shows the boundaries of the Klamath National Forest. Note from the figure that significant portions of the KNF are classified as Wilderness including the Siskiyou, Marble Mountain, and Trinity Alps Wilderness Areas, all of which are excluded from any forest management activities.

Figure 2.5—Klamath National Forest Boundaries

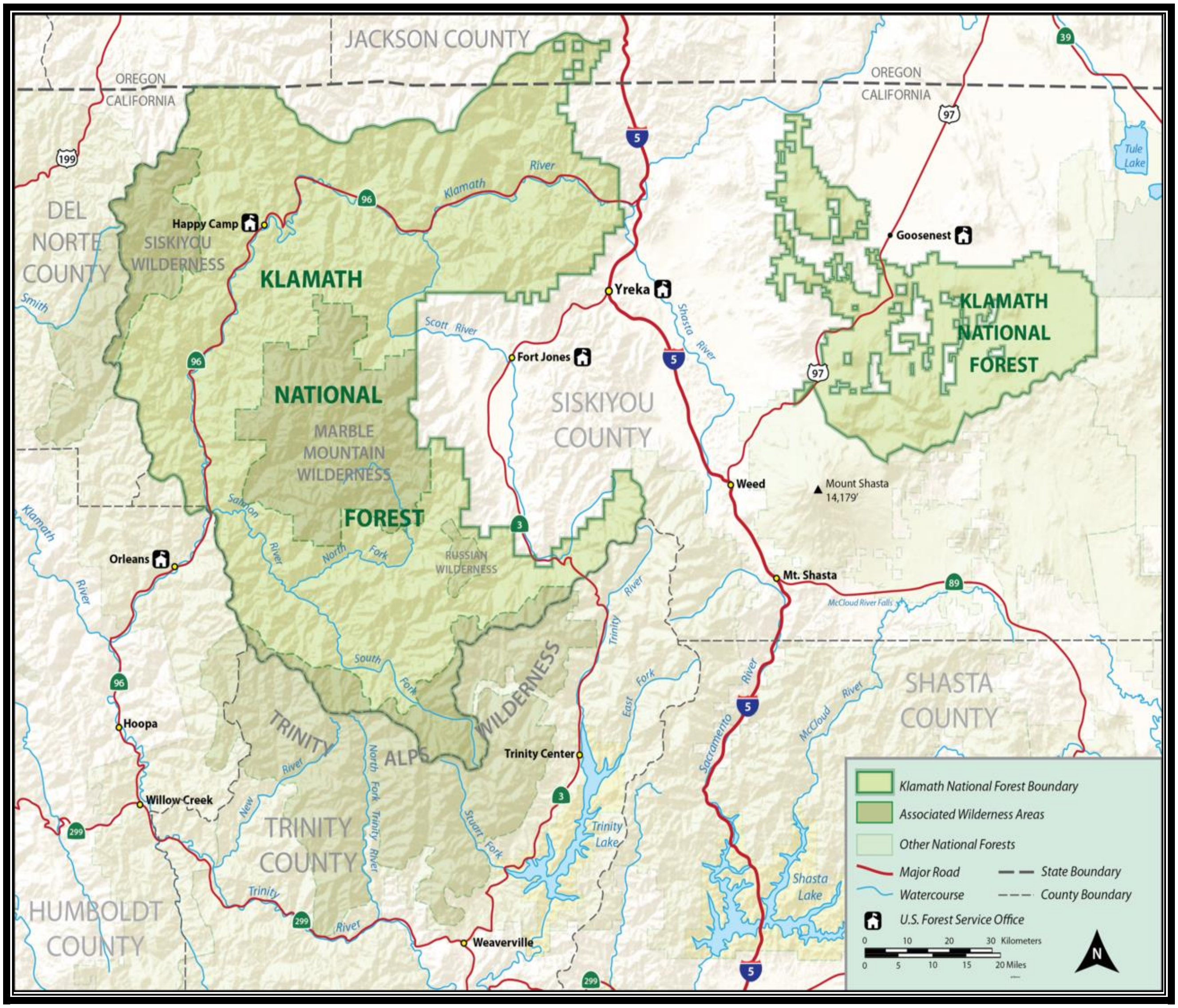


Table 2.6 provides a 10-year history of timber, fuelwood, and biomass harvest on the KNF. The data are from the USFS National Forest Products Cut and Sold Report (https://www.fs.usda.gov/forestmanagement/products/cut-sold/index.shtml). As the data show, an average of nearly 19 million board feet of sawtimber are harvested each year, or about 66,100 BDT/year. Additionally, there is a combination of just over 30,000 BDT per year of small diameter material harvested in the form of fuelwood, biomass, and post-and-pole stock.

Table 2.6—10-Year Klamath National Forest Harvest History (MBF/year & BDT/year in rightmost column)

Material Type	2014 MBF	2015 MBF	2016 MBF	2017 MBF	2018 MBF	2019 MBF	2020 MBF	2021 MBF	2022 MBF	2023 MBF	Average MBF	Average BDT
Sawtimber	22,833	19,135	40,722	23,677	17,521	13,346	7,364	6,234	18,194	19,871	***18,890***	***66,100***
Post & Pole	45	74	48	28	56	42	4	6	24	26	***35***	***100***
Fuelwood	5,517	4,781	4,358	4,289	5,489	4,221	4,512	2,888	5,944	4,207	***4,621***	***16,200***
All Other	6,227	4,296	7,102	3,220	1,336	2,810	6,899	756	1,336	6,326	***4,031***	***14,100***
Total	***34,622***	***28,286***	***52,230***	***31,214***	***24,402***	***20,419***	***18,779***	***9,884***	***25,498***	***30,430***	***27,576***	***96,500***

Several other things to note about these data:

- The volumes reported refer to annual cutting. The volume sold, but not yet harvested, is approximately 40% higher on average each year. It is not clear why there is such a large difference in the annual sold volume and the annual cut volume. One plausible explanation is that the timber cruising in preparation of the sale is consistently estimating a higher volume of standing timber to be harvested than is present in the harvest units. Or, related to the preceding, the pre-sale cruise volume may be fairly accurate but the actual amount utilized (and therefore scaled and reported as harvested) is lower than the cruise volume. This would mean that a significant volume of biomass material is harvested but not utilized, and thus burned in slash piles. Yet another possible explanation is that there is still sold timber standing on the stump waiting to be harvested. Finally, large fires in the area could have caused timber purchasers to table green sales while their work shifted to salvage operations.
- The dates shown in the table are represented as calendar years, but the actual period covered is the U.S. Federal government's fiscal year. For example, 2023 in the table covers the period October 2022 to September 2023.
- To BECK's knowledge, harvest data by Ranger District are neither published nor readily available. Thus, the data reported refer to the entire KNF. A considerable portion of the KNF is east of I-5 and too distant from Happy Camp to be considered part of the supply area. As further described in Section 2.5, BECK adjusted the harvest volumes downward to estimate the supply that is near Happy Camp.
- Sawtimber is generally defined as the portions of tree stems that are at least 5" in diameter at the small end, at least 12' long, and straight and sound enough to produce lumber. Only minimal amounts of material classified as post-and-pole stock are harvested each year, but a considerable portion of the material in the "all other" category could also likely be utilized as post/pole material. The fuel portion is material utilized as firewood. The "all other" category is material that is classified as biomass, non-saw, or cull logs (logs large enough to produce timber but having other defects such as rot and poor form that render them unusable for lumber production). Note that graphics are used in the following supply estimate sections to aid the reader in visualizing the types and sources of material harvested in the Happy Camp region.

The sawtimber harvested in Siskiyou County is mostly consumed by the two veneer mills in the county, which include Roseburg Forest Products in Weed and Timber Products in Yreka. BECK estimates that their combined annual demand is 125 million board feet per year. The average surplus of 86 million board feet (211 MMBF average annual harvest minus 125 MMBF annual demand) is exported beyond the county borders to other manufacturing facilities in Northern California and Southern Oregon.

It is BECK's experience that approximately 15% of the sawtimber harvest, on a weight basis, consists of the topwood portion of trees (that part too small to be utilized as sawlogs). This means that in Siskiyou County an estimated 110,500 BDT of topwood are generated annually (737,000 BDT of annual harvest x 0.15 proportion that is topwood = 110,500). BECK is not aware of any existing facilities in the HCSA that consume small diameter roundwood or topwood. As described in the following paragraph, these represent a considerable portion of the annual harvest.

Additionally, interviews with logging contractors revealed that some sawlogs harvested in the region are difficult to utilize. This includes logs of any species that are too large in diameter (> 30" at the large end) to be utilized at the nearby mills because logs exceeding 30" are difficult to process for veneer. Additionally, ponderosa pine and sugar pine logs of any size are difficult to utilize when harvested in the Happy Camp region. This is because mills that specialize in processing those species are too distant from the Happy Camp area for logs to be transported cost-effectively. BECK estimates that about 3 million board feet (or roughly 10,500 bone dry tons of currently difficult-to-market logs) are available annually from sawtimber harvested near Happy Camp.

2.5 ESTIMATED ANNUAL BIOMASS FEEDSTOCK SUPPLY VOLUME SPECIFIC TO THE HCSA

Given the preceding "baseline" information about historical timber harvest activity in Siskiyou County, this report section provides an estimate of the annual volume and types of material that would be available to a biomass utilization facility sited in Happy Camp. The types of material included in the estimate and discussion include: 1) sawtimber; 2) topwood/harvest residuals; and 3) small diameter roundwood. Each is described in further detail in the following subsections.

Note that another potential source of supply is standing dead trees salvaged after a wildfire. However, in the case of the wildfires that most recently devastated large areas around Happy Camp, in BECK's view the timber is no longer salvageable for utilization in a sawmill because too much decay has occurred. This is especially true if any business developed following this study would most likely not begin operations for at least one year. Thus, it is not included as a source of supply for a sawmill. It might still be salvageable for biomass heat/power.

2.5.1 Sawtimber

BECK has estimated the annual sawtimber supply from two potential sources. The first is the "baseline" average given historical timber harvesting levels in the HCSA. The second is additional sawtimber volume potentially available if a program were implemented to remove hazard trees along roadways. The volumes available from each source are described in more detail in the following paragraphs.

Baseline Sawtimber Volume—Forest Information and Analysis data indicate that 19.6 million board feet of sawtimber are harvested annually in the HCSA. This aligns with information provided in interviews with logging contractors and U.S. Forest Service representatives. This baseline level of harvest volume is not expected to change significantly in the future. Given the 3.5 BDT/MBF factor, this means that a total of 68,600 BDT of sawtimber is harvested annually in the HCSA. As previously described, most of this material is consumed at existing mills in the region. However, BECK estimates that 3 million board feet (or 10,500 BDT) of sawlogs harvested each year in the HCSA are either too large in diameter to be processed at the existing mills, or are pine species which none of the mills within a cost-effective transportation distance are willing to process.

Hazard Tree Removal Sawtimber Volume—In addition to the baseline level of sawlog harvest described in the preceding paragraph, there is potentially sawtimber available from a program designed to remove hazardous trees near roads. These are trees that are large in diameter, judged to be potential hazards because they lean toward roads or are in poor condition (near death or recently dead). BECK is not aware of any such current program. However, if a market for large diameter sawlogs were present, such a program could possibly begin.

Table 2.6A provides an estimate of the standing volume of large diameter (> 17” DBH) sawlog trees in the HCSA. The values in the table represent the standing inventory of sawlogs in millions of board feet. The exception is the rightmost column, where the board foot totals have been converted to bone dry tons. Importantly, the only trees included in the standing volume estimates in the table are those greater than 17” in *diameter at breast height* (DBH). Each row in the table is a category classifying the standing volume by the distance to the nearest road. Each column in the table is a size category. As the data in the table show, there is a total of 920 million board feet of standing trees in the supply area greater than 17” in diameter. As highlighted in the table, of that total 106.6 million board feet are found less than 100’ from an existing road. That volume, nearest to existing roads, would be the focus of a hazard tree removal program.

Table 2.6B on the following page shows the estimated annual amount by county that could be harvested as part of a hazard tree removal program. As the data show, an estimated 2.428 million board feet of sawlogs are within 100’ of existing roads and could be harvested each year as part of a hazard tree removal program. The estimate assumes that each year, 2.0% of the large diameter trees (> 17” diameter) found within 100’ of an existing road could be harvested because of factors such as death or near death because of insect, disease attack, or wildfire.

In summary, BECK estimates that the future baseline sawtimber harvest volume in the HCSA will be 19.6 million board feet per year (68,600 BDT/year). This could be supplemented with an additional 2.4 million board feet per year (8,500 BDT/year) of sawtimber volume if a hazard tree removal program were implemented in the region.

Table 2.6A—Estimated Annual Standing Volume of Trees that Might Support a Hazard Tree Removal Program (MMBF and BDT in thousands)

Standing Volume of Trees Greater than 17” Diameter at Breast Height						
Distance to Road	**17.0” to 18.9” DBH**	**19.0” to 20.9” DBH**	**21.0” to 28.9” DBH**	**29.0” + DBH**	**Total in MMBF**	**Total (BDT in 1000s)**
100’ or less	0	2.5	11.2	92.9	106.6	373.1
101-300’	13.6	14.6	27.6	108.4	164.2	574.7
301-500’	4.0	5.9	18.2	37.0	65.1	227.7
501-1000’	7.0	13.9	51.3	32.9	105.1	367.8
1001’ to 1/2 mile	18.6	8.3	34.0	181.1	242.0	846.9
1/2 to 1 mile	3.2	7.7	8.8	54.8	74.6	261.0
1 to 3 miles	3.6	7.2	14.5	35.1	60.5	211.7
3 to 5 miles	1.9	18.2	31.4	51.1	102.6	359.2
Total	**52.0**	**78.3**	**197.0**	**593.3**	**920.6**	**3,222.2**

Table 2.6B—Estimated Annual Volume of Sawtimber Available from a Hazard Tree Removal Program (MMBF/year & BDT/year in thousands)

Estimated 17" DBH and Greater Hazard Tree Annual Harvest Volume (0.15% of Total Standing Volume)						
Distance to Road	**Del Norte**	**Siskiyou**	**Jackson**	**Josephine**	**Total in MMBF**	**Total in BDT**
100' or less	*0.000*	*1.929*	*0.231*	*0.268*	***2.428***	**8.50**
101-300'	0.010	3.138	0.075	0.674	**3.897**	**13.64**
301-500'	0.457	1.930	0.063	0.415	**2.866**	**10.03**
501-1000'	0.060	3.478	0.693	1.155	**5.386**	**18.85**
1001' to 1/2 mile	0.431	5.269	0.994	1.994	**8.687**	**30.40**
1/2 to 1 mile	0.324	1.703	0.539	0.838	**3.404**	**11.91**
1 to 3 miles	0.188	1.715	0.063	0.196	**2.162**	**7.57**
3 to 5 miles	0.000	1.117	0.000	0.012	**1.128**	**3.95**
Total	1.469	20.279	2.659	5.551	**29.958**	**104.85**

2.5.2 Harvest Residuals and Topwood

Harvest residuals refers to the non-sawlog material created by timber harvesting activity. As previously described, it includes things like tree limbs, cull material, and the small diameter top portion of large trees. For this analysis topwood has been categorized as a distinct subcategory of harvest residuals. A commonly applied rule of thumb regarding harvest residuals is that one BDT of harvest residuals is generated for every thousand board feet of logs harvested. This means that a total of 19,600 BDT of harvest residuals is generated in association with the 19.6 million board feet of timber harvested in the HCSA each year.

However, as described in Section 2.4, BECK estimates that (on average) 15% of the sawtimber harvest weight is made up of the small diameter topwood portion of the stems. This means that of the 19.6 million board feet (or 68,600 BDT) of sawtimber harvested annually in the HCSA, about 10,300 bone dry tons per year are topwood (68,600 BDT/year times 15%). It also means that of the total of 19,600 BDT/year of logging slash, 10,300 BDT are topwood and the balance of 9,300 BDT is limbs and cull material.

2.5.3 Thinning

Thinning forest stands that are overstocked with small diameter trees represent another potential source of biomass. Forest managers are interested in treating such stands because it improves the health and vigor of the remaining trees by reducing competition for nutrients, water, and sunlight. Additionally, there is less fuel in the stands after a thinning treatment, which reduces the risk of wildfire. Based on a combination of analyzing FIA information and interviews with local foresters and logging contractors, BECK estimates that thinning activities would generate an average of 6.5 BDT of small diameter roundwood stems per acre. It is estimated that 2,000 acres of pre-commercial thinning can be completed each year within the HCSA. This translates into 13,000 BDT/year of small diameter stems.

2.5.4 Summary of Annual Supply

Table 2.7 summarizes the various sources of supply described in the preceding sections. As the data in the table show, a total of 19.6 million board feet of material is produced annually in the HCSA. This equals 88,200 BDT when including an estimated 6,000 BDT/year of recoverable logging slash available, 10,300 BDT/year of topwood. Of that amount, most of the sawtimber is already utilized by existing mills, but 6.6 MMBF (10,500 BDT/year) of sawlogs could be available to a new facility using small stems in Happy Camp. Additionally, an estimated 2.4 MMBF/year (8,500 BDT/year) of hazard tree sawlogs are estimated to be available should there be a focus on removing hazard trees. There are also 13,000 BDT/year of small diameter stems from thinning. These are very small stems that are costly to harvest and only have limited utility among currently available conversion technologies.

Table 2.7—Summary of Annual Sawtimber and Biomass Supply in the Happy Camp Region

Source Type	MMBF per Year	BDT per Year	Available Portion (BDT/year)
Baseline Sawtimber	19.6	68,600	10,500
Hazard Tree Removal Sawtimber	2.4	8,500	8,500
Logging Slash	n/a	9,300	6,000
Topwood	2.9	10,300	10,300
Thinning	n/a	13,000	13,000
Total	**28.6**	**109,700**	**48,300**

2.6 HAPPY CAMP BIOMASS DELIVERED COST

In addition to having an adequate and secure supply of biomass raw material, another critical element of biomass utilization is the delivered cost of biomass raw materials. Therefore, this report section provides an estimate of the costs associated with harvesting, processing, and transporting various types of biomass.

As background information, it is helpful to understand that a variety of functions contribute the cost of biomass. Before any harvesting activity happens, a landowner incurs costs in planning and administering a timber/biomass sale. These can include (but not be limited to) costs to inventory and identify the trees to be harvested, mark out timber sale boundaries, prepare a harvest plan and/or sale prospectus, and advertise the timber/biomass sale to prospective buyers. Typically, the value the landowner is paid for the harvested material offsets the cost of planning and administering the sale. Once harvesting activity begins, costs are incurred that include harvesting trees; removing them from where they are felled (a process called *yarding*) to a landing where they can be further processed and stored prior to transport; and transport to a conversion facility.

Numerous factors affect the cost of biomass. To name just a few, these include: the harvest prescription as called for in the timber sale plan, the tons of material harvested per acre, the average size of the trees to be harvested, the types of equipment that are allowed to operate on the site, the times of the year and/or soil and weather conditions during which equipment is allowed to operate, and the distance between the harvest site and markets. **Table 2.8** on the following page provides cost estimates for the various types of material available and its various forms as found in the HCSA. A discussion and interpretation of the table information can be found on the page following the table.

Table 2.8—Summary of Estimated Delivered Sawlog and Biomass Costs in the Happy Camp Region ($/BDT in top portion of table and $/MBF as appropriate in the bottom portion of table)

Manufacturing Process Step	Material Type and Cost per BDT																	
	Sawlogs from Sawtimber Trees			Sawlogs from Hazard Trees			Topwood in Log Form			Small Diameter Trees in Log Form			Topwood in Chip Form			Small Diameter Trees in Chip Form		
	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.
Cutting	10	30	20	10	30	20	n/a	n/a	n/a	20	50	35	n/a	n/a	n/a	20	50	35
Yarding	10	30	20	10	20	15	n/a	n/a	n/a	20	50	35	n/a	n/a	n/a	20	50	35
Process & Load	5	15	10	5	15	10	15	25	20	30	40	35	n/a	n/a	n/a	n/a	n/a	n/a
Hauling	10	40	25	10	40	25	10	40	25	10	40	25	10	40	25	10	40	25
Grinding/Chipping	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	28	32	30	28	32	30
Total	**35**	**115**	**75**	**35**	**105**	**70**	**25**	**65**	**45**	**80**	**180**	**130**	**38**	**72**	**55**	**78**	**172**	**125**

Manufacturing Process Step	Material Type and Cost per MBF																	
	Sawlogs from Sawtimber Trees			Sawlogs from Hazard Trees			Topwood in Log Form			Small Diameter Trees in Log Form			Topwood in Chip Form			Small Diameter Trees in Chip Form		
	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.
Cutting	35	105	70	35	105	70	n/a	n/a	n/a	70	175	123	n/a	n/a	n/a	n/a	n/a	n/a
Yarding	35	105	70	355	70	53	n/a	n/a	n/a	70	175	123	n/a	n/a	n/a	n/a	n/a	n/a
Process & Load	18	53	35	18	53	35	53	88	70	105	140	123	n/a	n/a	n/a	n/a	n/a	n/a
Hauling	35	140	88	35	140	88	35	140	88	35	140	88	n/a	n/a	n/a	n/a	n/a	n/a
Grinding/Chipping	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total	**123**	**403**	**263**	**443**	**368**	**245**	**88**	**228**	**158**	**280**	**630**	**455**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**

Several things to note about the costs in the preceding table:

- Topwood is the lowest-cost feedstock. However, the opportunity to utilize topwood does not exist unless there is an associated sawtimber harvest, largely because topwood is a sawtimber harvesting by-product which has no cost assigned to cutting and yarding functions. Note also that processing and loading topwood is more costly than the same functions for sawtimber. This is because the piece sizes for topwood are much smaller than sawlogs. This in turn means that the processing equipment is much less productive when handling many small topwood pieces rather than fewer, larger sawlogs.
- Sawlogs are the next least expensive raw material. Their costs are low relative to small diameter trees and sawlogs from hazard trees because the equipment for cutting, yarding, processing, and loading is most efficient when operating with sawtimber-size trees.
- Sawlogs from larger trees and hazard trees are almost never chipped or ground because their value is much higher when they are converted to lumber or veneer. Therefore, no grinding and chipping costs are included for those products.
- In contrast, topwood and/or small diameter trees may be ground or chipped for some utilization technologies such as biomass heat/power, pellets, biochar, etc. Therefore, costs for topwood and small diameter trees after grinding/chipping are shown in the last two columns on the right side of the table. Costs are also shown for when topwood and small diameter trees are left in roundwood form, which would be appropriate for use as firewood, posts/poles, etc.
- Prices are shown on both a $/BDT basis and a $/MBF basis. Note, however, that $/MBF pricing is generally only used for sawlogs. The prices shown on a $/MBF basis for topwood and small diameter roundwood in log form are for reference only. Also, when material is ground or chipped it is almost always measured on a weight basis.

2.7 BIOMASS SUPPLY RISKS, OPPORTUNITIES, CONCLUSIONS, & RECOMMENDATIONS

As will be described in the following chapters, the wood products utilization businesses considered in the analysis are scaled to match with current levels of forest management. However, they also have the capacity to increase in scale should management levels increase. Additionally, the costs of harvesting, processing, and transporting wood fiber from the forests in the HCSA to a wood products manufacturing facility are consistent with costs in other regions. This means that from a raw material costs are not a limiting factor on the development of a wood products manufacturing business in Happy Camp.

There are, however, some supply related risks in the HCSA. First, and perhaps most importantly, the USFS is the primary timberland manager in the HCSA. Since the USFS is a Federal agency it is subject to laws and public influence which can affect the agency's ability to manage federal lands. Currently, reducing the risk of wildfire is a publicly accepted mission which allows the USFS to manage lands in the area. This is expected to be the case for many years, but even these management activities could be derailed by a lawsuit if management activities become controversial. Given any wood manufacturing business's overwhelming reliance on the USFS as a raw material source in the HCSA region, supply risk exists should public policy change to cause supply reductions.

Secondly, wildfire has had a tremendous impact on the timberlands around Happy Camp. It is likely that there will be wildfires influencing the area in the future. Wildfires can provide a short-term boost to biomass supply as hazard trees and salvage treatments produce volume. Long-term, wildfires can impact available supply as they reduce the standing inventory of the area until the trees grow back. Reduced standing inventory translates to lower sustainable annual harvest levels.

Despite the preceding supply related risks, there are some mitigation measures available. First, master stewardship agreements facilitate more efficient implementation of forest restoration efforts. These agreements are between the USFS and an entity focused on ecological restoration. Examples of such entities include Tribes, conservation groups, and wildlife organizations. For example, currently the Karuk Tribe has an agreement with the Six Rivers National Forest, but not the Klamath National Forest. Working in partnership with an entity that has a stewardship agreement could help secure supply. Similarly, the Mid Klamath Watershed Council and the Western Klamath Restoration Partnership are conservation organizations in the region that aim to create resilient ecosystems, communities, and economies through collaborative partnerships. These organizations seek solutions that find a balance between natural systems and human processes. Given all of the preceding BECK recommends that any entities seeking to develop wood products manufacturing businesses in the HCSA also seek to develop partnerships with the Karuk Tribe, the USFS, and conservation organizations such as MKWC, and WKRP so that each group has a voice in forest management activities being planned and implemented within the HCSA.

CHAPTER 3 – HAPPY CAMP BIOMASS TECHNOLOGY SCREENING

Three key processes are involved in this study, including: 1) Estimating the supply and cost of biomass in the Happy Camp, California area; 2) Screening biomass utilization technologies to identify which are most appropriate for Happy Camp; and 3) Completing a feasibility analysis for a preferred technology (or technologies). This chapter provides a screening of potential utilization technologies.

3.1 POTENTIAL SMALL DIAMETER UTILIZATION TECHNOLOGIES FOR HAPPY CAMP

Table 3.1 provides a list of 15 biomass-utilizing technologies considered in this study. Note the list is organized into three categories: technologies where the principal product is some form of energy, those that are traditional and/or engineered wood products, and finally a category of miscellaneous product types. Also note that the list includes a wide range of operational scales, with some being very small businesses and others much larger in scale and capital expense. The section following the table provides a brief description of each business/technology.

Table 3.1— Listing of Biomass Business Opportunities

Energy-Related	Traditional and/or Engineered Wood Products	Other Miscellaneous Products
Biomass Combined Heat & Power	Lumber (Small, Specialty Sawmill)	Animal Bedding
Bundled Firewood	Oriented Strandboard (OSB)	Bark/Compost/Mulch
Densified Fuel Bricks/Logs	Posts & Poles	Biochar
Liquid Biofuels	Woodstraw	Essential Oils
Wood Pellets	Wood Wool Cement	Wood Fiber Insulation

3.2 BIOMASS UTILIZATION TECHNOLOGY SCREENING METHODOLOGY

To focus the small-diameter utilization technology screening assessment on opportunities judged most viable in the Happy Camp region, BECK completed a screening process by which the list of 15 technologies in the preceding table was narrowed to a select few. The first step in the screening process was developing criteria to be applied to each technology. Accordingly, BECK developed 12 criteria as illustrated in **Table 3.2** on the following page.

The criteria are organized by various themes related to feasibility such as timing, raw material, economics, and degree of commercialization. Each criterion was assigned a max score, with some criteria having higher (or lower) max scores, which provides a weighting to each criterion. The weighting levels were based upon the BECK team's judgment. Each technology was given a score for each criterion. The scores were assigned through an iterative process with BECK staff members first independently scoring each technology followed by the BECK staff jointly discussing and adjusting scores. The final scores were then summed and the technologies ranked by total score. The technologies receiving the highest scores were judged most viable for the Happy Camp region.

Table 3.2 – Small Diameter Utilization Technology Screening Criteria

Criteria Type	Max Score	Criteria
Timing	6	The business/technology can be constructed and operational within 18 to 24 months of receiving financing.
Timing	6	The business/technology has a high likelihood of successfully obtaining required permits, licenses, etc., and these can be obtained within 18 to 24 months of receiving financing.
Timing	6	The business/technology can utilize an existing site to help speed the development process and lower development costs.
Raw Material	6	The business/technology will utilize otherwise unused raw materials (i.e., there is limited competition with existing users, or it is complementary to existing users).
Raw Material	10	Raw material security: Alternate source raw material (e.g., mill residuals) is not available to competitors at substantially lower cost.
Raw Material	6	The business/technology, in a single location, is scaled or can be expanded to utilize the amount of raw material harvestable in the supply region.
Raw Material	6	The business/technology does not require utilization of a specific tree species.
Economics	14	The business/technology economic structure is such that it can operate profitably (during the majority of an economic cycle) at the delivered raw material costs identified in the supply study.
Economics	4	The business/technology is such that the capital costs relative to revenues and operating costs mean the developer can reasonably expect a 10-year or less payback period.
Economics	14	The business/technology must be able to demonstrate that there is a defined and supportable market segment for the product, with potential demand from multiple customers.
Proven Technology	16	The business/technology proposed must have been successfully demonstrated in a commercial setting, at commercial scale, with similar raw material mix, for at least two years.
Proven Technology	6	The business/technology equipment vendors must be able to offer commercial warranties as to performance, environmental compliance, and completion, and be able to bond such warranty through commercial sources.
Grand Total	**100**	

The intent of the scoring process illustrated in the preceding table is to apply a degree of objectivity to an inherently subjective decision. Given the subjectivity in the process, note that the relative differences among scores are indicative of differences in viability, but not definitive. The following list below describes the categories used to group the screening criteria and the relative value of each type in the overall viability score.

- **Timing – 18 Points:** In this analysis, the speed at which a business could be operational was part of the screening criteria. A major consideration was whether the business could use an existing site in Happy Camp to reduce development time. Also included in the timing criteria was whether the business could have equipment operational with 1.5 to 2 years of receiving financing. The same timeframe was used to determine if public permit processes could be navigated successfully. In short, these criteria judged whether the business could be operational in less than two years.
- **Raw Materials – 28 Points:** Raw material supply, cost, and other characteristics (size, quality, moisture content, etc.) are the most critical aspects of nearly all forest products businesses' viability. In this screening, the raw materials criteria focused on competition for raw materials in the area, competitors' access to raw materials, scalability, and flexibility in tree species.
- **Economics – 32 Points:** Solid economic performance is obviously a critical requisite in the viability of any business. These criteria were used to determine if the business could operate profitably through the business cycle. They also ranked the probability of recouping the capital investment within a ten-year period. Markets for the products from the technology were also evaluated.
- **Proven Technology – 22 Points:** These criteria judged the current status of technologies to determine whether successful businesses are using them, or whether they are more experimental. They also considered whether the equipment used – once operational – is supported by manufacturers with guarantees/warranties.

Two of the raw material criteria had a special "Fatal Flaw" status. The Fatal Flaw status was developed because in BECK's experience in technology screening, some technologies score well on most criteria, but the given technology may have an inherent flaw that destroys the technology's viability for a given situation. In this case, the two fatal flaws considered were: 1) the scale of the business being too large for Happy Camp, and 2) if the technology in the Happy Camp context utilizes fiber sourced directly from the forest while other businesses making the same product use raw materials at a lower cost.

For example, most wood pellet manufacturers use mill residuals (such as sawdust or planer shavings) as raw material. Relative to raw material sourced from roundwood (small logs), those materials often have much lower delivered cost, need less processing before use (which also lowers cost), and lack significant yield loss (as compared to the loss of bark, which is unsuitable for use in pellet manufacturing).

3.3 BIOMASS UTILIZATION TECHNOLOGY SCREENING RESULTS

BECK staff performed the screening to determine the biomass utilization opportunities judged most viable for the Happy Camp Region. **Table 3.3** shows the screening scores for the 15 technologies considered. The higher the score, the more likely in BECK's judgment the technology will be viable. As previously described, some technologies were judged to have fatal flaws if located in the Happy Camp Region. Those technologies are highlighted in red in the table. As the results in the table indicate, a small, specialty sawmill; wood wool cement; and bundled firewood all ranked highly. Thus, the following chapter describes a high-level feasibility study for locating all three of those businesses at a single site in the Happy Camp area. See **Appendix 1** for a full listing of technologies, screening criteria, and scores.

Table 3.3 – Screening Scores for Small Log Utilization Technologies

Biomass Utilization Technology	Screening Score
Lumber (Small, Specialty Sawmill)	92
Wood Wool Cement	88
Bundled Firewood	87
Posts & Poles	81
Densified Fuel Bricks/Logs	70
Animal Bedding	70
Oriented Strandboard (OSB)	69
Bark/Compost/Mulch	64
Woodstraw	61
Wood Pellets	58
Biomass Combined Heat & Power	53
Wood Fiber Insulation	53
Essential Oils	52
Biochar	42
Liquid Biofuels	29

3.4 DISCUSSION OF BIOMASS UTILIZATION TECHNOLOGIES CONSIDERED IN THE ANALYSIS

To provide further context to the preceding technology screening, the following subsections provide descriptions of each technology considered.

3.4.1 Animal Bedding

Wood shavings are commonly used in association with various animals and livestock where the shavings serve as a soft bedding material and absorbent for animal waste. Among large animals it is mostly used in horse stalls, and to a lesser extent in dairy operations. Shavings are also commonly used as a bedding/absorbent material in poultry operations, and in smaller quantities for small caged pet animals and lab animals. See **Figure 3.1** on the following page, which shows an example wood shavings product.

BECK is not aware of any published information regarding the size of the animal bedding market. However, for prior project work, BECK employed U.S. Agricultural Census data to estimate the horse population in the Western U.S as shown in **Table 3.4** on the page following Figure 3.1. That information was then used to infer the size of the animal bedding market for horses. As shown in the table, it is estimated that there were slightly more than 590,000 horses in those states as of the 2022 Census. Assuming that 15 percent of those horses are bedded in stables and that each of those horses uses one bag of shavings every other day, the market translates into an annual usage of over 16.2 million bags of shavings per year.

An industry standard is that each bag of shavings is compressed to 3.25 cubic feet in volume, but is advertised as expanding to 10 cubic feet when spread out in a stall. Bags typically weigh about 25 pounds and pine is a preferred species. BECK estimates that each bag contains the equivalent of 1 cubic foot of solid wood. Assuming a weight of 25 pounds per bag (at 10% moisture content), the estimated size of the bagged shavings market for horses in the Western US is about 180,000 bone dry tons per year. Note that the table also shows a consistent downward trend in horse population over the last decade.

Figure 3.1—Example Wood Shavings Bedding Product

Table 3.4—Western U.S. Horse Population (2012, 2017, & 2022)

State	2012	2017	2022
AZ	98,394	78,133	61,878
CA	142,555	99,621	92,831
CO	110,360	97,562	75,992
ID	61,439	48,469	44,412
MT	97,921	85,540	63,784
NM	50,723	43,366	34,901
NV	22,464	48,596	12,055
OR	70,427	64,024	60,127
UT	58,979	52,936	49,735
WA	64,616	52,694	44,968
WY	72,461	55,718	49,735
Total	**850,339**	**726,659**	**590,418**

Historically, bagged wood shavings have been produced from the by-products of sawmills' planing operations. Several sawmills in the Western U.S. and Western Canada have installed bagging machines to produce shavings for sale as animal bedding. However, during the Great Recession, many sawmills operated at severely reduced rates, leading to limited supplies of planer shavings for animal bedding. This in turn caused the development of machines that can convert small diameter roundwood directly into wood shavings. The shavings resulting from these machines tend to be "fluffier" and more absorbent than planer shavings produced at sawmills. Thus, the shavings produced from roundwood are often preferred by horse owners.

At the retail level, a bag of shavings typically sells for about $10.00. The value of the bag at the mill is a function of the cost of transporting them to market and the amount of markup the retailer places on each bag. BECK estimates that a roundwood-to-wood shavings operation would consume about 12,500 bone dry tons of feedstock per year.

There is a large market for bagged shavings for horses in Southern California. However, there are two problematic logistic issues. First, there is an existing producer near Sonora that is located closer to the market, and therefore, would have a transportation cost advantage. Exacerbating this issue is that shavings by nature occupy a lot of space but weigh relatively little per unit of volume. This means that trucks generally "cube out" before weighing out. In other words, the space available on a truck is occupied before the truck's weight limit is reached. Compared to heavier items, this adds to the cost of trucking on a per unit basis. Key issues for consideration for this technology are market-related, including identification of an adequate market within a reasonable transportation distance of the plant; the FOB mill sales price; and other competing bagged shavings producers. These businesses, while industrial in scale, are not at the scale that requires hundreds of millions in capital investment.

3.4.2 Bark/Compost/Mulch

Decorative bark, compost, and mulch are a grouping of products that can be produced from biomass. While the products differ in their purposes, all have the common factor that they provide ground cover for purposes including landscaping, soil moisture retention, weed growth control, soil enhancement, erosion control, soil temperature regulation, and safety cushioning (when used as ground cover in playgrounds). It is possible to produce bark, compost, and mulch products from biomass sourced directly from the forest in the form of small diameter stems. From feedstock delivered in roundwood form, the bark would first be removed and collected. Then the small diameter stems would be chipped, ground, and/or hammermilled so that biomass is reduced to a size appropriate for the desired end-use product. The material is often also passed over screens so that pieces of the same size can be grouped. For compost and mulch the reduced-size pieces are mixed with other organic materials and allowed to decompose over time. Eventually the resulting compost/mulch is packaged into bags, or sometimes bales or whole truckloads, and distributed to market. Bark used as a ground cover is also commonly screened for uniform size and then packaged into bags.

Importantly, most existing operations currently rely heavily on sourcing their raw materials for making bark, compost, and mulch in the form of by-products from milling operations such as sawmills and veneer/plywood plants. In other words, during the process of producing lumber, plywood, and other similar forest products, the mills create bark, sawdust, shavings, and chips that are often purchased by businesses producing these landscaping products. This is important because the forest products manufacturers typically do not assign any cost to their by-products; rather, the materials are viewed as a by-product of their process that are typically sold at whatever price the market is willing to pay. Market prices for materials like bark and sawdust vary over time and by region, but typically are less than $20 per bone dry ton FOB the producing mill's bin. In many cases, mills sell the material to buyers for only the cost of transporting the material to the buyer's site.

This means that a business seeking to produce landscape materials derived directly from roundwood products will have much higher raw material costs because the material will bear the embedded costs of harvesting, processing, transporting, and chipping/grinding the raw material. Most operations in this line of business are large, industrial-scale facilities.

Figure 3.2—Example of a Bark Product

3.4.3 Biomass Combined Heat & Power

Biomass combined heat and power (CHP) is the process of either directly combusting or gasifying woody biomass to produce heat and electricity. **Figure 3.3** on the following page shows a rendering of a biomass power plant including fuel storage silos on the right side of the picture (not typical; biomass is usually stored in an open pile), an elevator for transporting fuel from the pile to the boilers, and a turbine generator on the left side of the picture. In the case of direct combustion, woody biomass is combusted in the controlled conditions of a boiler where the material is thermochemically converted to gases, which in turn convert water into steam. The steam is then used to generate electricity in a turbine generator. Additionally, when there is a heat load (a lumber dry kiln, for example), a portion of the steam is extracted from the process to heat the dry kiln; thus the term "combined heat and power." When there is no associated heat load, all the steam is used for generating power. This technology has been commercially proven many thousands of times around the world. A general rule of thumb is that it takes 1 to 1.2 bone dry tons of woody biomass fuel to generate 1 megawatt hour[4] of electricity when using a direct combustion process.

In the case of gasification, the woody material is heated in an airtight vessel. As the material heats, combustible gases are released. Called syngas, those gases are captured and burned in an internal combustion engine that generates electricity. This technology has also been commercially proven. However, using woody biomass sourced directly from the forest is problematic for gasification because the material is inherently variable in piece size, piece geometry, and moisture content. Additionally, the syngas often contains various tars that must be precipitated out through cooling before the gas is combusted in the internal combustion engine. The cooling lowers the energy efficiency of the process. Failure to remove tars from syngas quickly leads to fouling the internal combustion engine, resulting in high maintenance and greater associated downtime.

Figure 3.3—Rendering of a Biomass Power Plant

[4] A megawatt hour is a measure of electric output equal to 1,000 kilowatts of power generated during an hour. A megawatt hour of power can meet the average power demand of 750 homes over an hour. A power plant with a capacity of 5 megawatts can produce 5 megawatts of power per hour, or roughly 40,000 megawatt hours over the course of a year. Thus, if a power plant is paid a rate of $100/megawatt hour for the power it produces, a 5 MW plant generates roughly $4 million in annual revenue. It also means that a 5 MW plant consumes roughly 40 to 44 thousand bone dry tons of fuel per year.

The business aspect of this technology involves selling the power and/or heat. In the case of power, electric utilities are required to purchase electricity from a biomass power plant so long as it is a qualifying facility as defined by PURPA (the Public Utilities Regulatory Policies Act of 1978). In most cases, the utility is required to purchase the power from the qualifying facility at their *avoided rate cost*. This is a value calculated by each utility, equal to whatever it would cost that utility to produce the amount of power that qualifying facility would like to sell to the utility. In California, current avoided rate costs are in the range of $40 to $50 per megawatt hour.

Biomass-generated power is considered renewable, and thus might qualify for higher rates. However, during the last several years the costs of renewable power from wind and solar projects have also dropped into cost levels ranging around $45-50 per megawatt hour. These circumstances have made it very difficult for biomass power projects to be economically viable except in special circumstances; for example, when the power will be used internally rather than sold to the grid. Importantly, in such situations the developer's current cost of power must be lower than the cost of producing biomass power, and the developer's power consumption would ideally be consistent 24/7/365. Another example is when special programs such as California's BioMAT program offer biomass power producers above market rates for the power they produce.

Another important aspect of biomass power projects is that there must be a nearby substation for the plant to be able to interconnect to the power grid. Substations are located near high voltage transmission lines and serve to change the high voltage power from the transmission line to a lower voltage for a distribution system. Building a line from a power plant to a substation is costly. Thus, locating adjacent to a substation is critical. Still, even when located near a substation, there are significant capital costs associated with interconnection for purchasing and installing the equipment needed for switching voltage levels.

Finally, biomass power involves the production of steam and necessarily entails very high pressures and temperatures. Thus, there is some inherent safety risk for nearby equipment operators and technicians. Accordingly, most states (including California) have requirements specifying that boiler operators must have proper training and possess a boiler operator's license. While the training and licensing process are not overly burdensome, several of the staff at the plant would be required to carry the license. This might be an obstacle in a small community such as Happy Camp.

Key aspects of biomass feasibility include the cost of fuel, the power sales price, the ability to also sell thermal energy for heating, and the ability to obtain the required permits – especially air quality. The economics of this business are significantly hampered when attempted at a small scale, since many of the operating costs are fixed regardless of the size of the business.

3.4.4 Biochar

Biochar (see **Figure 3.4**) is a high-carbon charcoal produced from woody biomass using pyrolysis. Note that pyrolysis involves heating the biomass in the absence of oxygen. This breaks the wood down into various gases, liquids, and a form of charcoal commonly called "char." This is a high-carbon material that can be processed into products like activated carbon and biochar, used as a soil amendment. The resulting biochar, if produced in a low-temperature process, may contain about 50 percent of the wood's original carbon. Since wood is typically 50 percent carbon, the resulting biochar will have about 25 percent of the weight of the original dry biomass. The biochar will be roughly 85 percent carbon. The process of producing biochar is exothermic (i.e., releases heat), producing syngas, bio oils, and heat in excess of the amount of energy required by the pyrolysis process. The process of biochar production consumes only about 15 percent of the total energy output available from the feedstock material.

Figure 3.4—Biochar Produced from Woody Biomass Material

A variety of kiln and closed-vessel processes can be used to produce biochar, including microwaves. Gasification may be used, but the higher temperature will lower the biochar yield to only about 20% of the original carbon. From a technical perspective, biochar manufacturing has been proven. However, one of the finer points that is often overlooked is that the process yields the most consistent products and works best when the incoming feedstock is made of pieces that are consistently sized and shaped, with consistent moisture content between and within pieces.

Biochar can be used as a soil amendment, improving yields of various crops. It can be used to elevate pH, add low levels of nutrients, and increase water retention. In this regard, it is similar to the well-established practice in California of spreading biomass ash on agricultural fields. The major selling point of biochar is that it is quite stable and can be used to sequester carbon in the ground if buried. In addition, buried biochar can also reduce emissions of soil nitrogen and methane, further enhancing its carbon sequestration benefits.

In recent years, biochar's carbon sequestration benefits have been recognized so that biochar producers can not only sell the biochar for use as a soil amendment, but can receive a Biochar Carbon Removal (BCR) credit for every ton of carbon dioxide equivalent sequestered by placing the biochar material into service in a way that permanently sequesters the stored carbon in the material. The biochar producer can then sell those carbon credits to entities voluntarily seeking to reduce or fully offset their carbon emissions. The value of these carbon credits can be quite high, which can make biochar production a viable business. BCR prices were reported in the range of $100 to $200 per ton during 2023.

However, according to BECK industry contacts, biochar producers have had difficulty monetizing the carbon credits. This is because they can only be claimed after the material is placed in service. Relatively few customers are interested in using biochar as a soil amendment. This is because biochar can be expensive relative to other soil amendments that accomplish many of the same objectives; a lack of standardization among biochar products and producers makes buyers uncertain about the material's performance characteristics; most current biochar producers are smaller operations and consumers perceive risk in having assured supplies; many existing agricultural practices require modification to equipment, infrastructure, and standard practice before biochar can be integrated into more widespread use; and finally, limited awareness of biochar's benefits has been reported among farmers and gardeners.

The key issues related to biochar feasibility are access to stable markets, ability to monetize the associated carbon credits, and (perhaps most importantly) access to a secure and economically priced feedstock. Biochar operations using raw material sourced directly from the forest might be at a significant cost disadvantage compared to operations that use lower-cost raw materials sourced from mill residuals or even urban wood waste. Additionally, some existing forest products manufacturing operations can adjust the settings on their boilers for less complete combustion of the boiler fuel. This results in higher production of fly ash, which they then sell as biochar. While such operations may not be able to produce large quantities, their cost of production is very low for the material that they do produce because the biochar is essentially a by-product of an existing process; as such, little or no cost is likely assigned to its production.

3.4.5 Bundled Firewood

As the name suggests, bundled firewood is a biomass utilization business built on converting solid wood into firewood bundles. **Figure 3.5** shows an example of bundles made from small diameter trees. The size of each firewood bundle varies among producers, but the most common is a bundle totaling 0.75 cubic feet, which is typically firewood cut to 16” lengths and stacked into a bundle 9” wide and 9” high. The bundles are typically stacked onto pallets (approximately 60 per pallet) and then shipped to the market on flatbed trucks. Options vary for wrapping the bundles. In the figure, the bundles are wrapped with stretch film; other manufacturers use shrink wrap, while still others use plastic strapping or twine. Regardless, each bundle's packaging typically includes the name of the manufacturer, the size of the bundle, and information about various attributes such as species, moisture content, whether it has been heat-treated to kill bugs and other undesired passengers, etc.

Note that bundles made from small diameter trees, which tend to have small knots and minimal large deviations in grain, allow production of uniformly sized and shaped bundles. This in turn allows for more consistently shaped and sized pallets, easier truck loading and unloading, and more attractive displays in the retail outlets where bundled firewood is commonly sold. One downside to using smaller trees is that productivity diminishes as stem diameter decreases. This is especially true with fully mechanized operations where the firewood is cut to length and split using a firewood processing machine.

Figure 3.5—Firewood Bundles Made from Small Diameter Logs

Several firewood bundling operations exist at various locations in the Western U.S. The scale of each operation varies considerably, but the most efficient and highest production producers consume approximately 10,000 to 15,000 bone dry tons of raw material annually. These operations typically include rolling stock for removing logs from trucks, storing them in log decks, and moving logs to processing equipment; a firewood processor for converting long logs into firewood lengths and smaller split pieces; a dry kiln for drying firewood; and equipment for bundling the firewood into 0.75 cubic foot packages, which are then palletized.

Bundled firewood has limited markets. It is not typically sold for home heating. Rather, the typical buyer lives in an urban area, and buys a few bundles at a time for use on a camping trip, backyard firepit, or occasional burning in a fireplace where the purpose is ambience rather than heating. For this type of customer, the convenience of purchasing just the quantity that will be consumed in a single use justifies the high cost of the material. Note that assuming a retail sales price of $8.00 per bundle and 167 bundles per cord, the cost of bundled firewood on a per-cord basis is nearly $1,350, which is about four times the going rate for a cord of firewood sold on a bulk basis.

Based on past project work, BECK estimates that in the Portland, Oregon market area the bundled firewood consumption rate is 0.4 bundles per person per year. Other areas might be slightly higher or lower depending on factors such as climate and the public's interest in activities such as camping and backyard firepit activities. Key factors in firewood bundling feasibility are secure access to an adequate supply of cost-effective and preferred species such as Douglas-fir and various hardwoods (oak, madrone, etc.) and access to nearby markets. This is a business that can be effective at a relatively small scale of operation.

3.4.6 Densified Fuel Bricks/Logs

Converting wood fiber into densified briquettes (or densified fire logs) is another option for utilizing woody biomass; see **Figure 3.6**. The business is based on the concept of densifying wood particles (typically sawdust-size pieces) into small logs, bricks, or puck shapes that can be burned in traditional wood stoves and fireplaces, as opposed to a specialized stove needed for burning wood pellets. The benefits of these products are that nearly all the moisture is removed from the wood before and during the densification process. Thus, the material typically burns more efficiently than firewood. Another advantage of briquettes over other densified fuel such as wood pellets is that the briquettes can be burned in existing fireplaces and wood stoves. In contrast, a homeowner who elects to heat their home with wood pellets must first purchase a wood-burning appliance designed specifically for combusting wood pellets.

The manufacturing process involves preparing the raw material, which includes reducing it in size with chippers, grinders, and/or hammermills to sawdust-size pieces typically less than 1/4" in size. It also includes drying the material to approximately 10% moisture content. In other words, 10% of the material's weight after drying is water with the balance being the weight of wood. For perspective, in freshly harvested trees about 50% of the total weight is water and 50% is wood. Thus, a significant amount of moisture is removed before densification. The feedstock must also be free of contaminants, such as metal, plastic, or chemicals.

The briquetting process involves feeding the clean/appropriately sized/dried wood fiber into a press. A piston or screw-type auger feeds the material in. Within the press, the temperature of the material rises as pressure increases. At a certain point, the lignin component of wood plasticizes and the material begins to flow in conformity with the shape of the cylinder. As the material exits the press it is cooled; during this phase, the cooling lignin acts as an adhesive that bonds the wood particles together, typically in the shape of a cylinder or brick. After cooling, the briquettes (or pressed logs) are packaged and stored for shipment to market. Care must be taken to keep the material dry, lest it fall back to sawdust.

The keys to successful operation of a wood briquetting business are access to nearby markets and the availability of low-cost feedstock. Using only raw materials sourced directly from the forest can be problematic in keeping raw material costs low because the material must bear the costs of felling, processing, and transporting the material to a manufacturing facility. Additionally, at the manufacturing facility, the material must be reduced in size at additional expense. Most operations manufacturing densified wood briquettes rely on mill by-products such as sawdust as their primary raw material source. Another factor is that many homeowners prefer the ease of heating with natural gas, oil, or propane, all of which use systems that automatically feed the fuel to a burner. Heating with briquettes, in contrast, requires the homeowner to continually stoke the fire. Thus, during periods when prices for fossil fuel are relatively low, homeowners will opt to use those fuels for home heating because of their convenience. Another key to success for this technology is that it can be economical at a relatively small scale of operation.

Figure 3.6—Examples of Densified Wood Briquettes

3.4.7 Essential Oils

Essential oils are a group of products used in applications such as aromatherapy for massages and baths, in personal care products such as lotions and creams, and for industrial uses such as cleaning agents. Some essential oils are extracted from different types of wood, especially pines and cedars. **Figure 3.7** shows some examples of essential oil products. Wood essential oils all have very high sales values: for example, ponderosa pine essential oil currently sells for about $7.50 per milliliter at the retail level. As a point of reference, the bottle shown in the figure below holds about 5 milliliters. Essential oil from incense cedar and Western red cedar are currently selling for about $4.25 and $3.50 per milliliter, respectively, at the retail level.

Figure 3.7—Example Essential Oil Products from Wood Feedstocks

The most common process for manufacturing essential oils from wood raw material involves using steam distillation. In other words, steam is passed through wood fiber, which causes the essential oils contained in the wood to evaporate. Then the steam is condensed back to water form and the oil is separated from the water. The resulting oil is then typically filtered to remove any remaining plant materials and contaminants. The oils are then packaged into bottles and distributed to the market. Unlike many other forest products, which are mostly sold through an industrial distribution network, essential oils are normally sold to end-use consumers via online platforms, retail stores, and specialty health-and-wellness shops.

As with most forest products businesses, the key to a successful essential oil manufacturing business is access to a secure, stable, and affordable raw material supply. Also, yields of essential oil are very low relative to the raw material's weight. For example, oil yields equal to only 0.25% to 2.0% of the material's weight are common. Yield is a function of the size and geometry of the pieces, with more surface area exposed to steam and longer distillation time translating into higher yields. Yield also varies by species and age; where the feedstock is primarily the heartwood of older trees (which contain higher concentrations of aromatic chemicals), the yield is better than that from the sapwood portion of trees (where aromatic chemicals are less concentrated). Another key is access to low-cost thermal energy in the form of steam. For example, an essential oil manufacturer that could utilize waste heat from some other existing operation would have a significant cost advantage over a similar manufacturer that had to generate their own steam for distillation.

3.4.8 Liquid Biofuels

Woody biomass material can be converted to liquid biofuels such as bioethanol and biodiesel. The liquid fuels can then be used for fueling vehicles such as cars, planes, etc. These are viewed as renewable substitutes for fossil fuels. Like other processes described here, the first step is reducing wood fiber to smaller piece sizes to enhance the processing of the material. There are several pathways to converting woody biomass to liquid fuel. For example, to produce bioethanol, cellulosic biomass is broken down into fermentable sugars using enzymes or acids, which convert cellulose to glucose. The glucose is then fermented with yeast to produce ethanol. Then the ethanol is distilled to produce purified material. Similarly, to produce biodiesel, a process called transesterification involves reacting triglycerides with methanol or ethanol to produce fatty acid methyl esters and glycerol. Woody biomass is converted into biodiesel through a pyrolysis process (or gasification) followed by a Fischer-Tropsch synthesis.

While both preceding processes have proven possible at lab and pilot scales, BECK is not aware of any facility successfully producing liquid biofuels from woody biomass feedstocks at industrial scale – this despite numerous efforts aimed at commercializing these technologies. One recent example of a project that did not come to fruition is Red Rock Biofuels in Lakeview, Oregon. That project was slated to produce renewable aviation fuel. Despite more than $300 million invested in the project, it never reached operational status. Also, in the event a technology breakthrough proves this business can be scaled to an industrial level, the capital investment and scale are immense and in BECK's view, not appropriate for Happy Camp.

3.4.9 Lumber – Small, Specialty Sawmill

Sawmilling is the process of converting logs into lumber. The lumber produced is used for a variety of purposes including (to name a few) building construction, industrial uses, and furniture. Also, the by-products of sawmilling such as bark, sawdust, shavings, and chips can be used as feedstocks for other forest products businesses. While the raw material for sawmilling inherently includes logs that are larger than what most would consider biomass, it has been included in the analysis for Happy Camp since a number of larger diameter trees are available as hazard trees along roadways or part of timber sales. Industry contacts reported to BECK that there are very limited nearby markets for these larger logs. Thus, a small-scale sawmill designed to produce specialty lumber products is included in the analysis. **Figure 3.8** provides an example of typical small-scale sawmill equipment.

Figure 3.8—Example of Small-Scale Sawmill Operation

As with nearly all other forest products manufacturing processes, the key factor in successful sawmill operation is access to a secure and cost-effective raw material supply. In fact, it is common for sawmills to spend 65-75% of their operating costs to purchase logs. Thus, key advantages are access to regions where there is limited competition for logs and the ability to operate the sawmill in a manner that maximizes the volume and value of lumber produced from each log.

Depending on the species available, there are opportunities to produce specialty products such as large timbers, ungraded lumber for use as concrete forms, fencing blanks, and specialty dimension products made from species that are easily treated with chemical preservatives to extend their useful lives. Lumber produced locally is often preferred by community members in home projects.

3.4.10 Oriented Strand Board (OSB)

Oriented strand board (OSB) is an engineered wood product made from strands of wood that are oriented in a certain manner and then glued together to form a structural panel that is mainly used as sheathing for roofs and walls of buildings and also as the subfloor in buildings as shown in **Figure 3.9**.

Figure 3.9—Example of an OSB Panel

The manufacturing process involves converting small diameter stems into flakes. Creating the flakes involves first debarking the logs, after which specially designed machines chip the logs into strands that are typically about 1” wide, 4” long, and about 1/32” thick. Next the strands are dried so that all pieces have uniform moisture content. Then the strands are blended with resin adhesives and other additives and formed into a mat. The strands are generally oriented parallel to each other in the outer layers of the mat; the strands in the center of the mat are oriented perpendicularly to those at the outer edge of the mat. The formed mat is then pressed with heated platens, bonding the resin and strands into a panel. Finally, the panel is cooled and cut and trimmed to the desired size, typically a 4’ x 8’ sheet. OSB panels are then typically packaged into units that are about 3’ tall x 8’ long for shipment to market.

OSB plants are very large operations akin in size to pulp and paper mills. For example, a typically sized facility will consume 150 to 175 truckloads of small diameter logs per day (assuming 250 operating days per year). This means that the capital investment for constructing a new facility ranges well into hundreds of millions of dollars.

The market for OSB products is very closely linked to demand for building materials as dictated by the level of new home construction and repair and remodeling. There are currently roughly 50 OSB plants operating in North America with a combined production capacity production capacity of roughly 29 billion square feet (if all panel production is normalized to a 3/8” thickness basis). During 2024, however, the plants are only on pace to produce about 23.5 billion square feet of product. Thus, the existing manufacturers are expected to only operate at 80% of their total production capacity. Interestingly, there are no OSB plants within 1,000 miles of California, which is one of the largest housing markets in North America. Thus, an OSB plant located in California would have a significant freight-to-market cost advantage over other manufacturers. Despite these circumstances, in BECK’s judgment an OSB manufacturing facility is not appropriate for Happy Camp given the very large capital investment and large scale of such a project.

3.4.11 Posts & Poles

Post-and-pole manufacturing involves converting tree stems into posts and poles that are commonly treated with preservative chemicals. They are then deployed in applications such as fencing, support posts/poles for various agricultural processes, support posts for signage, and as decorative fixtures for log homes. Most of the existing post-and-pole manufacturers tend to be smaller-scale, family-owned businesses. **Figure 3.10** provides an illustration of post-and-pole manufacturing equipment.

Figure 3.10—Example of a Post Peeling Machine

There are two types of processes for manufacturing posts and poles. In the first, the manufacturing equipment removes the bark from tree stems while removing very little of the underlying wood fiber. This produces a post or pole that maintains the natural taper in diameter found in trees. In other words, one end of the post or pole will have a smaller diameter than the other end. Most tree species in the Western US have a taper rate of about 1/8" to 1/10" per linear foot. However, lodgepole pine trees, especially those grown in Western Montana, are known for having a much slower taper rate and thin bark. Both characteristics, combined with the ability to easily treat lodgepole pine with preservative chemicals, make it a preferred species for post-and-pole manufacturing. The second manufacturing process is called doweling. This is because the stem passes through a set of knives that rotate in a circular pattern, manufacturing the post or pole to a fixed diameter along its entire length.

As previously described, most posts and poles are used in ground-contact applications. Without preservative chemical treatment, this means that the wood will quickly rot. Thus, most posts and poles are treated in pressurized vessels that expose them to a fluidized mixture of chemical preservatives. Some post-and-pole manufacturers have preservative treatment equipment at their facility, but there are also many that only manufacture the posts and poles and then either sell them to others that have preservative treating capacity, or contract with others to have the posts/poles treated. Other value-added processes include pointing one end of the posts so that they are easier to drive into the ground, or chamfering the edges of the ends of posts and machining holes for placing fencing cross-braces.

A key to successful post-and-pole manufacturing operation is access to a secure, adequate, and cost-effective supply of raw materials. Also, the trees used as raw material should have good, straight form with as little taper as possible. This is because perhaps somewhat surprisingly, only about 50% of the cubic volume of input raw material ends up as a post or pole. The balance is lost as bark and/or shavings. Thus, care must be taken that the incoming feedstock is well suited for post-and-pole manufacturing.

3.4.12 Wood Fiber Insulation

As the name implies, wood fiber insulation (WFI) is a business based on producing insulation materials. However, unlike most insulation types such as fiberglass and mineral wool, WFI is made from 100% wood fiber feedstock. WFI is increasingly in demand as consumers view it as a product with a lower carbon impact than competing materials. This is because it comes from renewable sources, and because most wood fiber insulation products do not use any additional adhesives or binders to stay intact. Testing has shown that it performs just as well as other insulation materials.

There is only one existing WFI manufacturer in the United States, located in Maine on the site of a former pulp and paper mill. It began operating in late 2023. According to the developers of the facility, the plant has strong demand for its products, which include battens that fit between wall studs, loose fill that is blown into hard-to-reach places, and rigid panels which are installed over the top of wall sheathing. **Figure 3.11** illustrates rigid panel WFI installed over wall sheathing.

Figure 3.11—Example of WFI Rigid Board Product in Use

The feedstock for the plant is wood chips from nearby paper mills, with a secondary source being wood chips from whole log chipping operations. The manufacturing process involves feeding the wood chips into a disc refiner. The refiner, which consists of two large metal discs spaced closely together that rotate in opposite directions, breaks the wood chips down into a fibrous material. The refining process is very energy-intensive because of the high-horsepower electrical motors used to rotate the discs. The resulting fiber is formed into loose mats that are then pressed with heated presses into rigid panels or battens. Along with various adhesives, the heat helps the wood fibers bond to each other. The loose fill product does not include the use of adhesives. In all cases the fiber is treated with borates to reduce flammability. The plant in operation in Maine is a large facility consuming about 125,000 bone dry tons of raw material annually, or the equivalent of about 10,000 truckloads of raw material per year.

There are several keys to success for WFI manufacturing, including access to a secure, adequate, and low-cost source of raw material. Siting in an area with low electrical power costs is another key, since the manufacturing process is an intensive user of power. Another perhaps less obvious key is that the plant should be relatively close to large population centers, which would be the market for the material. Distance to the market is important because wood insulation products have very low density, which is what makes them a good insulator. However, this means that a truckload of products does not reach its maximum allowable tare weight before physically running out of space. It is estimated that the maximum cost-effective shipping distance for wood insulation products is about 400 miles.

3.4.13 Wood Pellets

As shown in **Figure 3.12**, wood pellets are wood fiber that has been densified and formed into a small, cylindrical pellet shape. In the U.S. most pellets are burned for heating homes and other buildings. Though not universally viewed as sustainable, current policy recognizes power produced from wood pellets as renewable. This means that in other parts of the world such as the United Kingdom and some Asian countries, coal-fired power plants have been, or are being, converted to combust wood pellets instead of coal to produce electrical power.

Figure 3.12—Example of Wood Pellets

Generating power from pellets has stimulated the development of wood pellet manufacturing facilities – particularly in the Southeastern US, from which nearly 10 million tons of wood pellets were exported in 2023. Many of the wood pellet manufacturing plants developed over the last decade in the U.S. South are focused on pellet export markets and have annual production capacities exceeding 500,000 tons per plant. More recently, there has been interest in developing large export-focused pellet production facilities on the U.S. West Coast. Drax, one of the major pellet exporters in the U.S. South, has started construction on a wood pellet export manufacturing facility in Longview, Washington. Drax is also reportedly working in partnership with Golden State Natural Resources to develop pellet manufacturing facilities in Lassen and Tuolumne Counties, California. The combined production capacity of those two plants is expected to be about 1 million tons per year. Pacific Northwest Renewable Energy is another company planning a wood pellet manufacturing and exporting facility in Grays Harbor, Washington. That company has yet to start construction. Finally, two smaller-scale pellet manufacturing facilities are being planned in conjunction with two sawmills in Oregon. Both reportedly have plans to export chips from the Port of Coos Bay.

For the wood pellet plants in the U.S. West that are targeting export markets, the planned feedstock is mill residuals in the form of sawdust and shavings. The wood pellet plants in the U.S. West that make pellets for home heating also use sawdust and shavings, but they are typically focused on using Douglas-fir sawdust and shavings. This is because Douglas-fir offers the best combination of heat and low ash production, which minimizes the need to clean the pellet appliance. The pellet plants in the U.S. South also use mill residuals as a key feedstock.

However, in those parts of the U.S. where pulpwood is plentiful and harvesting costs are low because of flat ground and uniform plantations, roundwood is also commonly used as a feedstock. The use of roundwood as a pellet feedstock in the U.S. West is much less common, because it is generally much costlier than mill residuals.

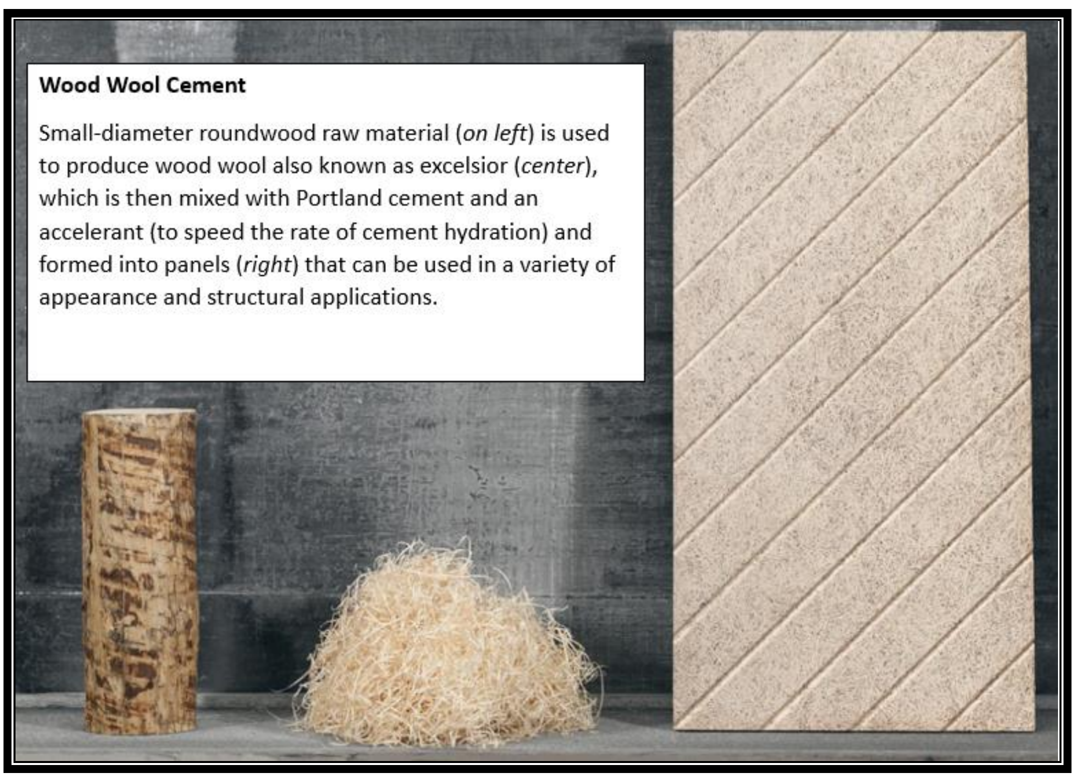
Getting all the wood fiber pieces consistently sized and having a consistent moisture content are key first steps in the pellet manufacturing process. This is easily accomplished with minimal hammermilling if the incoming feedstock is sawdust and shavings; however, if the incoming feedstock is chips from roundwood, more processing is required. Drying is typically accomplished by tumbling the feedstock through a rotary dryer tube that is connected to a heat source to allow for hot gases to flow through the tube. Next the dried feedstock is fed into a pellet mill, which uses a roller system to force the material through die plates. The heat and pressure generated during this process "plasticize" the lignin component of the wood fiber and allow the material to flow through the die and take on its cylindrical shape. Immediately after being extruded from the die, the pellets are cooled. This hardens the lignin, which allows the pellet to maintain its shape without added adhesives. Finally, the material is packaged in 40-pound plastic bags in the case of pellets for home heating, or stored in bulk for export pellets.

The key to success for wood pellet manufacturing is access to a secure, adequate, and cost-effective supply of raw material. Also, there are economies of scale for both capital investment and operations. Thus, the lowest-cost operations (excluding the cost of raw materials) tend to be larger in scale, often in excess of 250,000 tons of production per year. A risk in pellet manufacturing for power production is that future policy might change such that wood pellets would no longer be viewed as renewable.

3.4.14 Wood Wool Cement

Wood wool cement (WWC) is a panel product made from a combination of wood wool (also known as excelsior), Portland cement, and water as shown in **Figure 3.13**.

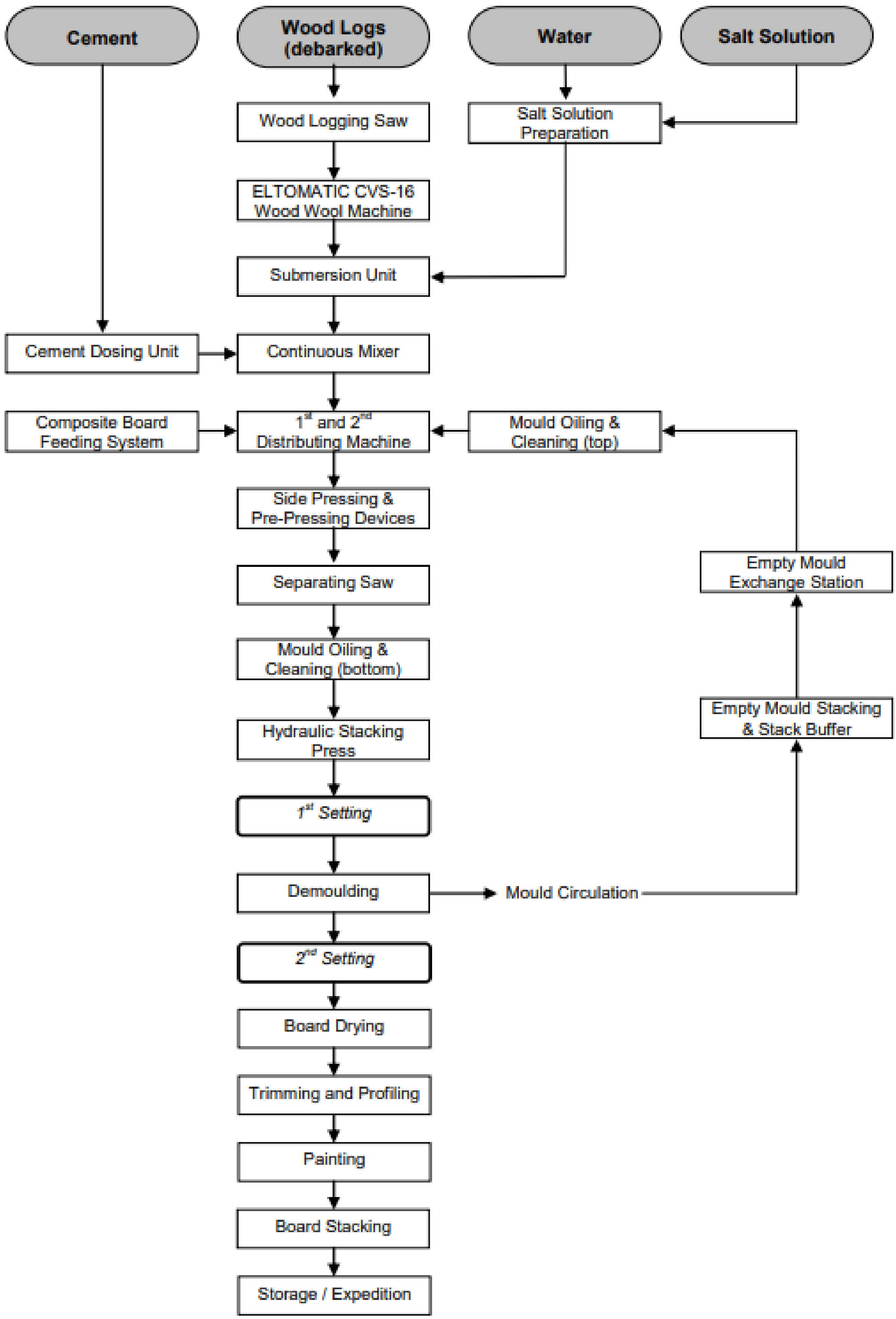
Figure 3.13—Wood Wool Cement



The main product type made from this mixture of materials is wood wool cement board (WWCB), an acoustic panel used mainly as decorative finish on ceilings and walls. WWCB's key properties are excellent sound absorption, good thermal insulation, fire resistance, and ease of design. It is available in many colors and is easily machinable to different shapes and sizes. Those attributes afford architects and designers an excellent balance of performance and flexibility in creative design. WWCB is also recognized for its sustainability as it contains wood – a renewable resource. WWCB is currently produced in 2' wide by 8' long sheets in thicknesses ranging between 1/2" to nearly 4". Product sales prices are not published, but industry contacts report that they range between about $0.90 and $1.40 per square foot (FOB plant).

Tectum is a similar, US-manufactured brand-name product made from wood wool. However, Tectum is made using magnesite (magnesium carbonate – $MgCO_3$) as a binding agent instead of Portland cement. As a result, Tectum is only suitable for indoor applications, whereas WWCB can be used both indoors and outdoors as it resists decay. WWCB used in exterior applications in Europe remains in service after more than 70 years. For example, WWCB is used in sound barrier walls along highways and railroads, and as exterior cladding on homes and commercial buildings. **Figure 3.14** on the following page provides an illustration of the basic steps included in the WWCB manufacturing process.

Figure 3.14—Key Steps in Manufacturing Wood Wool Cement (per Eltomation, a manufacturer of WWC equipment)



Another WWC product is wood wool cement-large wall element (WWC-LWE). It can be used as a structural element, such as a wall system in a building. The WWC-LWE product is produced as a whole wall section with dimensions about 12” to 15” thick by 9’ to 10’ wide (the wall height when the panel is placed in use) by up to 20’ long. Those large pieces form whole walls, leading to fast and labor-efficient construction. The market for WWC-LWEs is still developing in the U.S.; BECK is aware of several architects who are working on getting these materials accepted into U.S. building codes. The products have already been adopted into European building codes and have been used in home construction for several decades, especially in Sweden. Aside from excellent insulating properties, a key benefit to constructing homes with WWC materials is that since the wood is encapsulated in cement, the buildings are much more resistant to fire. This is especially important in a region like California – and especially Happy Camp, where wildfires have been a recurring problem. **Figure 3.15** illustrates a home in Sweden constructed using WWC-LWEs.

Figure 3.15—Home in Sweden Constructed from WWC-LWE

An industrial-scale WWC manufacturing facility would cost somewhere in the range of $40-50 million. Such a facility would require a total of approximately 15,000 bone dry tons of wood fiber annually and produce about 4.2 million cubic feet of WWC product each year. Additionally, the plant would require about 17 laborers per shift. Most industrial-scale operations in Europe operate 3 shifts per day, 5 days per week. Staffing to fulfill other roles such as sales, accounting, and raw material procurement would be in addition to the manufacturing labor. It is important to note that a much lower-cost and smaller-scale approach might be well suited for Happy Camp. The raw material for manufacturing WWC is small diameter trees, which typically (depending on equipment specifications) cannot exceed 12” in diameter. A variety of species work well in the manufacturing process, including nearly all Western conifers.

3.4.15 WoodStraw & Other Soil Erosion Control Products

Controlling soil erosion is important for areas containing disturbed soils including construction sites, roadways, oil and gas drilling sites, mining operations, and areas burned in wildfire. One of the most common soil erosion prevention measures is to spread agricultural straw across the erodible area. The mulch intercepts raindrops and thereby mitigates the impact of rain hitting and displacing bare soil. The agricultural straw also slows runoff, which decreases the chance for erosion to occur. Agricultural straw is inexpensive relative to other options, and readily available in most areas. However, it also has several serious drawbacks, starting with the reality that even mild winds can easily blow the straw off the sensitive area after application. It also decomposes quickly, thus losing effectiveness, and commonly has seeds embedded in the material that introduce noxious weeds to sensitive sites where they are neither present nor desired.

To address these drawbacks to agricultural straw, Forest Concepts, LLC of Auburn, WA developed WoodStraw™ (hereafter referred to as WoodStraw). It is manufactured through a relatively simple process in which low-grade wood veneer is fed through a machine called a “wood muncher,” very similar to a paper shredder. The result is small pieces of wood that are either 6.3” or 2.5” long by 3/16” wide and 1/8” to 1/10” thick. Fifty percent of the pieces (on a weight basis) are 6.3” long and the other half are 2.5” long. The WoodStraw is then spread on areas of bare ground susceptible to erosion. **Figure 3.16**, on the following page, provides an illustration of WoodStraw spread across a surface.

Forest Concepts has produced and sold its WoodStraw erosion control product from their location in Auburn, but they have also sought to commercialize the enterprise through licensing agreements. Heartwood Biomass currently has a licensing agreement with Forest Concepts, operating a biomass campus operation in Wallowa, Oregon and currently developing another biomass campus facility in Tuolumne County, California. Additionally, Mountain Pine Manufacturing, Inc. in Craig, Colorado is also producing WoodStraw.

It is common to use fishtail veneer sheets as a raw material for WoodStraw. Since logs are not perfectly cylindrical, the first layers of veneer produced when a log is peeled for veneer are various odd-shaped pieces. Once a log has become fully rounded, it begins producing full veneer sheets. Those first sections are called fishtail veneer and they have limited uses, one of these being WoodStraw manufacturing. The current producers typically purchase fishtail veneer from nearby veneer and plywood operations. Examples of such operations include the Roseburg Forest Products and Timber Products operations in Weed and Yreka respectively. Historically, this type of veneer can be purchased for about $50 to $75 per ton. Other key costs are labor (two people), packaging (the material is sold in 50-pound bales, 600-pound bales, or in bulk), and freight cost to deliver the material to end users. A single wood muncher machine can produce about 0.9 tons of WoodStraw per hour, which is closely matched to a baling machine that can bale about 0.8 tons of WoodStraw per hour. Market prices for the finished product vary, but license holders have sought to sell the material at about $300 per delivered ton.

Figure 3.16—WoodStraw Erosion Control Mulch

Source: Mountain Pine Manufacturing (www.mpinem.com/projects)

CHAPTER 4 – HAPPY CAMP BIOMASS BUSINESS FEASIBILITY STUDY

Three key processes are involved in this study, including: 1) Estimating the supply and cost of biomass in the Happy Camp, California area; 2) Screening biomass utilization technologies to identify which are most appropriate for Happy Camp; and 3) Completing a feasibility analysis for a preferred technology (or technologies). This report chapter contains the feasibility analysis for a small-scale, specialty sawmill business and a wood wool cement-large wall element business. Included in both analyses are assessments of markets, product prices, manufacturing profiles (productivity rate, number of shifts, yield, etc.) raw material costs, capital costs, and financial performance. Note that to the extent possible, the analyses were completed under the assumption that both businesses would or could be co-located at the former Sierra Pacific Industries sawmill site. As noted, some costs were considered as being shared between the businesses.

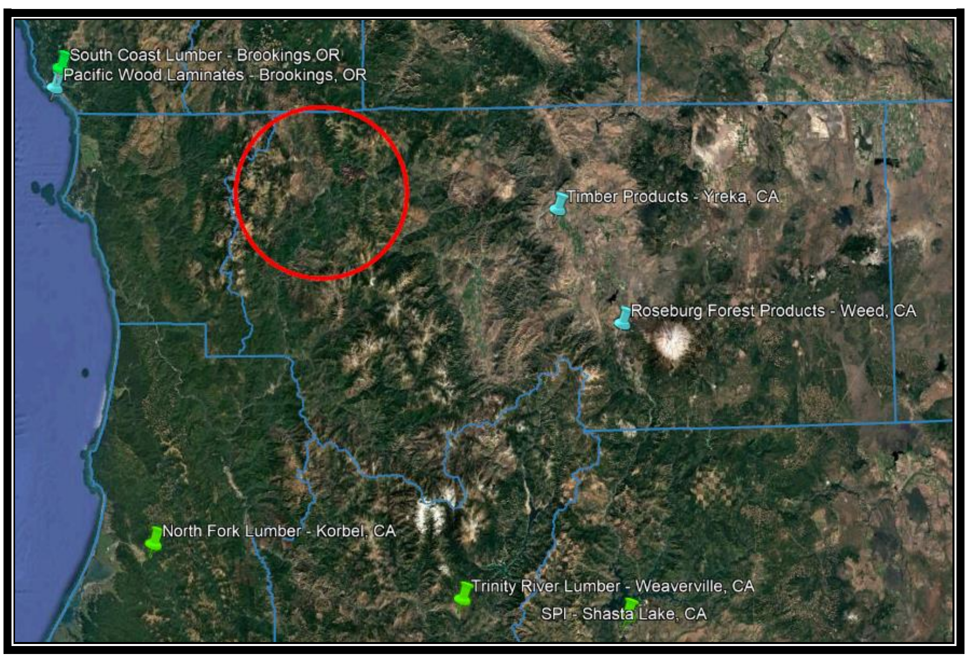
4.1 SMALL-SCALE, SPECIALTY SAWMILL

This report section provides an analysis of a small-scale, specialty sawmill operation.

4.1.1 Small-Scale, Specialty Sawmill Conceptual Description

The 15-mile radius supply area around Happy Camp is distant from the existing sawmills and veneer/plywood plants in Northern California and Southern Oregon. While saw and veneer logs harvested around Happy Camp are utilized at the existing mills despite the long haul, a subsection of the larger diameter logs (30” plus in diameter) that are harvested in the HCSA is difficult to market because the equipment in the nearest mills cannot accept large logs. Logging contractors in the region report that the only viable option for large diameter logs is selling them to the Sierra Pacific Industries mill in Shasta Lake, California, which is about three hours distant from the HCSA. Also, it is reported that the SPI Shasta Lake mill is frequently oversupplied with large diameter logs that are salvaged after wildfires. Therefore, the SPI Shasta Lake mill is not always buying large diameter logs from distant locations. It is estimated that the annual supply of large diameter logs in the HCSA is about 3 million board feet (Scribner short log scale). **Figure 4.1** depicts the locations and operators of existing sawmills and veneer mills in northern California and southern Oregon. The red circle indicates the HCSA.

Figure 4.1—Existing Sawmills and Veneer Mills in Northern California and Southern Oregon



In addition to the oversupply of large logs in the Happy Camp supply area, large diameter logs are well-suited for producing specialty lumber products such as large timbers and high-grade shop and molding lumber. A mill producing those kinds of products contrasts with the vast majority of the softwood lumber produced in the Western US, which is processed into dimension lumber such as 2” x 4” through 2” x 12”. Given these circumstances, the small-scale, specialty sawmill concept investigated here entails developing a small sawmill designed to process the large diameter logs available in the HCSA into a variety of specialty lumber products, which tend to be higher in value and do not directly compete with the lower-cost, commodity-type dimension lumber products produced at most other Northern California sawmills.

4.1.2 Small-Scale, Specialty Sawmill Market Analysis

Table 4.1 shows the historical volume of softwood lumber produced in California from 2015 to 2023 per the Western Wood Products Association (WWPA). As the data in the table show, lumber products have been fairly consistent in the range of 2 billion board feet per year. To provide perspective, the mill considered in this analysis would produce about 3.3 million board feet per year, or about 0.15% of California’s total production. About 80% of all lumber produced in California is also consumed in California per WWPA.

Table 4.1—California Softwood Lumber Production (2015 to 2023, board feet in billions)

Year	Lumber Production
2015	1.957
2016	2.029
2017	1.928
2018	2.005
2019	2.100
2020	2.246
2021	2.189
2022	2.151
2023	2.069

Table 4.2 shows the estimated size mix of softwood lumber produced in the Western US in 2023. As the data in the table show, 55% of all lumber is produced to 2” (nominal thickness) sizes; 5% is produced as small timbers such as 4” x 4” and 5” x 5”. Another 5% is produced as large timbers (greater than 6” in thickness and width). The remaining 35% of production spans a variety of other sizes and products such as 1” thick lumber, ties, pallet cants, and shop and molding lumber.

Table 4.2—Estimated 2023 Western US Lumber Production by Size (board feet in billions)

Region	% Dimension (2”nominal)	Estimated 2023 Production of Dimension (BBF)	% Small Timbers (3”– 5”)	Estimated 2023 Production of Small Timbers (BBF)	% Large Timbers (6”+)	Estimated 2023 Production of Large Timbers (BBF)	% Other	Estimated 2023 Production of All Other Sizes	Total 2023 Production (BBF)
U.S. West	55%	7.6	5%	0.7	5%	0.7	35%	4.8	13.8

Each of the following subsections describes the typical applications for the lumber products to be produced by the sawmill.

Large Timbers—Generally defined as beams greater than 6” in thickness and width, large timbers are used in post-and-beam and timber-frame construction as shown in Figure 4.2. As the figure illustrates, the posts (vertical orientation) and beams (horizontal orientation) are much larger than the 2” thick dimension lumber typically used to frame residential buildings. This type of specialized construction generally leaves the beams exposed, which many consider to increase the aesthetic appeal of a building. This type of construction is increasing in popularity along with the growth in mass timber construction.

Timbers are graded structurally as either #1 or #2. Knots and other natural features in beams are not considered defects unless their magnitude exceeds the limits prescribed in the applicable timber grading rules. Another key feature of large timbers is the location of the tree pith (the centermost portion in the cross section of a tree), which is also known as ‘heart center.’ The area around the pith is where the wood fibers are the weakest. Therefore, the grading rules for timbers 8” x 12” and smaller are that the timber has to be free of heart center. For timbers larger than 8” x 12” the pith is to be boxed in the center of the beam. Also note that timbers may be sold rough or surfaced. Most timbers are sold green (i.e., not kiln-dried), but some timbers are sold kiln-dried. Most softwood mills are configured to cut lumber to 16’ lengths, with some that can cut up to 20’ lengths; even fewer can cut 24’ or longer lumber. The ability to produce longer lengths is important for timbers, as some designs in post-and-beam construction call for long spans as shown in **Figure 4.2**. Note, however, the mill considered here can produce up to 20’ lengths – with the option to add greater length capacity in a second phase of development.

Figure 4.2—Illustration of Large Timbers Used in Post & Beam Construction

Source: Timber Frame HQ

Shop & Molding Lumber—Shop- and molding-grade lumber is commonly sawn from pine logs in the Western US. It is commonly produced in thicknesses between 1” and 2”, and is used in applications such as trim and molding, furniture, cabinetry, and millwork. The left side of **Figure 4.3** shows a typical run of pine shop-grade boards while the right side of the figure illustrates molding-grade boards. The molding-grade boards have fewer knots and less wane. Note that shop and molding-grade boards are sold to remanufacturers who then process the material into its final form.

Figure 4.3—Illustration of Shop- and Molding-Grade Pine Boards

Source: Sierra Pacific Industries

An important consideration for the Happy Camp application is that both pine logs and pine boards can become stained by the action of fungi (commonly called blue stain). When in log form the preventative against staining is to keep the logs wet by sprinkling them with water. This reduces the amount of oxygen available to the logs and thereby reduces the action of the fungi. After the logs have been converted to lumber, it is quickly stacked using wood sticks (called stickers) between the courses of lumber in a unit. This allows air to flow across the pieces of lumber, which begins the drying process and prevents staining. Mills also tend to quickly kiln-dry lumber, since kiln-dried lumber is not susceptible to staining. In the case of Happy Camp, the cost of kilns would be excessive for the relatively small volume of material to be processed. Therefore, wetting the logs in the log yard and quickly placing green lumber on stickers would be essential practices.

Preservative-Treated Lumber—Another category of lumber that would be produced at the sawmill is dimension lumber and small timbers (4” x 4” and 4” x 6”) from true firs such as white fir, treated with preservative chemicals so that they can be used in applications exposed to the elements. True firs such as white fir (plentiful in the HCSA) are easily treated with preservative chemicals. Thus, there is a good market for manufacturing dimension lumber and small timbers from white fir and then treating them with chemicals. **Figure 4.4** illustrates a 4” x 6” treated small timber made from fir. Note that in the lumber industry similar species such as white fir, grand fir, noble fir, subalpine fir, etc. are grouped together into a species group. In the case of the firs, the species group is called Hem-Fir and can include a mix of hemlock and the true firs (Douglas-fir not being classified by the industry as a true fir).

Figure 4.4—Pressure-Treated Hem-Fir Small Timber

Lumber Prices—The data in **Table 4.3** illustrate the assumed sales value of the various lumber products that the sawmill would sell. As the data show, it is assumed that the Douglas-fir lumber will sell at an average price of $732 per thousand board feet, white fir would sell at an average of $418 per thousand board feet, and ponderosa pine would sell at an average of $645 per thousand board feet. The key to the higher sales price average for Douglas-fir is the higher prices for the 6" and 8" timbers.

Given the limited scale of the operation and the focus on logs with a narrow set of characteristics, other key conceptual plans for the operation are that it would produce a very limited product mix (i.e., only a few lumber sizes). Also, lumber would not be graded but rather sold as "mill run," for each size category. This means that all lumber produced from the mill would be sold at one price for each species and size combination. This assumption is reflected in the table except for ponderosa pine. In that case, since the values are so high, the material would be graded.

The prices shown are as reported by Random Lengths, a price reporting service for a variety of lumber and wood panel products. The prices used were the average price during 2023 and 2024 year-to-date. In BECK's judgment this period represents a reasonable future estimate of long-term average prices. This is because it includes the recent effects of inflation on manufacturing costs, and in turn prices, but also avoids the abnormally high prices that occurred in 2021 and 2022.

Also note that the prices were adjusted downward by varying amounts for each species and size from the actual averages reported by Random Lengths. The downward adjustments were made to account for the possible sawmill's inability to kiln-dry and plane lumber. Both of those processes increase lumber's value and utility. In BECK's judgment, however, for this small-scale sawmill the capital expense for purchasing such equipment is not justified.

Additionally, for the timbers the products are supposed to be free of heart center (no pith in the timber) and grade out as #1 and better. Prices were adjusted downward because it is unlikely that all of the material produced would meet this specification. Note that the discounting is also partially offset by the design of the sawmill, which would allow lengths of up to 32'. The ability to exceed the typical length of 32' would allow the mill to retain higher pricing levels despite lacking planing and drying capabilities.

Table 4.3—Assumed Lumber Sales Values by Species and Size/Grade

Size/Grade	Douglas-fir	% of Total	White fir	% of Total	Ponderosa pine	% of Total
1x4	135	1%	190	2%	n/a	n/a
1x6	135	1%	200	2%	n/a	n/a
2x4	451	11%	402	10%	n/a	n/a
2x6	459	6%	393	15%	n/a	n/a
2x8	403	5%	340	6%	n/a	n/a
2x10	507	3%	354	5%	n/a	n/a
2x12	543	12%	408	15%	n/a	n/a
4x4	626	6%	500	15%	400	10%
4x6	639	10%	500	14%	n/a	n/a
4x8	654	5%	n/a	n/a	n/a	n/a
4x10	651	3%	n/a	n/a	n/a	n/a
4x12	590	12%	n/a	n/a	n/a	n/a
6x6	1487	5%	n/a	n/a	450	6%
6x8	1320	4%	n/a	n/a	n/a	n/a
6x10	1320	2%	n/a	n/a	n/a	n/a
6x12	1320	3%	n/a	n/a	n/a	n/a
8x8	1678	5%	n/a	n/a	n/a	n/a
8x10	1566	2%	n/a	n/a	n/a	n/a
8x12	1645	4%	n/a	n/a	n/a	n/a
3 shop	n/a	n/a	400	12%	573	18%
2 shop	n/a	n/a	473	4%	1565	12%
Moulding	n/a	n/a	n/a	n/a	3209	4%
6/4 P. 99	n/a	n/a	n/a	n/a	318	50%
Avg./Tot.	**779**	**100%**	**418**	**100%**	**645**	**100%**

4.1.3 Small-Scale, Specialty Sawmill Raw Material Supply & Cost

It is quite common in the sawmilling industry that the cost of purchasing logs accounts for about two-thirds of all operating costs. Therefore, it is important to understand delivered log costs and the various factors that impact log cost. For the purposes of this analysis, it was assumed that on average, every 1,000 board feet of logs is equal to 6 green tons. It was also assumed that logs would be delivered to Happy Camp from the Happy Camp Supply Area at an average delivered cost of $70 per ton. The raw material supply is expected to total 18,000 green tons per year. Thus, the total annual raw material expense is estimated to total $1.26 million per year.

Included in the delivered costs are *stumpage costs*: the cost of purchasing the right to harvest standing timber from the timberland owner. Also included is the logging cost, which includes the costs of felling the trees, yarding them to a landing area, manufacturing the trees into logs, and loading the logs onto a truck. Finally, delivered log cost includes the cost of transporting logs from the forest to the sawmill site. As previously stated, BECK estimates that all these costs would total $70 per ton on average. As perspective, given the assumption of 6 tons per thousand board feet, another way of expressing the delivered cost is that it totals to $430 per MBF Scribner[5] (6 tons per MBF x $70 per ton). All the preceding assumptions are based BECK's experience in past projects and knowledge of the cost structure in logging and trucking industries in Northern California.

Another issue affecting log cost, when the cost is expressed on a finished lumber volume basis, is mills' efficiency in converting logs into lumber. This issue is called *yield* or *recovery*, and the more volume or value a sawmill recovers from a given volume of logs, the more it effectively lowers the cost of the logs per unit of finished lumber produced. The conversion efficiency varies widely among sawmills and is affected by factors such as log size, saw kerf, lumber target sizes, saw filing and equipment maintenance, and product mix. Also, some mills are equipped with technology that scans the log prior to sawing to generate a 3D model of the log's shape; associated computer software calculates the optimal sawing pattern. The mill considered here does not include that type of optimization technology since the small annual volume does not justify its high capital expense.

Given the preceding, for this analysis it assumed that the mill would process the log volumes with the yield factors and lumber production shown in **Table 4.4**.

Table 4.4—Log-to-Lumber Recovery and Lumber Production Assumptions

Tree Species	Annual Green Tons of Logs	MBF of Logs	MBF Logs to MBM Lumber Yield	Annual Lumber Production
Douglas-fir	11,160	1,860	1.10	2,046
White fir	3,600	600	1.10	660
Ponderosa pine	3,240	540	1.08	583
Total/Average	**18,000**	**3,000**	**1.10**	**3,289**

4.1.4 Small-Scale, Specialty Sawmill Process Description

The following section describes the basic manufacturing steps in the sawmill business. Note also that **Appendix 2** includes a layout drawing of the sawmill.

1. *Log Receiving and Storage* – Logs will be unloaded from log trucks and placed into storage in the log yard using a large front-end loader. The same loader will also move logs from storage to the log infeed section of the sawmill. Note that ponderosa pine logs and lumber are susceptible to blue stain, a fungus that causes a discoloration to the sapwood portion of the log and/or lumber. This issue is mitigated by

[5] Scribner is a commonly used system in the US West for estimating the board foot volume of logs.

sprinkling water on the logs, which lowers the oxygen levels in the wood fiber below the point at which the fungus can survive.

2. *Log Debarking & Bucking*—Large, industrial-scale sawmills have dedicated pieces of equipment for debarking logs prior to sawing and for *bucking* (cutting long logs into shorter lengths). Logs will be cut down from the delivered length of about 32' to 40' to lengths appropriate for processing in the sawmill, which will mostly be 16' to 20'. Given the small scale of this operation, the capital cost of debarking and bucking equipment is not justified. Therefore, the sawmill will be equipped with a small circular sawblade that runs just ahead of the bandsaw blade that will make the actual cuts. The circular saw will only cut to a very shallow depth, to effectively debark the log where the bandsaw blade will enter the cut. Regarding bucking, it is assumed that the logs will be measured for length and bucked manually with chain saws.

3. *Primary Breakdown*—As previously described, the first saw a log will encounter during the sawmilling process is a horizontal bandsaw. This type of mill is designed so that the log remains stationary and secured by log dogs while the bandsaw passes through the log. After each pass, the mill reciprocates to the starting point and makes another pass. The depth of the cut into the log is adjusted for each pass to achieve lumber of the desired thickness and/or width. To extract the maximum amount of volume and grade from each log, the log is periodically rotated by a log turning device and then re-dogged to hold it securely held in place. The equipment selected for the mill has all the required items for completing these functions. **Figure 4.5** provides an illustration of the primary breakdown equipment, which is a horizontal band mill.

Figure 4.5—Illustration of Primary Breakdown Equipment for Small-Scale, Specialty Sawmill

5. *Resaw*—After the primary breakdown squares the log into what is called a *cant* (resembles a roofing beam), the resaw is a secondary piece of equipment that cuts boards and timbers from the cant.
6. *Board Edger*—Some of the lumber pieces produced at the primary breakdown will have bark along one edge or both edges, or it might have wane. Wane is a section of a piece of lumber where its edges are not square due to the rounded nature of the log. A multi-saw board edger will remove bark and wane edges to produce square-edged pieces. This machine can also be used to remanufacture boards that do not meet specifications after the first cuts.
7. *Sorting and Stacking*—Sawn lumber will be manually sorted and stacked, with kiln stickers between each layer. With a simple product mix and low piece counts per minute, the staffing levels allocated will be able to keep up with the sawmill production. Note, however, that some of the timbers will be very large and heavy. Therefore, a loader will be used to remove the large timbers from the green chain and stack them in preparation for shipping. Importantly for the ponderosa pine shop and molding lumber, it will be important to have stickers placed between each course of lumber. The stickers will allow air to flow over the boards and reduce the likelihood of blue stain developing.
8. *Shipping*—Lumber units will be strapped with metal bands and then stored to await shipment. Since all the lumber is sold green, it can be stored outside while awaiting shipment. Lumber will be “stuffed” into standard cargo shipping containers using a forklift. The full containers will then be placed onto trucks and taken to the Oakland port for overseas shipping.
9. *Planing, Kiln Drying, and Length Trimming*—Large industrial-scale sawmilling operations typically kiln-dry lumber, then plane it to its final dimension and trim it to length. However, in this case the lumber will be sold green, which means not kiln-dried; rough, which means unplaned; and full-length, which means no end-trimming to precise length. While all of these steps add value to lumber, the capital cost for the required equipment is not justified given the small scale of the operation.

4.1.5 Small-Scale, Specialty Sawmill Capital Costs

The capital expenses for this business were estimated on an order-of-magnitude basis using the best available information from vendors and from past BECK projects. This includes quotes from equipment vendors for similar types of equipment and quotes specific to this project for other types of equipment. Additional estimates for costs related to buildings, installation, permitting, project management, etc. were modified from similar capital cost estimates on other projects to match the sawmill development plan considered in this study.

The budgetary capital cost estimate for the small-scale sawmill is $1.3 million including a $120,000 contingency allowance. Note that several pieces of rolling stock would be required (e.g., a large loader for unloading log trucks, and/or a compact wheeled loader for feeding logs to the sawmill and for sorting and stacking lumber units). Those items were assumed to be purchased used. **Table 4.5** below provides a more detailed description of the various components of the estimated capital cost.

Table 4.5—Budgetary Small-Scale Sawmill Capital Cost Estimate

Capital Cost Items	Dollars	Notes
Sawmill equipment	385,000	Assumes Wood-Mizer 2500 sawmill
Freight on sawmill equipment	25,000	Estimate
Sawmill installation	100,000	Some assistance provided by vendor & electrical allowance
Rolling stock	225,000	Assumes used equipment for rolling stock
Building	420,000	Assumes 50’ x 100’ building and 90’ x 90’ concrete slab
Miscellaneous (permits, spare parts, etc.)	25,000	Estimate
Subtotal	1,180,000	
Project contingency	120,000	Estimated to be 15% of total
Grand Total	1,300,000	

Two important things to note about the capital cost:

1. Not included in the estimate or analysis is an upgrade which would add a second breakdown line specially designed to process logs up to 45’ in length. The equipment vendor said that this piece of equipment would cost $100,000, including shipping to the site. It does not include the cost of installing the equipment or a building and/or foundation for housing the equipment. This piece of equipment can be added after the mill becomes operational if the owners determine that price premiums and markets for longer timbers justify the investment.
2. Sawmills are typically designed with the equipment installed in an elevated position with by-product handling systems positioned below. This approach allows inclusion of automated systems for easily moving waste such as slabs, edgings, sawdust, etc. away from the mill. However, elevating the equipment also adds significant capital cost. Therefore, given the small volume produced by the mill, BECK elected to not include elevating the equipment in the design; this means more labor in removing waste and lower productivity. BECK recommends that any entity pursuing this business option should evaluate the cost/benefit of elevating the sawmill equipment after the mill is operational and well-established.

4.1.6 Small-Scale, Specialty Sawmill Ongoing Operating Costs

The ongoing operating costs of the small-scale sawmill business were organized into direct manufacturing costs (e.g., labor, raw materials, supplies, utilities, etc.) and fixed costs (e.g., salaries, general and administrative, site lease, insurance, depreciation, etc.). The costs were estimated from a combination of the supply study completed as part of this project, estimated labor costs in the Happy Camp region, and estimated usage rates and costs of various supplies.

Labor—The mill will operate 2,000 hours per year and require direct staffing of four hourly employees. One would operate the primary breakdown, a second would move back and forth between the edger and resaw as needed, and a third would work on the green chain stacking and sorting lumber. The fourth would operate rolling stock including unloading logs from trucks, moving lumber units into storage, and loading outbound trucks. The average base wage rate for all the hourly employees is $27.50 per hour. A 40% fringe loading factor was applied to all hourly costs, which results in a fully loaded wage rate of $38.50 per hour. The total annual loaded wages paid to hourly employees at the sawmill are estimated to be about $308,000 per year. Additionally, there would be a salaried general manager who would handle log purchasing, lumber sales, and bookkeeping. The manager could also assist in mill operation as needed.

Supplies—The cost for various supplies such as parts, dunnage, safety equipment, etc. was assumed to total $20 per thousand board feet, which is based on the cost of supplies experienced at other similar mills. This results in an annual supplies cost of $66,000 per year.

Fuel, Oil, and Lubricants—The cost of fuel and oil for rolling stock and various lubricants for mill equipment and rolling stock was estimated at $4,000 per year assuming a fuel cost of $4.50 per gallon, consumption of 3 gallons per day, and 250 operating days per year. The cost of oil and lubricant was assumed to equal 20% of the cost of fuel.

Power—The total connected horsepower for the various equipment in the sawmill powered with electricity is estimated at approximately 125hp. The motors are assumed to consume slightly more than 66,000 kilowatt hours of power per year, since not all are operating continuously during the sawmill's operation. At an estimated cost of $0.275 per kilowatt hour, the power cost is estimated at $18,000 per year.

Repair & Maintenance—Repair and maintenance costs for the various mill equipment items and rolling stock were estimated to total $30,000 per year. This includes $10,000 for contracted services and $20,000 for costs associated with routine maintenance.

Log Cost—As described in **Section 4.1.3**, the cost for purchasing logs is estimated at $1.26 million per year. The total cost is slightly offset by the assumption that 1% of the value of the all logs can be resold to other mills instead of being sawn at the Happy Camp mill. Thus, the net annual log cost is estimated at $1.247 million.

General and Administrative Costs—The general and administrative costs include the salary and benefits of the mill manager, site lease, insurance, taxes and fees, depreciation, and other miscellaneous expenses. These are all estimated to total $393,000 per year. The largest costs are the manager's loaded salary of $140,000 per year, and depreciation which is $130,000 per year. Note that depreciation is a non-cash cost, thus actual cash flow to the operation is increased by the amount of the annual depreciation cost.

4.1.7 Small-Scale, Specialty Sawmill Financial Analysis

All the preceding information about capital costs, operating costs, sales realizations, productivity rates and yield factors were entered into a financial model. **Table 4.6** on the following page is a pro forma income statement for the small-scale sawmill business produced by the financial model. As the results show, the business is expected to generate nearly $300,000 in annual pre-tax cash flow. On a 100% equity basis, this business is projected to generate nearly a 23% annual return, or a 4.44-year simple payback period.

Table 4.6—Pro Forma Income Statement Financial Projection

Revenue/Cost Category	Annual Volume (MBF)	Dollars/Year	Dollars/MBF
Revenue			
Lumber Sales	3,289	2,209,000	71.59
Mill Residuals Sales	3,289	20,000	6.08
Total Sales	***3,289***	2,229,000	677.67
Costs of Goods Sold			
Raw Material			
Log Raw Material	3,289	1,260,000	383.07
Log Sales	3,289	(13,000)	(3.95)
Net Log Cost	***3,289***	***1,247,400***	***379.12***
Manufacturing Expenses			
Staffing – Hourly Labor	3,289	308,000	93.64
Supplies	3,289	66,000	20.07
Utilities	3,289	18,000	5.47
Fuel, Oil, Lubricants	3,289	4,000	1.22
Outside Maintenance	3,289	10,000	3.04
Repair & Maintenance	3,289	20,000	6.08
Subtotal Manufacturing Expense	**3,289**	426,000	129.51
General & Administrative Expenses			
Salaries & Benefits	3,289	140,000	42.56
Site	3,289	24,000	7.30
Insurance	3,289	12,000	3.65
Taxes & Fees	3,289	67,000	21.37
Depreciation	3,289	130,000	39.51
Other	3,289	20,000	6.08
Subtotal General & Administrative	**3,289**	**393,000**	**119.47**
Total Cost of Goods Sold	**3,289**	**2,006,000**	**628.12**
Gross Profit	**3,289**	**163,000**	**49.57**
+ Depreciation	3,289	**130,000**	**39.51**
= Annual Operating Cash Flow	3,289	**293,000**	**89.08**
Simple Payback Period in Years (Capital Expense divided by Operating Cash Flow)		4.44	

4.1.8 Small-Scale, Specialty Sawmill Feasibility Analysis Conclusions & Recommendations

For this small-scale, specialty sawmill business to work, simplicity in operation and design are critical in conjunction with manufacturing cost controls throughout the process. The primary equipment vendor considered in the analysis was Wood-Mizer. Their representatives provided a list of equipment and budgetary capital cost estimate based on the desired daily production level and general description of the log supply. This Indiana-based company has installed equipment in a variety of locations in the United States and California. Note, however, that other equipment vendors are able to provide similar equipment. For example, a capital cost estimate was also obtained from Bailey's, a California based forest products equipment supplier that distributes sawmills produced by a company called Wravor. Their sawmill equipment capital cost estimate is included in **Appendix 3**. The Wravor mill has a larger production capacity than the Wood-Mizer mill. The Wood-Mizer mill was judged better matched to the supply currently estimated to be available. However, if the operation were to increase in scale, which would improve economic performance, the Wravor mill may be more appropriate. More research and analysis are recommended to select appropriately scaled equipment and to validate the equipment productivity and lumber yields assumed in this feasibility study.

A key risk in the business is the assumptions made about the price discounts the mill will incur because the lumber will be sold green (not dried) and rough (not planed). Deeper analysis is recommended into the market value of timbers and the price discounts that must be given for only being able to sell green, rough lumber. Another risk is that the mill will lack the ability to produce large volumes of lumber. This may impede the ability to produce lumber matched to the sizes and grades specified by customers and to enter into programmatic contracts with customers (i.e., producing specified product mixes during specific periods).

Another key factor in the analysis is the assumed delivered log cost. The $70 per ton assumed price is likely to be stable given that the other mills that can easily utilize large diameter logs are a long distance from Happy Camp. However, since the delivered log cost is about two-thirds of all operating costs, an unexpected increase in log costs could quickly change the operation's financial performance.

As perspective, large industrial-scale sawmills in the Western US typically have annual production capacities of 250 million to 300 million board feet with some able to produce more than 500 million board feet. Thus, the mill considered here is tiny relative to those operations. This reality means that many cost-saving decisions were made to focus capital spending on only the items that can be fully utilized by such a small-scale operation. This means that many necessary operations such as log bucking, lumber grading, and lumber stacking are all completed manually. It also means that an experienced and knowledgeable manager will be needed to ensure the mill is operated efficiently. This includes close attention to log costs, log-to-lumber recovery, product mix, and lumber quality control. Management must also be able to train the crew in best practices.

4.2 PILOT-SCALE WOOD WOOL CEMENT MANUFACTURING

This report section provides an analysis of a pilot-scale wood wool cement manufacturing operation.

4.2.1 Wood Wool Cement Manufacturing Conceptual Description

Wood wool cement-large wall element (WWC-LWE) is a building material made of wood and cement, used as a structural exterior wall in buildings. There are currently no known buildings constructed of this material in the United States. However, the technology has been used in Sweden and other European countries for 70 years. Several characteristics of WWC-LWEs make them an appealing material for building homes in the Happy Camp area: superior performance in terms of insulative properties and acoustical properties, resistance to decay and fungus, and perhaps most importantly for Happy Camp, highly resistant to fire.

Given the circumstances listed in the preceding paragraph, the business concept tested here is the feasibility of developing a pilot-scale WWC-LWE manufacturing operation in Happy Camp. Developing a pilot-scale operation will allow for proving that the technology is acceptable for use in the United States and determining whether consumers accept this product as a building material. More specifically, the pilot-scale plant is designed to produce enough WWC-LWEs to construct 20 homes per year with each home having an average square footage of about 1,725 square feet.

While there are vendors that can provide all the equipment needed for manufacturing WWC-LWEs, the capital cost is expected to be roughly $40 million. In BECK's judgment, such a large capital expense is too risky for an emerging technology. Therefore, the pilot-scale plant will rely heavily on low-tech, low-cost equipment and labor rather than high-tech, high-cost equipment during the initial phase of proving the technology and market. The following sections provide an analysis of the feasibility of this concept.

4.2.2 Wood Wool Cement Manufacturing Market Analysis

Housing is a huge economic driver in the United States. **Table 4.7** shows the number of residential building permits issued by U.S. Census Region for the period 2019 to 2023. As the data in the table indicate, an average of about 1.55 million homes were constructed each year during the period. Of the total, more than half occur in the South. The West is the next most active, accounting for 24% of the total. More detail about the level of activity specific to California is provided in the next paragraph.

Table 4.7—Residential Building Permits by U.S. Census Region (2019 to 2023 in 1,000s)

Census Region	2019	2020	2021	22022	2023	Average	% of Total
Midwest	184.8	198.7	232.0	220.8	195.1	206.3	13%
Northeast	137.6	134.0	167.9	156.8	140.8	147.4	10%
South	701.0	761.5	903.5	909.3	829.9	821.0	53%
West	347.0	357.4	426.6	393.5	345.4	374.0	24%
Total	**1,370.4**	**1,451.6**	**1,729.9**	**1,680.4**	**1,511.1**	**1,548.7**	100%

Table 4.8 illustrates the number of housing starts in California by Metropolitan Statistical Area (MSA). As the data in the table show, a total of 111.76 thousand building permits were issued in California in 2023 with the amount roughly evenly split between single-family and multi-family residences. Note that several MSAs around Happy Camp such as Crescent City, Eureka-Arcata, and Red Bluff are not individually listed in the table, but are included in the row labeled "Other."

Happy Camp is not assigned to an MSA, but given the number of annual housing starts for the smallest MSA on the table it is likely that given "average" levels, the number of housing starts in Happy Camp is very low. Specific data was not available, but there are 127 million households in the US, and 1.5 million new housing starts per year, or a new housing start rate of about 1.1%. Happy Camp had about 350 households in 2022 per the U.S. Census. Thus, the likely number of new housing starts in Happy Camp each year is about 4 homes (350 households x 1.1% new home start rate per household). While these statistics do not indicate a strong market for new homes in Happy Camp, the wildfires that destroyed hundreds of homes in the region create special circumstances where housing demand is expected to be much stronger than average rates. For this reason, BECK concludes that a pilot-scale WWC-LWE plant aiming to produce enough material for 20 homes per year is reasonably sized.

Table 4.8—Single-Family & Multi-Family Residential Construction Permits in 2023 by California Metropolitan Statistical Area (in 1,000s)

Metropolitan Statistical Area	Single-Family	Multi-Family	Total
Los Angeles-Long Beach-Anaheim, CA	12.04	18.73	30.77
Riverside-San Bernardino-Ontario, CA	12.46	7.81	20.27
Sacramento-Roseville-Arden-Arcade, CA	7.93	4.01	11.94
San Diego-Carlsbad, CA	3.05	8.42	11.47
San Francisco-Oakland-Hayward, CA	3.02	4.52	7.53
San José-Sunnyvale-Santa Clara, CA	2.04	4.19	6.23
Fresno, CA	2.38	0.78	3.15
Bakersfield, CA	2.25	0.21	2.45
Santa Rosa, CA	1.02	1.33	2.35
Stockton-Lodi, CA	2.17	0.00	2.17
Other	1.42	0.27	1.69
Vallejo-Fairfield, CA	0.94	0.48	1.41
Visalia-Porterville, CA	1.04	0.13	1.17
Oxnard-Thousand Oaks-Ventura, CA	0.40	0.76	1.16
Madera, CA	1.11	0.00	1.11
San Luis Obispo-Paso Robles-Arroyo Grande, CA	0.59	0.37	0.96
Chico, CA	0.69	0.24	0.93
Modesto, CA	0.72	0.09	0.81
Hanford-Corcoran, CA	0.57	0.17	0.75
Salinas, CA	0.46	0.16	0.62
Yuba City, CA	0.59	0.02	0.61
Santa Cruz-Watsonville, CA	0.24	0.30	0.54
Santa Maria-Santa Barbara, CA	0.36	0.11	0.47
Merced, CA	0.40	0.00	0.41
Napa, CA	0.28	0.05	0.33
El Centro, CA	0.18	0.08	0.26
Redding, CA	0.21	0.00	0.21
Total	**58.53**	**53.23**	**111.76**

4.2.3 Wood Wool Cement Manufacturing Raw Material Supply & Cost

According to the European manufacturers of WWC-LWEs, the density of the finished product is about 350 kilograms per cubic meter, which translates to about 21.9 pounds per cubic foot. WWC-LWE panels comprise five key raw materials including:

1. *Wood*—the raw material used to form wood wool.
2. *Water*—a key ingredient that is mixed with cement.

3. *Cement*—a mixture of limestone and clay or shale that undergoes a chemical reaction called hydration after it is mixed with water. When hydration is complete the cement is transformed into firm, hardened mass.
4. *Sodium Silicate*—a chemical compound that increases the hydration rate of cement.
5. *Oil*—applied to the interior surface of the panel molds to ensure the material is easily released from the molds after the curing process.

The key assumptions for WWC-LWE production are:

- Average home size is 1,723 square feet.
- Each panel is assumed to be 1' thick by 8' long by 9' high (note these panel size assumptions may be adjusted slightly as building designs are further developed).
- Given the preceding home size and panel dimensions, the annual volume of WWC-LWE needed for 20 homes is about 875 to 900 cubic meters per year, or about 31,000 to 32,000 cubic feet per year. The annual volume estimate does not adjust the volume down for door and window cutouts.
- The total annual volume translates into about 430 panels per year or an average of 1.7 panels per day.
- The plant will operate for a single 8-hour shift for 250 days per year.

Each of the following paragraphs describes the usage rates and estimated costs for these raw materials.

Wood—per European WWC-LWE manufacturers, the wood input (at 20% moisture content at the time of manufacturing) per cubic meter is 94.5 kilograms. After making a slight adjustment for using species (like Douglas-fir) that have a higher specific gravity than the spruce and aspen commonly used in Europe, this translates to a usage rate of 5.9 pounds of wood raw material per cubic foot of finished panel. Given the assumed production of material for 20 homes, the annual usage of wood is estimated to be 100 bone dry tons per year. For perspective, this amount is equal to eight full truckloads of logs. The usage rate includes a yield loss of 25% due to the need to debark the logs prior to conversion into wood wool, loss of fine particles, and limited ability of the equipment to process 100% of each raw material block.

The machines for making wood wool typically cannot accept pieces that are larger than 12" in diameter. Thus, the process tends to use smaller size material, typically in the range of 6" to 10" in diameter. The delivered cost of wood raw material varies based on factors such as transportation distance, average material size (diameter), and whether the material is sourced from the tops of trees harvested as sawlogs, or trees that are too small to be utilized as sawlogs. For the purposes of this analysis, it is assumed that the average delivered cost is $65 per bone dry ton. Given annual wood usage of 100 bone dry tons, the total annual cost for wood raw material is estimated to be about $6,500.

Water—per European WWC-LWE manufacturers, the water usage rate is 115.5 liters per cubic meter of finished panel. This translates to 30.5 gallons of water used per cubic meter of panel. This further translates to annual water usage at the pilot-scale level of nearly 27,000 gallons, or roughly 100 gallons per day assuming 250 working days per year. Note that most of the water evaporates during the cement hydration process, but there is still a small amount of water retained in the WWC-LWE material, estimated to total just over two pounds of water weight per cubic foot of finished panel material.

The Happy Camp Community Services District (HCCSD) is the utility that provides water to Happy Camp. Per the HCCSD website, water is provided to customers at a rate of $40 per month for the first 25,000 gallons used and an additional charge of $0.50 per thousand gallons used per month above 25,000 gallons. Thus, for the purpose of this analysis of the pilot-scale operation, the assumed cost of water is $480 annually ($40 per month x 12 months per year).

Cement—per European WWC-LWE manufacturers, cement usage is 210 kilograms per cubic meter of finished panel. This translates to about 465 pounds of cement per cubic meter, or about 13 pounds per cubic foot. It also translates into annual cement usage of about 200 tons of cement.

According to IBISWorld, the average bulk price of cement is about $150 per ton. However, since the pilot-scale plant will use a relatively small quantity, it has been assumed for the purpose of this analysis that the cement cost is $275 per ton, which is the approximate cost for Portland cement purchased in pallet quantities from retail suppliers. Given annual consumption of 200 tons per year and a cost of $275 per ton, the total annual cost for cement is estimated to be about $55,000.

Sodium Silicate—per European WWC-LWE manufacturers, sodium silicate is included at a rate of 6 kilograms per cubic meter of finished panel. This translates into 13.2 pounds of sodium silicate per cubic meter, or about 0.4 pounds per cubic foot.

Sodium silicate is commonly known as water glass and is sold in an aqueous solution that is 40% sodium silicate. According to several chemical supply companies, the material is sold in 55-gallon drums at a price of about $450 per drum. Given the usage rate described above it is estimated that the pilot-scale facility will require 18 fifty-five-gallon drums per year. This translates to an annual cost of $8,100 for sodium silicate.

Oil—per European WWC-LWE manufacturers, the oil usage rate is 0.1 kilograms per cubic meter of finished panel. This translates to about 0.22 pounds of oil per cubic meter, or 0.006 pounds per cubic foot.

Cement form release oil is commonly sold in five-gallon buckets. Given the usage rate described above it is estimated that the pilot-scale facility will consume 5 five-gallon buckets per year. The cost per bucket is estimated at $55. Thus, the total annual cost for release oil is estimated at $275.

4.2.4 Wood Wool Cement Manufacturing Capital Costs

Lowered capital cost is one of the primary benefits of a pilot-scale operation. This is because it allows the operation to start up, begin generating revenue, and move to develop markets without risking a large capital expense. This is especially true for WWC-LWE, since the US market is unproven. Therefore, this report section provides an estimate of the capital expense associated with a pilot-scale facility located in Happy Camp. Note that a minimalist approach was taken in the analysis. In other words, it was assumed that labor would be favored over equipment.

The key equipment items and the estimated cost for pilot-scale operation are shown in **Table 4.9**. As the data in the table indicate, the total capital expense is estimated to be $160,000. This includes a $18,000 contingency allowance and $20,000 for a wood excelsior machine. Another $16,500 is for six cement mixers (each having 12 cubic feet of capacity) for mixing the wood wool, cement, water, and sodium silicate. The largest capital expense is $50,000 for a used skidsteer (often called a Bobcat due to the popularity of one model) for moving wood and other raw materials. A larger item is $35,000 for a used mobile crane for lifting and moving finished panels. The remaining capital expenses are for miscellaneous smaller items such as tools for fabricating panels (saws, drills, routers, etc.) and tools for processing the wood raw material (chainsaws, draw knives, etc.)

Several other considerations are important to note. First, it is estimated that one wood excelsior machine operating about 1,500 hours per year will produce enough wood wool material for 20 homes. Similarly, it is estimated that six cement mixers are needed. Each cement mixer has a volumetric capacity of 12 cubic feet. Thus, the total capacity is 72 cubic feet. It is estimated that the wood wool, cement, and sodium silicate mixture's volume prior to placement in the mold is twice that of the panel's volume after curing. Each panel's volume is 72 cubic feet and the mixing time is 15 minutes per batch. Therefore, it is estimated that the total amount of mixture needed for a panel can be processed in about a half hour given 72 cubic feet of capacity among all 6 mixers and running two batches in each mixer. It is believed that half an hour of processing time is short enough that the material will not begin curing too quickly.

Another key assumption related to capital costs and pilot-scale operation is that it is assumed that one of the existing buildings at the site of the former sawmill in Happy Camp will house the operation. This approach allows the pilot-scale operation to avoid the capital expense of purchasing land and buildings. As further described in the operating cost section, a lease fee is included for using the existing site and buildings. It is expected that the cement mixers are all mobile and therefore do not need to be affixed to the building. The wood excelsior machine, however, should be fixed to the building to prevent vibration. The expense for this is expected to be minimal. Finally, note all of the preceding estimates are based on an initial review new equipment vendor websites and used equipment suppliers. Any subsequent feasibility analysis and preliminary engineering will require a deeper analysis to more fully estimate the capital costs and other costs for transporting and installing equipment.

Finally, wood products manufacturing operations typically have a truck scale and equipment for unloading logs from trucks. None of that equipment is assumed for this pilot-scale operation. Rather, it is assumed the logs will be delivered by self-loading/unloading trucks. Also, the volume on each truck will be determined either by a volumetric measurement, or some other method agreed between the pilot-scale plant and the supplier.

Table 4.9—Estimated Capital Expenses for a Pilot-Scale WWC-LWE Operation

Capital Expense ($)	Capital Expense Item
20,000	Wood excelsior machine
16,500	Cement mixers
35,000	Mobile lift crane (used)
50,000	Skidsteer (used)
5,000	Molds
5,000	Panel fabrication equipment
3,000	Log processing equipment
2,500	Office supplies
5,000	Other miscellaneous supplies
142,000	***Subtotal***
18,000	Contingency
160,000	***Grand Total***

Figure 4.6 provides a representative illustration of typical equipment. From the top of the figure and moving clockwise the items include a mobile lift crane, cement mixers, wood excelsior machine, and skidsteer. Note that the figures are only meant to depict the types of material that will be purchased. The actual equipment items purchased will differ. Also note that the wood excelsior machine and cement mixers all operate on electrical power. None of the motors on the equipment items are overly large. Given that, and the industrial nature of the operations formerly operating on the site, it is assumed that the available electric service will be able to operate all the equipment.

Figure 4.6—Representation of Key Equipment Items (actual items purchased will differ)

Wood Wool Cement Manufacturing Ongoing Operating Costs

Labor—By far the largest operating cost for the WWC-LWE operation is wages and salaries for the people working at the facility. For the pilot-scale plant, it has been assumed that there will be three hourly laborers paid $27.50 per hour with 40% fringe costs for expenses such as insurance, workers' compensation, Social Security, Medicare, etc. Those workers will handle receiving and storing raw materials, and preparing raw material for processing. Note that for wood, this will include debarking the stems and cutting them into shorter lengths for processing on the wood wool manufacturing equipment. As previously stated, the approach in this pilot phase is using labor rather than equipment. Thus, the debarking, cutting pieces to shorter lengths, and placement of the pieces into wood wool machines are all accomplished by hand. Additionally, there will be one manager who is compensated with a salary of $100,000 per year and 40% fringe loading. The fully loaded annual cost for all hourly labor and salary is estimated at $294,000 per year.

All four staff members will work together to convert the raw materials into WWC-LWEs. For example, it is expected that for about two-thirds of each day, the work will focus on preparing the wood raw material and converting it into wood wool. The balance of each day will be focused on mixing the wood wool with cement and other materials, placing the mixture into the molds, removing cured panels from molds, and fabricating the molds to accommodate cutouts for doors, windows, plumbing, electrical, etc. As previously described, to produce enough material for constructing 20 homes per year, the operation will need to average production of 1.7 panels per day. Given this goal and the productivity of the equipment, it is believed that this staffing level will be able to achieve the required production.

Power—The wood wool machine and the cement mixers all operate on electrical power. It is estimated that the machines will consume 31 megawatt hours of power per year. Assuming a power cost of $275 per megawatt hour, this translates into an annual power cost of $8,438.

Site Lease—As previously described the former sawmill site in Happy Camp has buildings and space that are appropriate for meeting the needs of the pilot-scale WWC-LWE plant. It has been assumed that the site can be leased for an annual fee of $24,000.

Miscellaneous Supplies—It is assumed that the cost of miscellaneous supplies is $7,500. This includes the cost for items such as fuel and oil for rolling stock and saws, gloves and safety equipment for workers, parts for equipment saws and rolling stock, etc.

Repair and Maintenance—Repair and maintenance costs are estimated at 10% of capital cost, which would equal $16,000. The assumption used here is consistent with the repair and maintenance cost levels, relative to capital expense, experienced at a variety of forest products manufacturing operations.

General and Administrative—G&A expenses are estimated at $15,000 per year. They include expenses for items such as property and liability insurance, office expenses, etc.

Depreciation—Depreciation is calculated based on a 10-year straight-line depreciation schedule and a $160,000 capital expense. This translates into a $16,000-per-year depreciation expense.

4.2.5 Wood Wool Cement Manufacturing Financial Analysis

Given all the preceding estimates of capital costs, raw material costs, and operating costs, the pro forma income statement shown in **Table 4.10** provides an estimate of the operation's financial performance. As the information indicates, the operation provides a positive cash flow and is projected to pay back the capital investment in just under a year. Note that the sales value of $22.50 per cubic foot for finished panels is based on two assumptions. The first is that it provides about a 16% margin over the estimated costs. The second is that at a cost of $22.50 per cubic foot per panel, the estimated cost for the panels when installed in a structure will be cost-competitive with other forms of building construction such as conventional stick-built homes.

Table 4.10—Pro Forma Income Statement Financial Projection

Revenue/Cost Category	Annual Volume (FT3)	Dollars/Year	Dollars/FT3
Revenue			
WWC-LWE panels	***30,960***	***696,600***	***22.50***
Raw Material Costs			
Wood	30,960	6,332	0.20
Water	30,960	480	0.02
Cement	30,960	55,404	1.79
Accelerant	30,960	8,100	0.26
Mold Oil	30,960	275	0.01
Raw Material Cost Subtotal	***30,960***	***70,591***	***2.28***
Operating Expenses			
Staffing – Hourly Labor	30,960	231,000	7.46
Staffing - Manager Salary	30,960	140,000	4.52
Site Lease	30,960	24,000	0.78
Power	30,960	8,438	0.27
Supplies	30,960	7,500	0.24
Repair & Maintenance	30,960	16,000	0.52
General & Administrative	30,960	15,000	0.48
Depreciation	30,960	16,000	0.52
Subtotal Operating Expense	***30,960***	***528,529***	***19.35***
Annual Operating Margin	30,960	168,071	5.43
+ Depreciation	30,960	16,000	0.52
= Annual Operating Cash Flow	30,960	184,071	5.95
Simple Payback Period in Years (Capital Expense divided by Operating Cash Flow)		0.87	

4.2.6 Wood Wool Cement Manufacturing Feasibility Analysis Conclusions & Recommendations

The key conclusions and recommendations that can be drawn from the preceding feasibility analysis are:

- The business appears feasible from technical and economic perspectives. However, there are number of issues where uncertainty exists. BECK recommends development of a pilot-scale operation to better assess and identify these issues. Careful monitoring and reflection on the pilot-scale operational experience will reduce the uncertainty and risk associated with ramping a WWC-LWE operation up to full industrial scale.

- Areas of with the highest levels of uncertainty and recommended mitigation actions include:
    - U.S. and California building codes do not currently accept the use of WWC-LWEs as structural elements in buildings. However, the material has been successfully used in Europe for decades and there are groups that have made progress on this issue in Arizona and Oregon. A critical element in the next phase of planning and business development is working with local building code officials to educate them on WWC-LWEs and ultimately gain approval for the material's use in Happy Camp.
    - There are a variety of "recipes" for mixing wood wool and cement. Variables include species, wood moisture content, cement type, wood wool strand size, and the relative proportions of wood, water, cement, and curing accelerant. An objective of the pilot-scale operation should be identifying a mixture of wood wool and cement that produces panels with the desired characteristics. Additionally, once an appropriate mixture is identified, processes and procedures must be standardized so that important product attributes such as strength, size, shape, color, weight, etc. are consistent during production.
    - Given the assumed sales price of $22.50 per cubic foot, preliminary calculations indicate that the installed cost for exterior walls in a home using WWC-LWE material is cost-competitive with conventional stick-built processes. However, to better understand the relative costs between WWC-LWEs and conventional materials, the pilot-scale operation must carefully track WWC-LWE production and installation costs to provide a more rigorous comparison between a WWC-LWE home and a stick-built home.
    - The pilot-scale operation is very labor-intensive. Therefore, a total of four staff were included to produce a relatively small volume of material. It is judged that a staff of four provides an adequate amount of labor, but there is some risk that an additional person is needed. Hiring additional help is an option, especially in the pilot stage where the main objective is proving the product's utility and market acceptance. While a full-scale industrial WWC-LWE business has not been modeled, it is reasonable to believe that the per-unit manufacturing costs will be lower if and when a full-scale manufacturing operation is launched.
    - Since concrete begins curing after it is removed from a mixer, there is a time window during which the material can be placed into molds. There is also a significant amount of wood wool and concrete that need to be mixed to form a panel. However, to avoid purchasing a costly large cement mixer, the plan is for the operation to rely on several smaller mixers. While the number of mixers is judged to be adequate, there may be a small risk that the mixers cannot produce enough material to fill a mold before some curing begins to occur.
    - The financial modeling did not include any allowance for working capital and assumed that there is enough demand for homes made from this material that the facility could run at full capacity. Any subsequent planning efforts should include an allowance for working capital so the business can ramp up production over time and include sensitivity analysis related to the manufacturing facility operating at less than full capacity.
    - All literature and experience reported by people with firsthand experience indicates that homes constructed with WWC-LWE materials are clean, comfortable, nice places to live. However, this is not known with certainty. Therefore, it is recommended that any individuals involved in further development of this business plan a trip to Europe to experience firsthand buildings made of these materials. This will assure that from an aesthetic perspective, the buildings are appropriate for use in Happy Camp, and ultimately the U.S.
- Some entities have expressed interest in further analysis, planning, and business development for a WWC-LWE operation in Happy Camp. It is recommended that those entities form a team to plan and

fund the next steps in business development. Identifying a team for developing the business and their respective roles is critically important. Another issue is identifying funding and resources for further analysis, planning, and development. Several potential sources of funding include:

- *U.S. Forest Service*—the USFS offers the Wood Innovations Grants Program to stimulate, expand, and support US wood products markets. The Happy Camp project would likely be very competitive in this program given the existence of this supply and feasibility study. Additionally, the project is in a fire-prone landscape and seeks to utilize small diameter trees; all these factors align very closely with the program's goals. The grant application typically opens in mid-October, closes in mid-November, and winners are announced the following spring. Thus, any interested parties would need to move quickly to engage with this program this year. More information is available here: https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation.
- *California Strategic Growth Council*—the Factory-Built Housing Pre-Development Pilot Program is funded with $12 million to fund pre-development activities for factory-built housing manufacturers. It is not clear, however, that the Happy Camp project would directly align with this program's objectives, thus more research is needed. More information is available here: https://sgc.ca.gov/grant-programs/factory-built-housing/.
- *CALFIRE Business and Workforce Development*—this grant program is aimed at strengthening the forest-sector workforce and businesses including funds for business development. However, applications are not currently being accepted for this program and it is not clear whether it will be resumed.
- *U.S. Department of Housing and Urban Development*—HUD offers the Community Development Block Grant Program for Indian Tribes and Alaska Native Villages. The purpose and goal of this program is the development of viable Indian and Alaska Native communities, including the creation of decent housing, suitable living environments, and economic opportunities. Partnering with the Yurok Tribe would not only be key to this program, but also to developing a market for the homes constructed during the pilot phase of business development. See here: https://www.hud.gov/program_offices/cfo/gmomgmt/grantsinfo/fundingopps/ICDBG.
- Private Equity—A variety of private equity contacts have expressed interest in this concept to BECK. They may come forward with support in various ways and at various times as further due diligence in this concept continues.

CHAPTER 5 – APPENDICES

The following sections contain appendices referenced in the body of the report.

5.1 APPENDIX 1 TECHNOLOGY SCREENING RESULTS

The table on the following page shows the detailed scoring for each technology for each criteria.

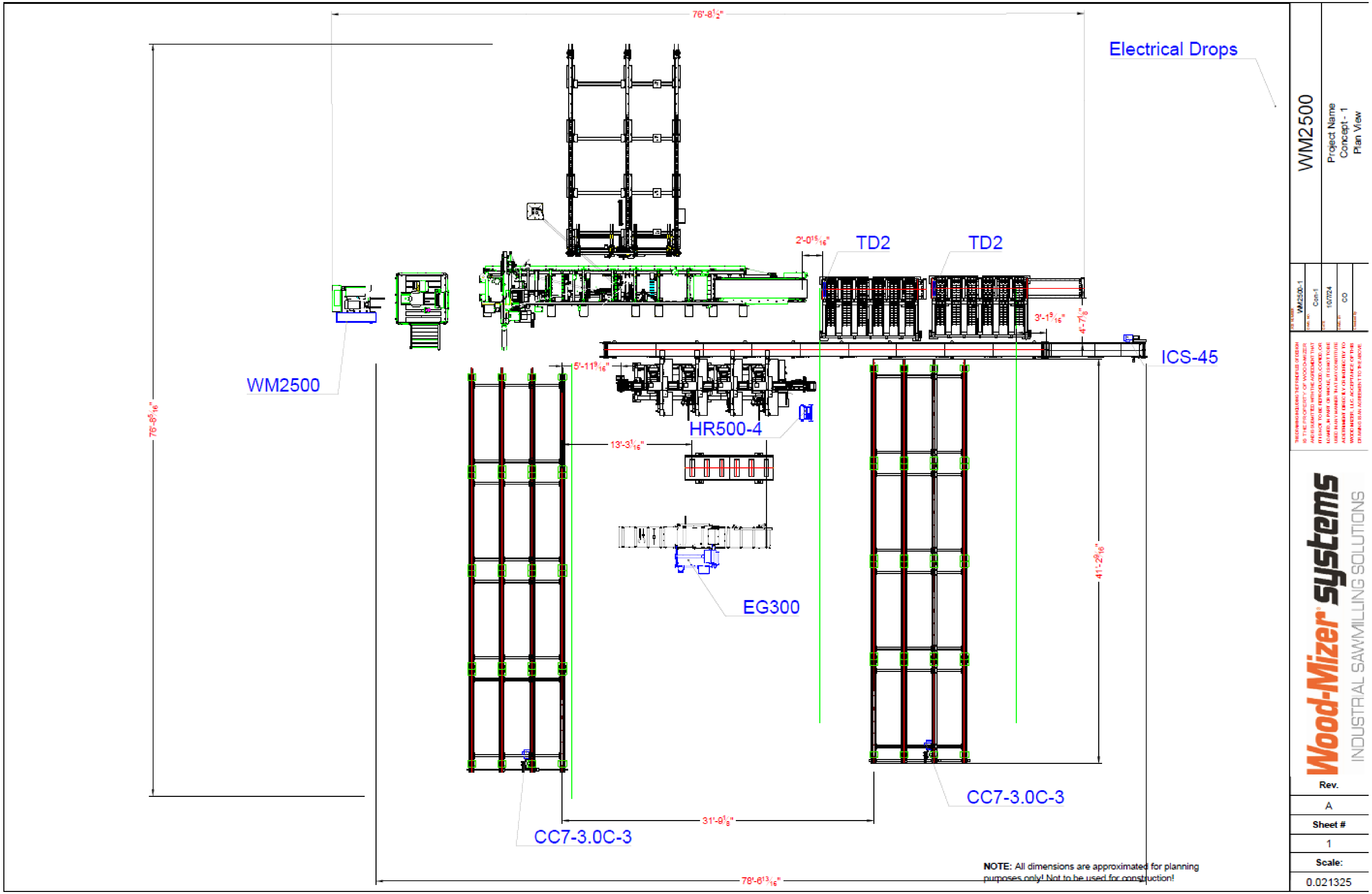
Technology Screening Matrix

Biomass Utilization Technology	The business/technology can be constructed and be operational within 18 to 24 months of receiving financing	The business/technology is such that it has a high likelihood of successfully obtaining required permits, licenses, etc. and they can be obtained within 18 to 24 months of receiving financing	The business/technology can utilize an existing site to help speed the development process & lower development costs	The business/technology will utilize otherwise unused raw materials (i.e., limited competition with existing users or complementary to existing users)	Raw material security - alternate source raw material (e.g., mill residuals) is not available to competitors a substantially lower cost	The business/technology, in a single location, is typically scaled to utilize annually approximately, or can be expanded/replicated to utilize the amount of raw material practically available in the supply region	The business/technology does not require utilization of a specific tree species	The business/technology economic structure is such that it can operate profitably (during the majority of time in an economic cycle) at the delivered raw material costs identified in the supply study	The business/technology is such that the capital costs are at a level relative to revenues and operating costs where the developer can reasonably expect to have a 10 year or less payback period	The business/technology must be able to demonstrate that there is a defined and supportable market segment for the product, with potential demand from multiple customers	The business/technology proposed must have been succesfully demonstrated in a commercial setting, at commercial scale, with similar raw material mix, for at least two years	The business/technology equipment vendors must be able to offer commercial warranties as to performance, environmental compliance and completion, and must be able to bond such warranty through commercial sources	Total Score
Lumber (Small, Specialty Sawmill)	5	6	6	6	10	6	5	12	4	12	14	6	92
Wood Wool Cement	6	6	6	6	10	6	6	12	3	11	14	2	88
Bundled Firewood	6	6	6	6	10	5	6	10	4	8	14	6	87
Posts & Poles	6	6	6	6	8	4	4	12	3	8	12	6	81
Densified Fuel Bricks/Logs	5	6	6	6	0	2	6	8	3	8	14	6	70
Animal Bedding	6	6	6	6	4	4	5	8	2	8	10	5	70
Oriented Strandboard (OSB)	1	2	4	6	8	0	6	12	2	8	14	6	69
Bark/Compost/Mulch	5	5	6	6	2	2	5	7	2	8	10	6	64
Woodstraw	6	6	6	6	3	2	6	7	1	4	8	6	61
Wood Pellets	3	4	6	6	0	2	4	8	1	8	10	6	58
Biomass Combined Heat & Power	2	2	6	6	1	5	6	1	1	1	16	6	53
Wood Fiber Insulation	2	2	5	6	0	0	6	10	2	9	6	5	53
Essential Oils	5	5	6	6	2	4	2	8	3	4	4	3	52
Biochar	5	4	6	6	2	2	6	2	1	2	2	4	42
Liquid Biofuels	1	1	4	6	2	0	6	1	1	4	2	1	29

5.2 APPENDIX 2 WOOD-MIZER LAYOUT DRAWING

The drawing on the following page shows the general arrangement of the sawmill equipment

Wood-Mizer Sawmill Layout Drawing



5.3 APPENDIX 3 WRAVOR QUOTE

The following pages contain a quote for Wravor sawmill equipment as provided by Baileys, a California based supplier of forestry equipment.

Baileys®

WRAVOR® ENGINEERING

10/31/24

Preliminary/Proforma Quotation- Happy Camp 10Meter/33' log length

1. **LOG DECK FOR PASSING LOGS ON THE THE HORIZONTAL BAND SAW – STANDARD VERSION**

2. HORIZONTAL BAND SAWMILL WRC 1250 AC

HORIZONTAL BANDSAW, Tariff code: 84659110	WRC 1250 AC
HEADRIG – positioned straight on the chassis ✓ **Strong and stable construction**: **welded wheels made from cast steel, full profile, wheels are fixed / beared from both sides** which enable stable construction during whole lifespan of band saw; saw head is angled put on the chassis – not the blade to enter with full surface of log but gradually from one side ✓ On each side there are **grinded pillars** with mounted sliding plastics and canals for greasing – enable perfect sliding of sawhead up-down ✓ **Spindles** enable accurate positioning of the band saw which is very important for accurate cut (possible single threaded and double threaded with frequency inverter) ✓ Automatic **hydraulic blade tensioning – protects blade from loosing** ✓ **Hydraulic pressure blade guides** – both guides are moving left-right and pressure blade slightly down to enable optimal cut	
✓ **Hydraulic hand for automatic removing of boards / pushing cut boards** back to exit belt. **additional hand for guiding boards** while exiting to exit belt ✓ **Hydraulic precutter** (follows the shape of log automatically) – extends lifespan of band blade ✓ **Central lubrication of saw head** (two options: manual pump and automatic-electric greasing) ✓ **Main electro** motor – more options of el.power, two start-up options: standard start-up with star delta starter or with frequncy inverter which enable reduced consupmtion of electricity at start, also speed of blade can be controlled which is especially important at cutting hardwood ✓ **Operation system Wravor with V130/280/560, Siemens, Schneider** – enables to operate log deck, band saw and outfeed conveyor only by one man, automatic movement of sawhead up at the end of log and then automatic movement down to the position of cut, many possible options for different sizes of cut and many other options – depending on operation system verson ✓ Electro components: Siemens, Schneider, Danfoss, Sew, Weg	

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capacity m3/8h - it's depending on: log diameter, log length, species of wood, way of sawing,(no.of cuts, no. of log turnings), equipment / confirguration of the saw, competence of operator, quality/condition of blade etc.	up to 55
Max diameter of log, cm (W/H)	125/109
Max lenght of log	10
Main drive motor Kw	75
Frequency inverter for main motor	1
Main wheels – made from **CAST** steel, profile without holes, **STRONG CONSTRUCTION** (fixed with bearings from both side – **STABLE construction**!) 	2
Main wheels - width	135
Diameter of the main wheels	1250
movement of bandsaw up/down – **DOUBLE** THREADED spindels TR 60x9 (18) **WITH FREQUENCY INVERTER**	2
Motor for movement of bandsaw up/down	11 kW
BLADE: PV 40 – stellit, lenght 9045, thickness 1,3mm (stellite), width 160mm	1
STEPLESS MOVEMENT OF MACHINE FORWARD-BACK WITH SEW DRIVE – FLAT ASYNCHRONOUS GEAR A87/GDRL100L 4BE5/TF/ES7S/V (WITH STEEL ROPE)/ASYNCHRONOUS SERVO DRIVE - **fast movement** of sawhead forward-backward - **fast stop of the band saw on particular point and fast start of movement**	1

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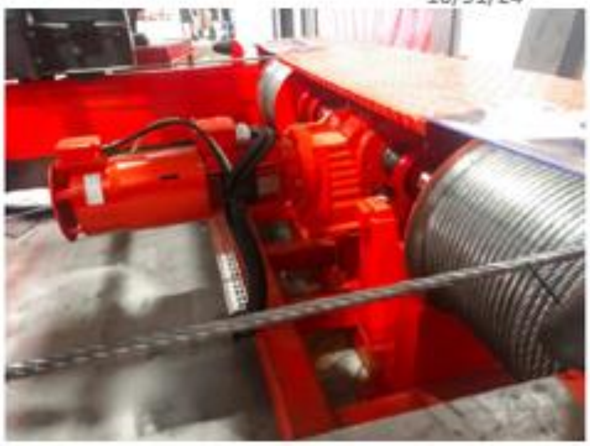

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Operation system: Wravor FastSmartCUT ADVANCED (PLC Schneider Ind. 4.0) with sensors for tracking: sawblade deviation, to follow/measure log length and log diameter  	1
hydraulic generator 40l reservoir with double pump 16+6l and 5,5kW electro motor, complete hydraulic connection 	1
Automatic – **hydraulic tensioning** of blade with plate – springs, that protects from fast loosing of bandsawblade	1
Left **movable hydraulic blade guide – linear pressure guides** Hiwin (made from special material) – enable precise, optimum cutting 	1
Right **movable hydraulic blade guide – linear pressure guides** Hiwin (made from special material) – enable precise, optimum cutting	1

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Hydraulic precutter with automatic taking down from log and deviation 	1
Hydraulic hand - vertical version (Guillotine) for pushing cutted boards back on transporter for boards 	1
additional han/ chains for guiding boards 	1
Separate command board – (with 2 joysticks and PLC Schneider) WITH CABINE (with air conditioning), located at the end of chassis on the podest  	1
Multifunctional joy stick 4 position – for easier and faster operation of sawmill line 	1

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Multifunctional joy stick 4 position – for easier and faster operation of sawmill line 	1
Laser 30mW - GREEN	1
4 cameras with 1 screen  	1 set
Sawdust solution: ventilator with hose which bring sawdust to the belt conveyoer standing alongside bands saw	1
Blade water cooling system with high pressure pump AKKITECH (water must be clean, soft, brought from plumbing to the band saw) 	1
Preparation for logdeck and exit conveyor (on the comand board)	1
Elec. Central greasing (automatic)  	1
RAIL  ✓ The length of sawbed is adjusted to max.log length (with additional equipment on the chassis) ✓ Strong construction, on the top there is profile with special hard resistable material with very lon glife spam (on which sawhead is moving forward-back)	

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 ✓ Fast centrating system of log (in the middle of chassis) with yhdraulic angles or hydralic centrators (moving right-left, up-down) ✓ Hydraulic grip pins with two cylinders are moving up-down, left-right and fix the log on all points regardless the shape of the log ✓ Hydraulic rollers – are moving up-down (indivitually or all together) and moving back-forward – to be able to level the log on the chassis and to move log forward-back and then to move last board / beam from the sawbed to the exit belt ✓ Hydraulic generator power – three possibilities of power ✓ equipment on the chassis is not fixed directly to steel construction but in between it's composite material (not steel-on steel) – for longer life span (composite material can be changed)	
rails welded (steel frame) - strong construction (length)	Ca 15 m
hydraulic grip with two cylinders – grip pins are moving left-right (grip pins fix the log on the chassis also in the case of curved log on all points) up-down 	7
hydraulic lifting of grip pins	7
mechanic log carrier 	2
hydraulical lifting of logs with driven roller (rollers are moving up-down individually – for levelling the log on chassis, and moving up-down all at together – to transfer last board from chassis to exit belt) 	7
Joint lifting of rollers	1
Hydraulic centrators - fast moving up/down, left-right - for fast positioning of logs in the centre of chassis  	5

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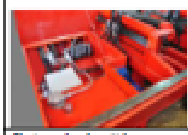
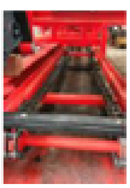
Fast truning system – 'V' log turners 	4
hydraulic generator – 200 l reservoar, 18,5kW electro motor with frequency inverter 	1
flat cabel with energy chain  	1
Outfeed conveyor with belt for boards (l = 4000mm, el.motor 2.2kW drive – one side of conveyor is moving up-down automatically (with sensors) 	1
Scrap conveyor under the chassis and transversal conveyor for waste  	1

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3.EXIT DRIVEN ROLLER CONVEYOR FOR BOARDS with syste for pushing boards/waste left – right

EXIT TRANSPORTER FOR BOARDS with system for pushing boards/waste left – right	1250
length of transporter with roller track	10m
Width (mm)	925
drive gear with electro motor 2,2 kW	4 pcs
driven chain for driven rollers	
protection of driven chains	
compl. of chain sorting system left/right drive gear with electro motor 2,2kW	6 pcs
mechanic track left	6 pcs
mechanic tracks right	6 pcs

4.TRANSVERSAL ARMS WITH DRIVEN CHAINS with turning device (to bring boards to infeed conv.to 20-160)

INFORMATIVE PICTURE

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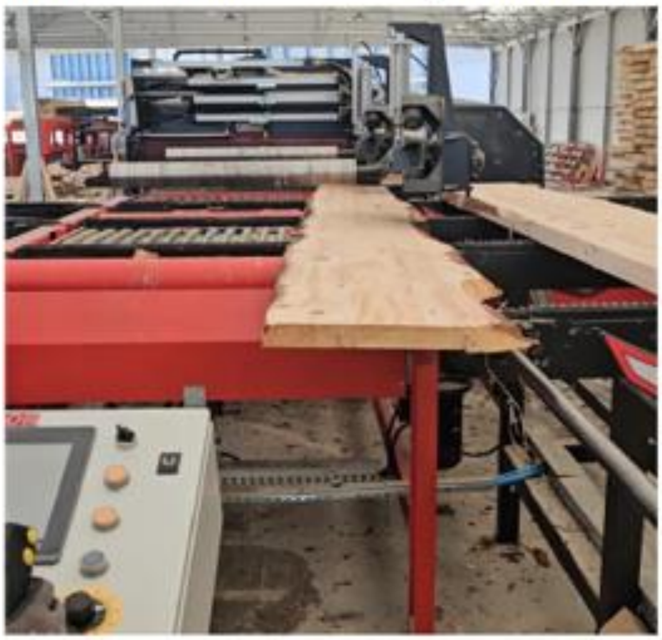
DRIVEN CHAIN TRANSVERSAL CONVEYOR with turning device	
number of automatic transversal arms	6
length of arms	3500mm
drive with el. motor and reduction gear	2.2kW

5.RE-SAW LINE WITH CIRCULAR SAW 20-160 consists of:

- DRIVEN INFEED CONVEYOR (with centration system) (l 5m)



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- MULTIRIP CIRCULAR SAW 20-160 4S


Multiblade circular saw Type 750 20/160 – one fix head, FOUR movable heads – SERVO MOVABLE (WITH ACTUATORS)	
Main motor	55 kW
min./max. cutting height	20mm / 160 mm
max. cut width	800 mm
Max. diameter of circular blade	ø 500 mm
Maksimal number of cutting blades	8 pcs
Maksimal width of cutting board, which goes to machine	1000 mm
6 fix saw blades, 2 together hydraulic moving saw blades left-right (number of saw blades depends on type of wood and height of wood which we intend to cut etc.)	
2 saw blades are included in price of machine	
Maks. paralel cut	600 mm
min. paralel cut	75 mm
6 pieces of driving rollers (4 Pcs lower, 2 Pcs upper)	
Hydraulic moving up and down of upper two driven rollers	
Automatic moving with frequency regulator, el. Motor 3 kW	
hydraulic generator, 9l pump 7 valves +3 kW el. motor	
Opening for sawdust on the top of saw (diameter in mm)	Ø 250
Automatic conveyor for sawdust lenght 2m , el. Motor 0,25kW - under the saw – bring sawdust, waste to longitudinal waste conveyor	1
Laser	5 Pcs
HMI Schnider with Wravor FastSmartCut optimisation program	
Machine includes 4 pc mobile heads +1 fix head with spacer for adjusting blades	

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OUTFEED COVNEYOR WITH SORTING SIDE BOARDS / BA (l11.2m)with BELT UNDERNEATH TO BRING SIDE BOARD ONE SIDE (l ca 4m)

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- **DRIVEN OUTFEED SORTING COVNEYOR WITH EJECTION TO LEFT AND RIGHT SIDE (l 11m)**

INFORMATIVE PICTURE

6. TRANSVERSAL CONVEYOR with STOPPERS

6 arms with driven chains

L: ca 4.5m

7. FLOW ALIGNING FOR BOARDS

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8. CHIPPER LINE

8.1 LONGITUDINAL CONVEYOR FOR SAWDUST AND WASTE – located alongside complete line

Length ca 50m

8.2 CHIPPER

TEHNICAL DATA	CHIPPER	WTA/1/600
	MOTOR POWER:	55kW
	KNIFES:	3 SECTION KNIFES
	INFEED:	600 mm
	DIMENSIONOF CHIPPS :	FROM 15 To 25mm
	MAX WOOD INFEED:	600 x 200mm
	INFEED MOTOR POWER	2 PCS. x 3 kW

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8.3 SEPARATION CONVEYOR FOR CHIPP AND SAWDUST

Length: ca 5m

Pricing Delivered to Happy Camp, Calif. $1,077,500 plus applicable taxes

Terms / Conditions

- *This offer (including photos) has informative status for customer. Final specification will be developed after receiving order from customer/after confirming tech. specification. End specification and drawing of sawmill line must be confirmed by the customer prior to starting production.*
- **Payment:** prepayment:
  50%: advance payment with confirming technical spec's, commercial terms, layout
  50%: prepayment before dispatch
- **Dispatch term:**apx 5-6 months after receiving deposit/ prepayment, confirming tech.specification and layout
- **Offer is valid** till: NOV 15-2024
- **Installation available upon request/additional cost.**

Sincerely,

Jim Haas
Industrial Sales Manager @ Bailey's
Cell-530-906-2466 / email jhaas@baileysonline.com

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Wravor Sawmill Layout Drawing