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Timber Use, Processing Capacity and Capability of Mills to Utilize Timber by Diameter Size Class Within the Arapaho & Roosevelt National Forests Timber-Processing Area

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Introduction

Insect and disease outbreaks in the central Rocky Mountains reached epidemic levels in the last two decades resulting in vast stands of dead trees across parts of Wyoming, Colorado and South Dakota. In the counties where the Arapaho & Roosevelt National Forests (NF) are located, annual mortality across all ownerships from insect and disease on timberland[1] is estimated to be 1,426,157 hundred cubic feet (CCF), accounting for 96 percent of total annual mortality in the study area (USDA, 2018). In comparison, fire, logging and other human caused mortality accounts for 1.3 percent; remaining mortality is from other (i.e. weather, animals, vegetation) or unknown causes (USDA, 2018). The states and the U.S. Forest Service have increased investments in forest health, hazardous fuels mitigation and safety protection on private and public lands (Wyoming State Forestry Division 2017; State of Colorado 2017; USFS MBRNF 2017). These treatments, designed to restore ecological condition and function and reduce fire hazard often require the removal of a mix of timber valuable enough to offset some of the costs along with smaller trees with limited value and markets (Wagner et al. 2000). The loss of milling infrastructure throughout the West during the 1990s and 2000s, combined with changing management objectives on federal lands, has raised questions about the industry's ability to purchase and use timber of varying sizes and quality at a rate adequate for forest management goals and economically sustainable for the industry (Keegan et al. 2005; Keegan et al. 2006). The expressed need to treat millions of acres in the western United States to meet management objectives has made accurate information on timber milling capacity and the capability of mills to handle timber of various sizes an important consideration for managers.

[1] Timberland: Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing at least 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Goals and Objectives

This report was prepared by the Forest Industry Research Program at the University of Montana's Bureau of Business and Economic Research (BBER) as a forest planning support document for the Arapaho & Roosevelt NF and seeks to:

1. examine the harvest of timber from the counties containing the Arapaho & Roosevelt NF timberland – the "study area";
2. analyze the timber flow and identify the Arapaho & Roosevelt NF "timber-processing area" – the counties containing facilities that received timber harvested from the study area; and
3. describe the number and types of facilities and quantify their total capacity to process timber, their capability to use timber of various sizes, and their use of timber. The study focuses on facilities that exclusively use timber in round form (i.e., logs). Facilities that use only mill residuals (e.g., sawdust or chips) are not included.

Definitions and Methods

This analysis is based on 2016 data for Colorado mills (Hayes et al. in press) and 2018 data for Wyoming mills (Marcille et al. in preparation) and follows the methods outlined in the Region 2 region-wide report (Simmons et al. 2019). When 2016/2018 data for a mill were not available, prior (2012/2014 or 2007/2010) data were used as a baseline and adjusted to reflect 2016/2018 harvest and market conditions. Mill survey data from Hayes et al. (in press), USFS Cut and Sold reports (USFS 2016/2018) and conversations with mill owners, were used to analyze timber harvest and flow from all ownerships within the study area (i.e., the counties containing Arapaho & Roosevelt NF timberland).

The Arapaho & Roosevelt NF timber-processing area (TPA) includes the counties in the study area as well as counties containing mills that received timber from the study area during 2016/2018. If historic (2012/2014) mill survey data indicated a substantial flow of timber into a

county, the county would be included in the TPA even if recent (2016/2018) flows were relatively small or non-existent. Finally, all other counties receiving timber from the study area were included if the volume from the study area represented more than 10 percent of the total timber received in that county.

In this report, "capacity" refers to the total volume of timber (a.k.a., roundwood or logs) that timber processors could utilize annually. Also known as "timber-processing capacity", it is a measure of input capacity and generally expressed in board feet Scribner or cubic feet. Input capacity is a useful measure when attempting to express the capacity of multiple types of mills in a common unit of measure because finished products (mill outputs and output capacity) are measured in a variety of units: board feet lumber tally for lumber, lineal feet for house logs, and pieces for posts, small poles, and log furniture. Input or timber-processing capacity is a measure of the volume of logs that a facility can process in a given year, given firm market demand and sufficient raw material for all shifts and products produced. Estimates in this report include the capacity of facilities that use timber in round form; this includes sawmills and facilities processing timber into house logs, log homes, posts, poles, log furniture, excelsior, fuel pellets, firewood, and landscaping chips.

In contrast, "capability" refers to the volume of trees of a certain size class (measured as diameter at breast height – dbh) that timber processors can *efficiently and economically* process annually. Most facilities are designed to operate using trees of a given size class. For example, log home manufacturers typically use trees ≥ 10 inches dbh, and post manufacturers primarily use trees < 8 inches dbh. Capability at these facilities is readily classified in a single size class. This is true for some sawmills, but sawmills can vary greatly in equipment, configuration, product output, and ability to process timber of various sizes (Wagner et a. 1998, 2000; Keegan et al. 2005, 2006; Stewart et al. 2004).

For each mill in the TPA, an estimate of the mill's capability to process timber of a given size was made based on literature (Wagner et a. 1998, 2000; Keegan et al. 2005, 2006; Stewart et al. 2004), conversations with mill owners and the most recent BBER mill census data, taking into consideration the financial feasibility and physical characteristics of the mill. For this report, three tree size classes were used: <7 inches dbh, 7-9.9 inches dbh, and ≥10 inches dbh.

BBER researchers first assigned capability to efficiently process timber in the <7 inch and 7-9.9 inch dbh classes. Capability to process trees ≥ 10 inches dbh was then calculated as the remaining proportion of total capacity *not* capable of efficiently using trees <10 inches dbh. Total timber-processing capacity and capability by dbh class are presented in both hundred cubic feet (CCF) and thousand board feet Scribner (MBF) to facilitate discussion among national forest managers, timber purchasers, and wood products facility operators.

Arapaho & Roosevelt National Forests Study Area

The Arapaho & Roosevelt NF study area is situated in the north central region of Colorado, spreading over seven counties (figure 1). The Arapaho & Roosevelt National Forests are administratively combined with the Pawnee National Grassland, which was not included in the study area because it does not include any timberland. The resulting study area contains approximately 1.8 million acres of timberland (USDA, 2018), of which 62 percent (1,114,638 acres) is managed by the US Forest Service (table 1). Approximately 12 percent of the timberland on the Arapaho & Roosevelt National Forests are considered suitable for timber production[2] (Sidon 2019).

Table 1 – Acres of timberland[1] by county and ownership in the Arapaho & Roosevelt NF Study Area.

County	National Forest	Private	Other Federal	State	Other Public	Total
Boulder	89,006	70,195	6,952	—	13,160	179,313
Clear Creek	61,430	22,858	—	10,620	5,715	100,623
Gilpin	20,606	27,475	—	—	—	48,081
Grand	403,416	97,421	37,734	6,418	6,559	551,548
Jefferson	81,802	101,336	—	12,095	41,413	236,646
Larimer	343,474	154,573	6,230	19,606	1,649	525,532
Summit	114,904	35,416	—	—	6,319	156,639
Grand Total	1,114,638	509,274	50,916	48,739	74,815	1,798,382

[1] Timberland: Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing at least 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Source: USDA Forest Service, Forest Inventory and Analysis Program, Tue Dec 18 20:21:21 GMT 2018. Forest Inventory EVALIDator web-application Version 1.8.0.00. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Northern Research Station. [Available only on internet: http://fsxopsx1056.fdc.fs.usda.gov:9001/Evalidator/evalidator.jsp]

[2] Lands suited for timber production – Area that defines where timber harvest for the purpose of timber production may occur. Timber harvest for purposes other than timber production may also occur here.

The total volume of timber harvested and utilized from all ownerships in the study area was estimated at 46,933 CCF (17,130 MBF) in 2016/2018 (table 2). Timber harvested from national forest timberlands in the study area accounted for 64 percent (30,205 CCF) of the timber harvested in the study area's seven counties. Private timberlands accounted for 23 percent (10,862 CCF) of the timber harvested in the study area. Timber from the Arapaho & Roosevelt NF was estimated to account for approximately 68 percent (20,408 CCF) of the National Forest timber and 43 percent of the total harvest for the study area. The species composition of the timber harvested in the study area was lodgepole pine (89 percent), ponderosa pine (5 percent), spruce (4 percent), with smaller volumes of subalpine fir, Douglas fir, aspen and Cottonwood (Hayes et al. in press; Marcille et al. in prep; Simmons et al. 2019).

Table 2 – Timber harvest by county and ownership Arapahoe Roosevelt NF Study Area, 2016-2018.

County	National Forest	Private	BLM[1]	State	Other public	Grand Total
	Hundred cubic feet (CCF)					
Boulder	682	—	—	—	1,416	2,099
Clear Creek	252	—	—	—	—	252
Gilpin	—	—	—	—	—	—
Grand	12,795	6,397	3,132	1,068	—	23,392
Jefferson	510	—	—	—	—	510
Larimer	959	2,308	—	63	186	3,516
Summit	15,008	2,156	—	—	—	17,164
Total	30,205	10,862	3,132	1,132	1,603	46,933

[1] Bureau of Land Management

Source: Hayes et al. (in press); Marcille et al. (in preparation); Simmons et al. 2019.

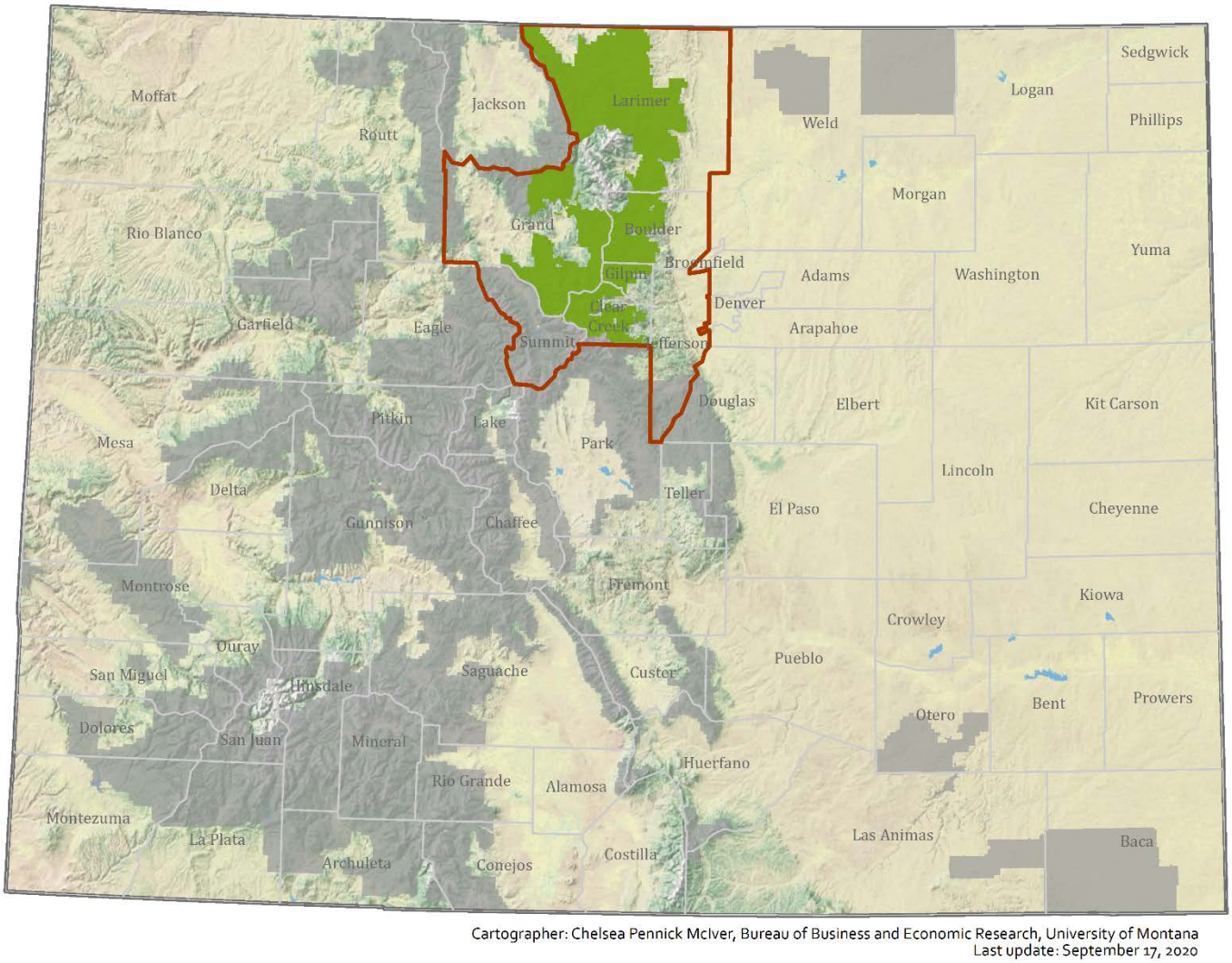

Figure 1 – Arapaho & Roosevelt National Forests and Study Area

Arapaho & Roosevelt NF Timber-Processing Area

A national forest's timber-processing area (TPA) establishes the geographic region *potentially* influenced by timber harvested from that forest by analyzing the *flow of timber harvested* from all ownerships within the study area. The analysis also describes the area and extent to which timber processors are dependent upon the timber harvested in these counties, and federal timber more specifically.

The Arapaho & Roosevelt NF TPA is made up of 16 counties. In addition to the seven Colorado counties in the study area, seven other Colorado counties and two Wyoming counties with timber-processing facilities received timber from the study area in 2016/2018 (figure 2). Montrose County, which is home to the state's largest sawmill, was included due to more recent timber flow patterns. Within the Arapaho & Roosevelt NF TPA there were 29 facilities operating as during 2016/2018 (table 3). The authors suggest that Arapaho & Roosevelt NF managers (e.g., timber sale administrators and forest planners) contact the facilities in the TPA to verify their current operating status as specific projects are being developed.

Table 3 – Active timber-processing facilities in the Arapahoe Roosevelt NF, 2016-2018.

Type	**2016, 2018**
Sawmills	12
Post/poles	6
Houselogs	5
Log Furnuture	3
Pellets	2
Other products	1
Total	**29**

Source: Hayes et al. (in press); Marcille et al. (in preparation); Simmons et al. 2019.

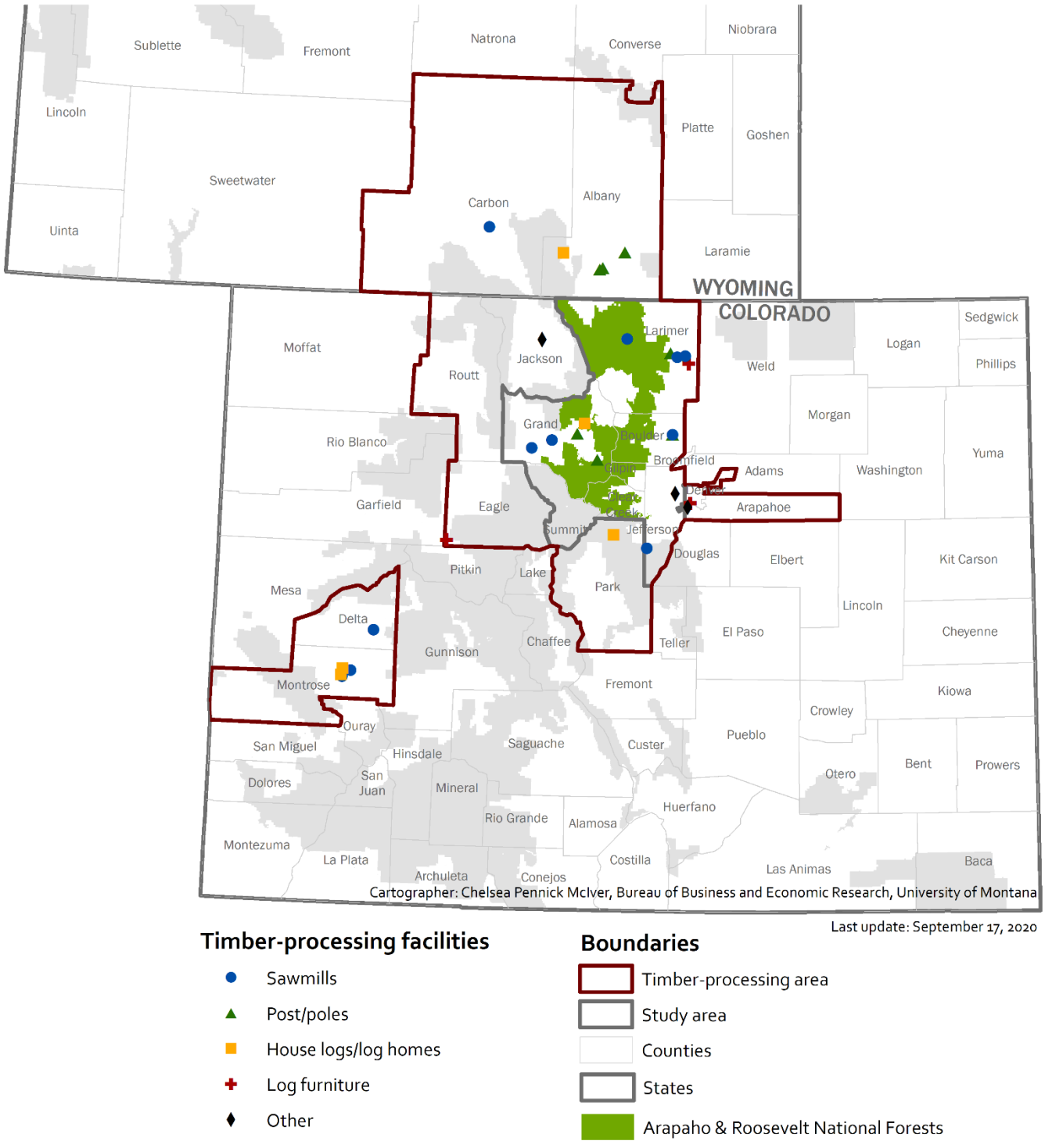

Figure 2 – Timber-processing facilities in the Arapaho & Roosevelt NF TPA by type.

Timber Flow

Of the 17,131 MBF (46,933 CCF) of timber harvested in the Arapaho & Roosevelt NF study area in 2016/2018, 43 percent (20,055 CCF) was processed in the county of harvest, 31 percent (14,710 CCF) was processed elsewhere within the study area, and 26 percent (12,168 CCF) was processed outside the study area but within the Arapaho & Roosevelt NF TPA (table 4). Nineteen of the 29 active facilities in the TPA were located within the study area, most of the remaining facilities were in adjacent or nearby counties in Colorado. Facilities within the study area processed 34,764 CCF (12,689 MBF), or 74 percent, of the timber harvested in the study area. These facilities processed 81,688 CCF (20,307 MBF) of timber from all ownerships and geographic origins. Approximately 62 percent of the timber processed in the study area came from the Arapahoe & Roosevelt NF and other National Forest timberlands. Private timberlands supplied the majority of the remaining timber. This flow of timber indicates that landowners within the study area relied on facilities within the immediate area to purchase the majority of their timber and that facilities in the study area had a strong reliance on Federal timber overall in 2016/2018.

Table 4 - Timber flow from the Arapahoe Roosevelt NF Study Area, 2016/2018.

County of harvest	Processed within the county of harvest	Processed elsewhere within study area	Processed outside study area
	percentage of harvest by county		
Boulder	—	100	—
Clear Creek	0	100	—
Gilpin	—	—	—
Grand	73	6	22
Jefferson	100	—	—
Larimer	72	—	28
Summit	—	64	36
Total	43	31	26

Source: Hayes et al. (in press); Marcille et al. (in preparation); Simmons et al. 2019.

Note: — denotes less than one percent.

Timber-Processing Capacity and Capability

Capacity to process timber in the Arapaho & Roosevelt NF TPA during 2016/2018 was 391,823 CCF (148,042 MBF) (figure 3). Capacity within the study area was 91,670 CCF (24,635 MBF)--23 percent of the total capacity in the TPA. Timber owners, particularly the Arapaho & Roosevelt NF, had a strong reliance on the facilities within the study to purchase their timber while facilities in the study area received timber from the TPA's broader timber market to source nearly 42 percent of the raw material for their products during 2016/2018.

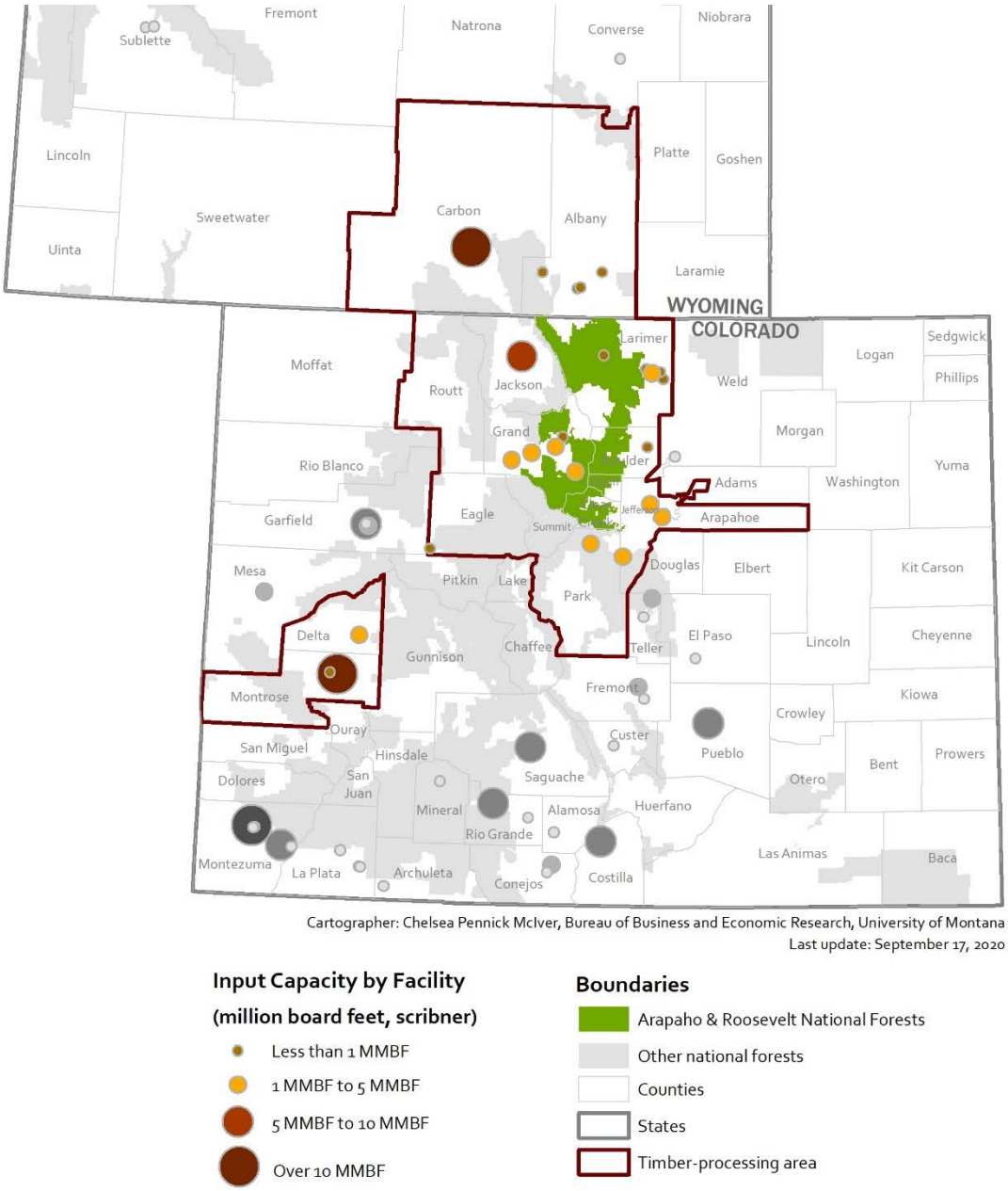

Figure 3 – Regional timber-processing facilities and input capacity

The author's estimate that nearly 61 percent (239,627 CCF or 105,429 MBF) of timber-processing capacity in the Arapaho & Roosevelt NF TPA is not capable of efficiently utilizing trees < 10 inches dbh (table 5). Capability to efficiently utilize trees 7-9.9 inches dbh accounts for 21 percent of total timber-processing capacity; while 18 percent of total capacity in the TPA can efficiently utilize trees < 7 inches dbh.

Table 5 – Annual capacity and capability of mills to process trees by size class for the Arapaho & Roosevelt NF TPA, 2016, 2018.

Hundred cubic feet (CCF)		*Thousand board feet, Scribner (MBF)*	
Tree dbh	**Capability**	**Tree dbh**	**Capability**
< 7 in.	69,545	< 7 in.	14,096
7 - 9.9 in.	82,650	7 - 9.9 in.	28,517
≥ 10 in.	239,627	≥ 10 in.	105,429
Total capacity	**391,823**	**Total capacity**	**148,042**

Source: Hayes et al. (in press); Marcille et al. (in preparation); Simmons et al. 2019.

Table 6 shows that mills in the TPA processed 264,518 CCF (96,348 MBF), indicating that approximately 68 percent of total capacity (on a cubic foot basis) within the TPA was utilized. Overall, national forests supplied 74 percent (about 195,314 CCF or 71,141 MBF) of the timber processed in the TPA of which 10 percent was from the Arapaho & Roosevelt NF. This suggests there is a strong dependence by the mills in the TPA on timber from multiple national forests, and a reciprocal dependence by the national forests on those mills. Trees with dbh ≥ 10 inches comprised 61 percent of the volume processed in the TPA. About 21 percent came from trees 7-9.9 dbh, while the remaining 18 percent was made up of trees < 7 inches dbh.

Table 6 – Annual volume of timber processed by tree size class for the Arapaho & Roosevelt NF TPA, 2016.

Hundred cubic feet (CCF)		*Thousand board feet, Scribner (MBF)*	
Tree dbh	**Volume used**	**Tree dbh**	**Volume used**
< 7 in.	46,800	< 7 in.	8,357
7 - 9.9 in.	56,026	7 - 9.9 in.	16,352
≥ 10 in.	161,691	≥ 10 in.	71,638
Total processed	**264,518**	**Total processed**	**96,348**

Source: Hayes et al. (in press); Marcille et al. (in preparation); Simmons et al. 2019.

At 67 percent utilization in 2016/2018, there is moderate unutilized capability, primarily at sawmills and houselog facilities, to process trees ≥ 10 inches dbh (77,997 CCF or 33,809 MBF). Approximately 68 percent of the capability to process trees < 10 inches dbh was used in 2016/2018 resulting in unutilized processing capability of 49,369 CCF or 17,903 MBF. Capability

in the < 7 inch dbh class had a utilization rate of 67 percent indicating unutilized capability of 22,745 CCF or 5,739 MBF. Available capability to process trees < 7 inch dbh is about 18 percent of the total unused capacity. Planning large scale or large numbers of treatments with substantial volumes of trees in this size class could strain or exceed the ability of the current infrastructure to profitably use the material without investments to increase capability.

Discussion

Two of the largest sawmills in the Rocky Mountain Region are located within the Arapaho & Roosevelt NF TPA. These facilities, combined with houselog processors, account for a considerable amount of the processing capability for trees ≥ 10 inches dbh. Many sawmills in the region have some capability to use trees 7–9.9 inches dbh. However, the feasibility and profitability of using smaller trees, primarily those in the 7-9.9 inch dbh class, is improved with green trees, since more lumber can be recovered and operating costs are lower with live trees than dead or salvaged trees. Similar relationships among log size and log quality for live versus dead trees relative to value have been documented by Fahey et al. (1986) and Loeffler and Anderson (2018).

As in most of the interior west, some (4 of 12) smaller sawmills in the Arapaho & Roosevelt NF TPA produce other products (e.g., firewood, posts, animal bedding, or pellets) in addition to lumber. This product diversification has augmented their capability to use smaller trees. When these multi-product sawmills are combined with facilities making other products (e.g., posts/poles, firewood, or chips) using trees in the < 10 inch dbh classes they account for 73 percent (110,560 CCF) of the capability in the < 10 dbh classes, roughly split between trees 7-9.9 inches dbh and trees <7 inches dbh. However, 78 percent of that capacity was utilized in 2016/2018. Capability to process trees < 7 inches dbh tends to be concentrated among facilities that produce only posts, small poles, chips, mulch, shavings and log furniture. Considering that it is less capital intensive (i.e. less expensive) to increase post and pole capacity than to re-fit a larger sawmill to process smaller diameter logs into lumber, with sufficient markets and timber supplies some facilities may consider making the investments to increase capabilities to process

trees < 7 inches dbh. Some of these smaller facility operators expressed the sentiment that recent federal opportunities (e.g. timber sales and stewardship projects) favor larger contracts, which are not economically viable for the smaller operators to bid on and thus can be a barrier to engaging more of this small-tree capability.

While the Arapaho & Roosevelt NF TPA has unutilized capability to process small-diameter timber, some sawmill operators have already reported using greater volumes of small diameter timber than they felt was financially sustainable for their operation. This is likely a reflection of the national forests and other land owners wanting to remove substantial quantities of small trees as part of efforts to reduce fire hazard, conduct forest restoration, and mitigate the impacts of widespread tree mortality. When considering removing trees from the landscape, land managers should balance their need to remove small and/or dead trees with the local industry's ability to profitably use that material. Offering larger quantities of small and/or dead trees than the industry can profitably use may lead to unsold sales and fewer acres being treated.

Facilities within the study area used 74 percent of the timber harvested in the study area yet pulled approximately 42 percent of the timber they processed from outside the study area, mostly from other National Forests. Capacity to process timber in the study area was 91,670 CCF in 2016 and overall capacity utilization was 90 percent. This observation suggests that for the right mix of timber by size and species more of the timber harvested at current or increased levels in the Arapaho & Roosevelt may be able to be sold to facilities within the study area thus keeping the economic benefits of timber harvested locally in the local economy.

A final note, many of the facilities throughout Region 2 are included in the timber-processing areas of more than one National Forest. So the sum of the capacity and capability of all the individual National Forests is greater than the total for the region. Although unused capacity for trees < 7 inches dbh in the timber processing area was approximately 22,745 CCF, suggesting the extent to which timber harvests for the size class may be increased and not

exceed existing processing capabilities, that unused capacity is shared with the TPA's of other National Forests in Region 2. The region wide report provides information on total capacity and capability for the whole region. We encourage coordination at the Regional, Forest, and even the district level among timber planning staff to share information about prospective projects and potential buyers to prevent offering more timber in certain size classes than can be processed.

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