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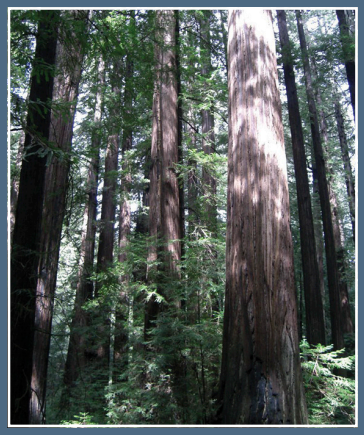
California's Forest Products Industry and Timber Harvest, 2016

Kate C. Marcille, Todd A. Morgan, Chelsea P. McIver, and Glenn A. Christensen





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Cover: (top row) Multi-age California timber and forestlands, and active California logging site; (middle row) redwood stand in Northern California, decked logs and log sorter in California mill yard, and redwood logs and finished fence boards; (bottom row) mill residual piles at California biomass energy facility, tree tops and logging slash pile, and cants being processed in a California mill. All photos by the University of Montana Bureau of Business and Economic Research.

Abstract

Marcille, Kate C.; Morgan, Todd A.; McIver, Chelsea P.; Christensen, Glenn A. 2020. California's forest products industry and timber harvest, 2016. Gen. Tech. Rep. PNW-GTR-994. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 58 p.

This report traces the flow of California's 2016 timber harvest through the primary wood products industry and characterizes the structure, condition, and economic impacts of California's forest products sector. Historical changes in the forest products industry are presented, as well as trends in timber harvest, production, sawmill capacity, mill residuals, and sales value. Also discussed are employment and worker earnings in the state's primary and secondary forest products industries. Periodic survey data collected from the forest products industry provides detailed information on California's timber resources, wood utilization, and the economic contributions of the industry to the state economy.

Keywords: Bioenergy, employment, forest economics, lumber production, mill residual, mill capacity, wood products, timber harvest, timber-processing facility, wood utilization.

Highlights

- A total of 80 primary forest products facilities operated in California during 2016. These included 32 sawmills, 23 bioenergy plants, 12 bark and mulch facilities, 2 veneer plants, 1 particleboard plant, and 10 manufacturers of other primary wood products.
- California's timber harvest was 1,572 million board feet (MMBF) Scribner in 2016, representing a 10 percent increase since 2012. More than 48 percent (759 MMBF) of the timber harvested came from five counties. Similar to 2012, Shasta County provided the largest proportion at 13 percent (208 MMBF) followed by Humboldt County at 11 percent (178 MMBF).
- About 80 percent of California's 2016 timber harvest came from private lands, 17 percent from national forests, and the remaining 3 percent from other public sources. Nearly all (97 percent) of the timber harvested in California was processed within the state.
- About 27 percent of California's 2016 timber harvest was comprised of true fir species, followed by Douglas-fir (24 percent), ponderosa pine (23 percent), and redwood (14 percent).

- More than 13 percent of the timber harvested in 2016 was dead. California's large-scale tree mortality event during 2015 and 2016 led to increased reporting of dead trees received by timber processors, up from 2 percent in 2012. Ponderosa pine—one of the species most affected by the bark beetle epidemic—saw a 16 percent increase in reported dead volume from 2012 to 2016.
- Converting all inputs, outputs, and mill residuals to cubic feet allows for more complete accounting of wood fiber from harvest through primary processing. Of the 367 million cubic feet (MMCF) of wood fiber (excluding bark) harvested in California in 2016, approximately 43 percent was used to generate energy, usually in the form of heat for steam or electricity. Another 32 percent of the volume became lumber, and the remaining 25 percent was used as raw material for a variety of other products.
- Total sales value for California's primary forest products was about $1.5 billion in 2016, with lumber accounting for 65 percent of the total reported products. The majority (74 percent) of all primary forest products manufactured in California were sold in state. Two sectors—sawmills and bioenergy plants—accounted for more than 83 percent of the industry sales value in 2016.
- California sawmills produced more than 2,000 MMBF of lumber in 2016, accounting for more than 6 percent of U.S. production of softwood lumber and just over 4 percent of U.S. consumption.
- California's forest products industry's annual capacity to process sawtimber has continued to decrease, from 6,000 MMBF Scribner in the late 1980s to 1,870 MMBF in 2016 (up slightly from 1,780 MMBF in 2012). Of this total timber-processing capacity, 73 percent was utilized in 2016.
- In 2016, approximately 57,890 workers, earning $3.64 billion, were employed in California's forest industry, including primary and secondary wood and paper products, private sector forestry and logging, and forestry support activities. Wood products manufacturing accounted for 50 percent of employment and 38 percent of earnings within California's overall forest industry.
- In addition to direct employment and income generated by California's forest industry, the University of Montana Bureau of Business and Economic Research estimated indirect and induced economic contributions for each sector of the industry. For example, the wood products manufacturing sector alone supported more than 66,200 full- and part-time jobs (direct, indirect, and induced) and an associated $3.43 billion in labor income during 2016. For every wood products manufacturing job in California, another 1.3 jobs are supported in a related sector of the state economy.

- California's primary wood-processing facilities produced nearly 2.1 million bone-dry tons (1.75 million bone-dry units) of residuals in 2016. Wood residuals accounted for 72 percent of total residual volume generated by primary processing facilities and bark constituted the remaining 28 percent of residuals.
- Nearly 58 percent of total residuals were utilized by the biomass energy sector, over 31 percent by the landscape bark and other products sector, and 11 percent by the reconstituted board sector; less than 1 percent of mill residuals went unutilized.

Contents

Introduction

This report describes the utilization of California's 2016 timber harvest and characterizes the condition, structure, and operation of the state's primary forest products industry. Primary forest products manufacturers are firms that process timber into goods such as lumber or veneer, and facilities such as biomass power and particleboard plants that use low-value woody biomass removed from harvest sites or wood fiber residuals generated by timber-processing facilities. This report also describes recent and historical trends in the state's timber use, including raw material sources, inventory, growth, and harvest. Other areas covered in this report include the extent and efficiency of California's wood-processing infrastructure and the volume and value of finished products and residuals, as well as employment and sales trends across the forest industry.

A statewide census of California's primary forest products manufacturers provided most of the information presented in this report. The industry census also included firms in adjacent states using raw material from California during the 2016 calendar year. The 2016 California forest products industry report focuses on changes within the state's forest products industry since the 2012 census (McIver et al. 2015). For a more detailed discussion of historical trends in timber harvesting and processing for California, see McIver et al. (2015) and Morgan et al. (2004, 2012).

The University of Montana's Bureau of Business and Economic Research (BBER) and the U.S. Department of Agriculture (USDA) Forest Service, Pacific Northwest (PNW) Research Station cooperated in the analysis and preparation of this report. BBER, in cooperation with the Forest Inventory and Analysis (FIA) program at the PNW Research Station, has been studying the region's forest products industry since 1998. This report represents BBER's fourth such study of California's timber harvest and forest products industry since 2000.

Forest Industries Data Collection System

In cooperation with the FIA programs at the Rocky Mountain and PNW Research Stations, BBER developed the Forest Industries Data Collection System (FIDACS) to collect, compile, and disseminate state and county information on the operations of the forest products industry across the West.

Primary forest products firms operating in California in 2016 were identified through various phone directories, industry associations, Internet searches, previous BBER censuses, and help from in-state cooperators. Through a written or electronic questionnaire, or via a telephone or in-person interview, information was collected from timber-processing and wood residual-utilizing facilities about their 2016 operations. Of the 80 primary wood-processing facilities operating in

California during 2016, about 64 percent responded to the inquiry and accounted for 77 percent of the state's timber harvest volume. Each wood-processing facility completed a single questionnaire, which included the following information:

- Plant location, production capacity, and employment
- Volume and type of raw material received, by county and ownership
- Species mix of timber received and live/dead proportions
- Finished product volumes, types (including energy), sales value, and market locations
- Residual volume produced, and utilization and marketing of wood and bark residuals

For those wood-processing facilities that did not return the questionnaire, a variety of sources were used to estimate values:

- Current data collected for facilities of a similar size, product type, and location
- Information on market trends and prices
- Data from other sources, including the Western Wood Products Association (WWPA 1964–2016) and Random Lengths (1976–2016)

Further, information from federal, state, and private sources was used to verify estimates of the total timber harvest, lumber production, employment, and sales value of products. Manufacturers who participated in the 2016 California forest industry census processed virtually all of the state's commercial timber harvest.

Information collected through FIDACS is stored by BBER. Results and summary tables are available online upon compilation and review (http://www.bber.umt.edu/fir). Key data from other sources are made available online to provide the most recent measures of general industry activity, and references to other publications characterizing forest industry conditions are included. Additional information is available by request. However, individual firm-level data are confidential and will not be released.

California's Timber Harvest, Products, and Flow

This section discusses the ownership of California's timberlands, historical trends in California's timber harvest, and the wood products industry's use of timber during 2016. It presents ownership and geographic sources of timber, species composition, types of timber harvested and processed, utilization of harvested wood fiber, and flow of the timber both within the state of California and from California to other states and countries.

Timber harvest data are available from several sources, including the California Department of Tax and Fee Administration (annual) (CDTFA 2018) and the PNW Research Station (annual and periodic); these sources were used for historical

comparisons. However, the detailed harvest volumes presented in this report for 2016 are the result of a full census of California and out-of-state mills receiving timber harvested in California during 2016, as described in the "Forest Industries Data Collection System" section of this report. Differences may exist between the numbers published here and those published by other sources. These differences are the results of differing reporting units and conversion factors, rounding error, and scaling discrepancies among timber sellers (agencies and private owners) and between sellers and buyers, as well as other reporting variations.

California's Timberlands

California has about 100 million ac of land area, of which 32 million ac (30 percent) are forested. Forest land is defined as "land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and not currently developed for a nonforest use" (Christensen et al. 2015, USDA FS 2019). Of the total forest land in California, private landowners hold 12.3 million ac (39 percent), national forest lands account for 15.3 million ac (48 percent), and other public lands account for 4.2 million ac (13 percent). About 16 million (52 percent) of the 32 million ac of forest land in California are classified as timberland. Timberland is forest land that is producing, or capable of producing, more than 20 cubic feet (ft^3) of wood per acre per year at culmination of mean annual increment and excludes reserved lands, such as national parks and wilderness areas (Helms 1998). Within California, national forests contain 8.8 million ac (54 percent) of timberland, private landowners hold approximately 7.2 million ac (44 percent), and other public landowners, including the U.S. Department of the Interior Bureau of Land Management and state and local governments, hold the remaining 2 percent (less than 1 million ac) (USDA FS 2019).

California's timberland contains approximately 335,000 million board feet (MMBF) Scribner of sawtimber (USDA FS 2015). Sawtimber is timber of "sufficient size and quality to be suitable for conversion into lumber" (Random Lengths 1993). Sawtimber volume is calculated from growing-stock trees that are at least 11 inches diameter at breast height (d.b.h.) for hardwoods, and 9 inches d.b.h. for softwoods. Measured in board feet Scribner, live sawtimber on timberland consists of 92 percent conifers and 8 percent hardwoods. By species, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) accounts for 31 percent of the Scribner board foot sawtimber volume on timberland. Other species contributing the majority of volume on timberland are true firs (*Abies* spp.) (16 percent), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) and Jeffrey pine (*Pinus jeffreyi* Balf.) (18 percent), redwood (*Sequoia sempervirens* (D. Don) Endl.) (10 percent), and sugar pine (*Pinus lambertiana* Dougl.) (5 percent) (USDA FS 2015).

Harvest by Ownership

The timber volume harvested in California during 2016 was nearly 1,600 MMBF Scribner (table 1), an increase of about 10 percent from the 2012 harvest of 1,400 MMBF and 9 percent less than the 2006 harvest of 1,700 MMBF.

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Table 1—California's timber harvest by ownership class, selected years

Ownership	2000	2006	2012	2016
	Million board feet[a]			
Private:				
Industrial	1,075.2	942.7	1,000.5	1,044.5
Nonindustrial private	800.7	555.8	185.1	199.9
Tribal	9.9	5.6	8.1	6.6
	1,885.8	1,504.1	1,193.7	1,251.0
Public:				
National forest	337.1	224.7	203.3	265.5
State	18.6	3.5	27.9	51.4
Bureau of Land Management	7.7	0.3	0.4	—
Other public	0.5	0.4	0.1	3.7
	363.9	228.9	231.7	320.6
Total	2,249.7	1,733.1	1,425.4	1,571.5
	Percentage of harvest			
Private:				
Industrial	47.8	54.4	70.2	66.5
Nonindustrial private	35.6	32.1	13.0	12.7
Tribal	0.4	0.3	0.6	0.4
	83.8	86.8	83.7	79.6
Public:				
National forest	15.0	13.0	14.3	16.9
State	0.8	0.2	2.0	3.3
Bureau of Land Management	0.3	0	0	0
Other public	0	0	0	0.2
	16.2	13.2	16.3	20.4
Total	100.0	100.0	100.0	100.0

[a] Volume in Scribner log rule.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Timber harvested from California's timberlands originated from three broad land ownership categories: industrial timberland, nonindustrial private forest land, and public lands. California's timber harvest consisted largely of true firs, Douglas-fir, ponderosa pine, redwood, and sugar pine.

Private lands have been the source of most of California's timber harvest since the 1940s (fig. 1). During the private harvest declines of the 1960s, 1970s, and 1980s, timber harvested from national forests became increasingly important as a source of raw material for California's forest products industry. Over the past three decades, both private and national forest timber harvests have declined, with reductions in harvest from national forests exceeding the reductions in harvest from private land. National forest timber offerings have declined since the 1980s for many reasons, including social, political, and legal constraints on harvesting. For more information on California's historical timber harvest, refer to McIver et al. (2015) and Morgan et al. (2012).

The share of timber harvest from industrial private lands grew from about 54 percent in 2006 to 70 percent in 2012 and decreased to 67 percent in 2016. The share and total harvest from nonindustrial private lands decreased dramatically from 32 percent (556 MMBF) in 2006 to 13 percent (185 MMBF) in 2012 and maintained a similar proportion in 2016 despite total nonindustrial private harvest increasing to nearly 200 MMBF. Combined, the timber harvest from industrial and nonindustrial private lands in 2016 accounted for nearly 80 percent of the total harvest in California in 2016—down slightly from 83 percent in 2012. However, private timberlands account for nearly 44 percent of the total timberland in the state (fig. 2). The majority of timberland acres and sawtimber volume in the state are managed by the U.S. Forest Service and other public owners (e.g., the Bureau of Land Management and the state of California), but national forests and other public lands accounted for only 20 percent (321 MMBF) of the total 2016 harvest—up from 16 percent (232 MMBF) in 2012.

Harvest by Geographic Source

Six multicounty geographic resource areas are used to describe major wood-producing regions in California (fig. 3): North Coast, Northern Interior, Sacramento, San Joaquin, Central Coast, and Southern California. In 2016, nearly 86 percent (1,300 MMBF Scribner) of California's total timber harvest came from the North Coast, Northern Interior, and Sacramento regions (table 2). Historically, these regions have provided more than 85 percent of California's timber harvest (Barrette et al. 1970; California State Board of Equalization 1978–2017; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012). Most of the remaining timber harvest volume came from the

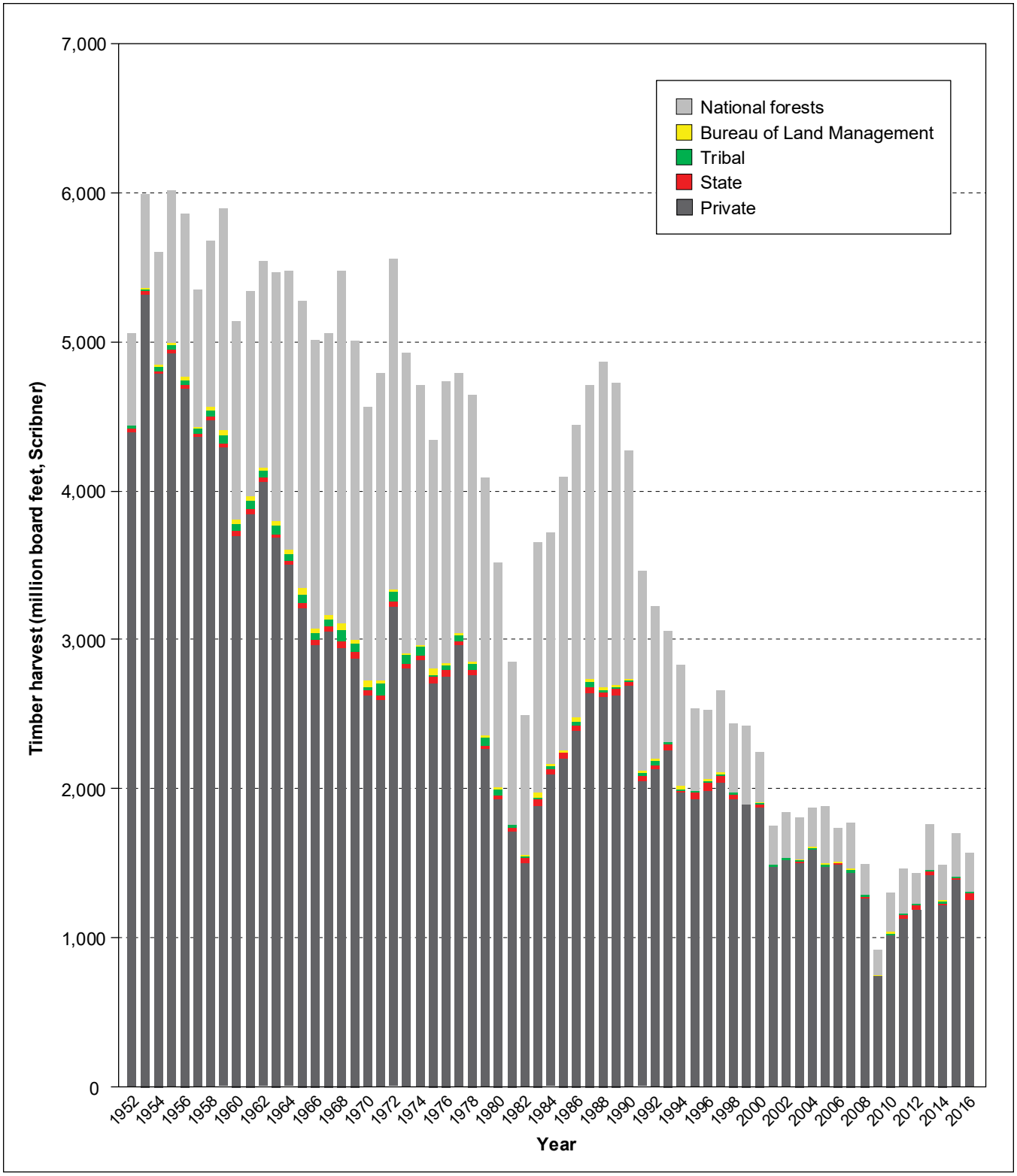

Figure 1—California's timber harvest by ownership class, 1952–2016.

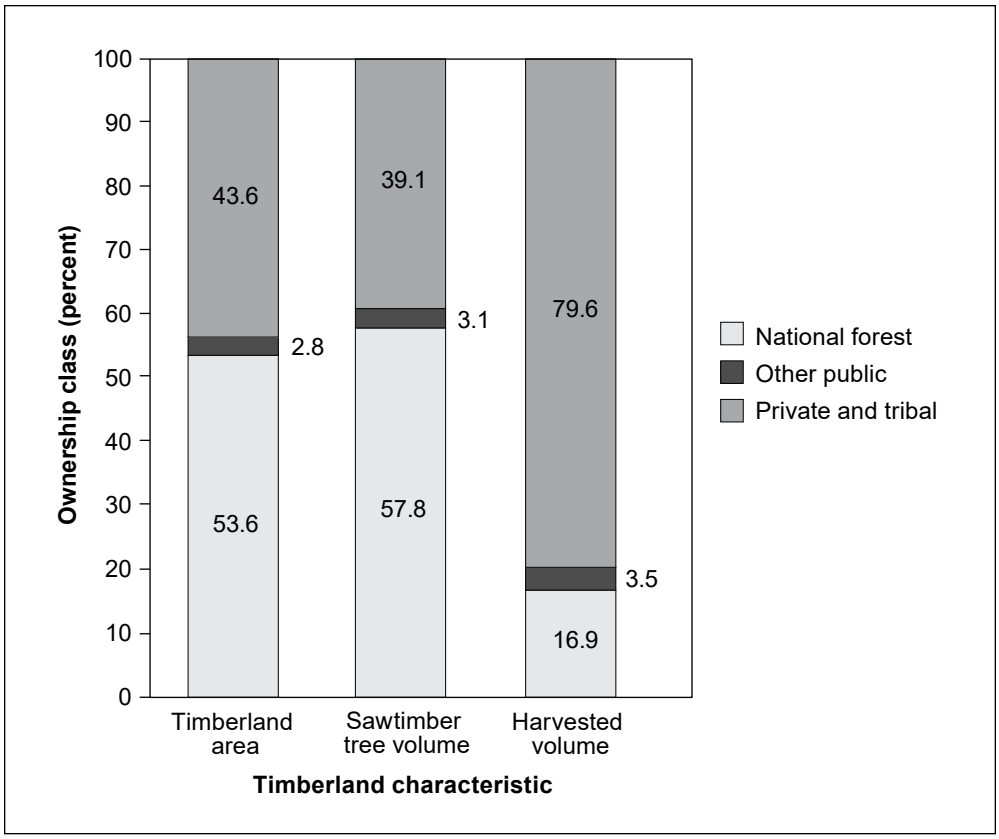

Figure 2—Characteristics of California's timberland by ownership class, 2016.

San Joaquin region, accounting for 12.5 percent (198 MMBF) of the 2016 harvest, up from 9.5 percent (135 MMBF) during 2012.

Five counties in northern California accounted for 48 percent (759 MMBF) of California's total timber harvest in 2016 (table 3). This represents a decrease in the proportional and total harvest contribution from 2012, when the top five counties in the state provided 55 percent (785 MMBF) of the total statewide harvest. As in 2012, Shasta County provided the largest proportion of California's timber harvest in 2016 at 13 percent (208 MMBF) followed by Humboldt County at 11 percent (178 MMBF). Historically, Humboldt County provided the largest share of California's timber harvest—around 20 percent of the annual total dating back to 1976—but was surpassed by Shasta County in 2012. Other California counties that have generally been top timber producers include Mendocino, Plumas, Shasta, Siskiyou, and Trinity (Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995, 1997). During 2016, timber harvest volumes were more evenly distributed across counties, with the top five counties providing decreasing proportional contributions to the overall state timber harvest.

Shasta County provided the largest proportion of California's timber harvest in 2016 at 13 percent (208 MMBF) followed by Humboldt County at 11 percent (178 MMBF).

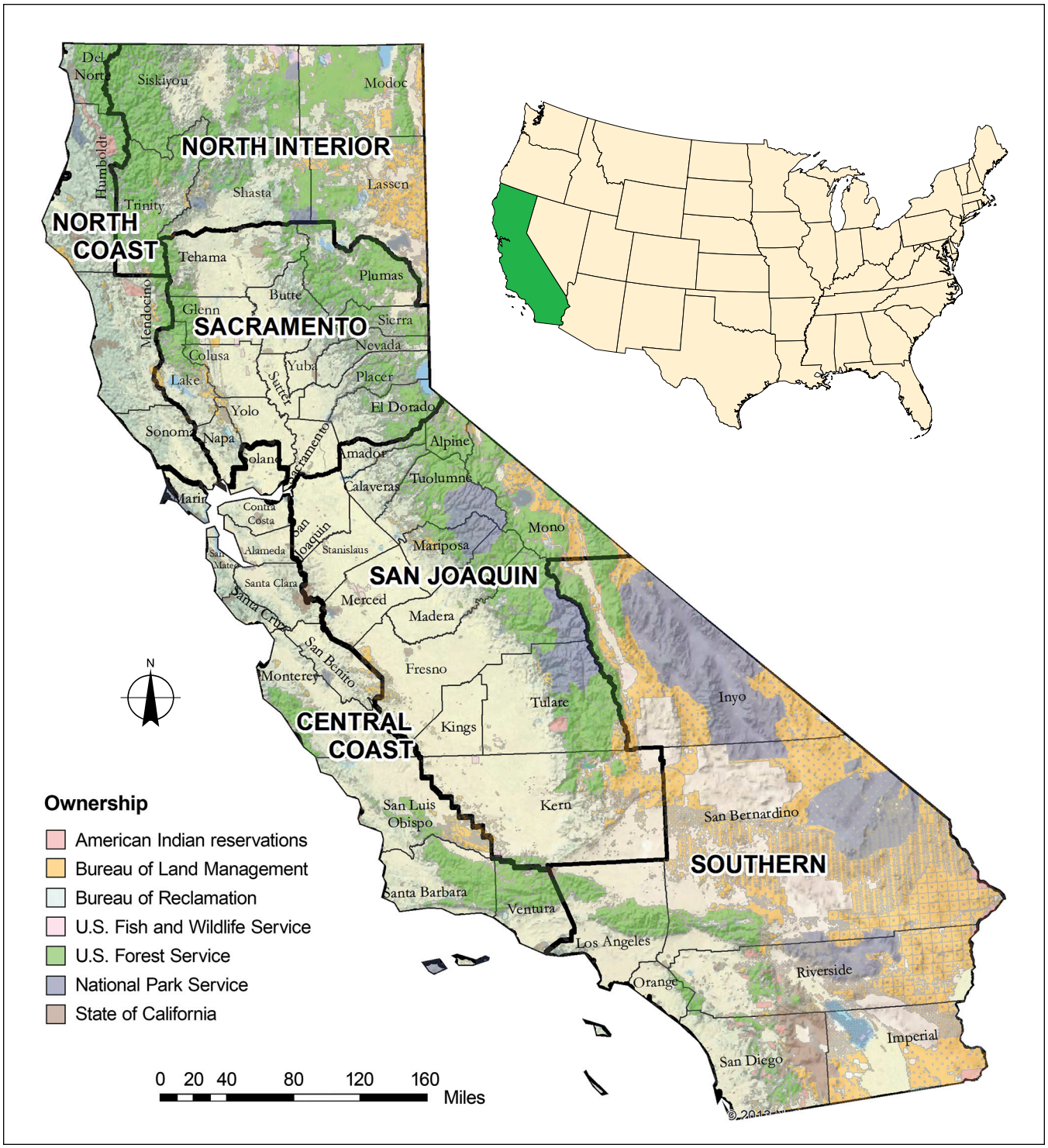

Figure 3—California's geographic resource areas.

Table 2—California's timber harvest by resource area and county, 2000–2016

Resource area	2000 volume[a]	2000 percentage of total	2006 volume[a]	2006 percentage of total	2012 volume[a]	2012 percentage of total	2016 volume[a]	2016 percentage of total
	Million board feet	*Percent*	*Million board feet*	*Percent*	*Million board feet*	*Percent*	*Million board feet*	*Percent*
Central Coast:								
Napa	—	—	0.3	[b]	—	—	—	—
San Benito	—	—	0.1	[b]	—	—	—	—
San Mateo	5.6	0.3	4.4	0.3	4.5	0.3	12.4	0.8
Santa Clara	4.2	0.2	4.4	0.3	3.5	0.2	—	—
Santa Cruz	19.6	0.9	9.7	0.6	15.7	1.1	11.2	0.7
Total Central Coast	29.4	1.3	18.8	1.1	23.7	1.7	23.5	1.5
North coast:								
Del Norte	50.4	2.2	17.6	1.0	19.3	1.4	31.1	2.0
Humboldt	435.3	19.3	345.7	19.9	215.1	15.1	177.9	11.3
Mendocino	193.5	8.6	123.1	7.1	108.8	7.6	106.6	6.8
Sonoma	28.1	1.2	9.9	0.6	8.2	0.6	10.4	0.7
Total North Coast	707.2	31.4	496.3	28.6	351.4	24.6	326.0	20.7
Northern interior:								
Lassen	69.3	3.1	77.9	4.5	83.8	5.9	74.0	4.7
Modoc	49.9	2.2	26.3	1.5	46.2	3.2	26.9	1.7
Shasta	194.3	8.6	209.0	12.1	229.1	16.1	208.0	13.3
Siskiyou	209.7	9.3	196.0	11.3	147.9	10.4	170.8	10.9
Trinity	99.6	4.4	98.0	5.7	60.4	4.2	75.9	4.8
Total Northern Interior:	622.6	27.7	607.2	35.0	567.5	39.8	555.7	35.4
Sacramento:								
Butte	86.4	3.8	89.2	5.1	52.5	3.7	49.3	3.1
El Dorado	106.7	4.7	99.1	5.7	50.1	3.5	71.1	4.5
Glenn	24.7	1.1	4.9	0.3	3.6	0.2	0.0	0.0
Lake	9.6	0.4	1.6	0.1	[b]	[b]	50.6	3.2
Nevada	59.6	2.6	39.4	2.3	19.0	1.3	9.5	0.6
Placer	40.4	1.8	47.4	2.7	21.4	1.5	45.3	2.9
Plumas	193.8	8.6	122.4	7.1	82.3	5.8	96.0	6.1

Table 2—California's timber harvest by resource area and county, 2000–2016 (continued)

Resource area	2000 volume[a]	2000 percentage of total	2006 volume[a]	2006 percentage of total	2012 volume[a]	2012 percentage of total	2016 volume[a]	2016 percentage of total
	Million board feet	*Percent*	*Million board feet*	*Percent*	*Million board feet*	*Percent*	*Million board feet*	*Percent*
Sierra	33.1	1.5	16.3	0.9	30.5	2.1	56.1	3.6
Tehama	105.3	4.7	45.7	2.6	62.6	4.4	58.9	3.8
Yolo	2.6	0.1	—	—	—	—	—	—
Yuba	36.9	1.6	7.2	0.4	20.9	1.5	22.8	1.4
Total Sacramento	699.0	31.1	473.3	27.3	342.8	24.0	459.6	29.3
San Joaquin:								
Alpine	—	—	b	b	—	—	—	—
Amador	22.8	1.0	28.7	1.7	13.5	0.9	3.4	0.2
Calaveras	67.0	3.0	34.9	2.0	41.4	2.9	58.8	3.7
Fresno	19.8	0.9	5.9	0.3	6.8	0.5	29.3	1.7
Kern	3.6	0.2	—	—	2.8	0.2	1.7	0.1
Madera	4.8	0.2	0.1	b	16.2	1.1	5.3	0.3
Mariposa	3.6	0.2	3.7	0.2	4.5	0.3	14.8	0.9
Merced	0.3	b	—	—	—	—	—	—
Stanislaus	—	—	—	—	—	—	0.9	0.1
Tulare	8.9	0.4	7.7	0.4	5.0	0.3	5.0	0.3
Tuolumne	60.7	2.7	47.2	2.7	45.2	3.2	79.1	5.0
Total San Joaquin	191.4	8.5	128.1	7.4	135.3	9.5	198.4	12.5
Southern California:								
Inyo	—	—	—	—	3.4	0.2	—	—
Riverside	—	—	—	—	—	—	8.3	0.5
San Bernardino	—	—	9.55	0.55	1.2	0.1	—	—
Total southern California	0	0	9.6	0.6	4.6	0.3	8.3	0.5
State total	2,249.7	100	1,733.1	100	1,425.4	100	1,571.5	100

— = zero.

[a] Volume in Scribner log rule.

[b] Volume is less than 0.05 million board feet or percentage of total harvest is less than 0.05 percent.

Sources: McIver et al. 2015; Morgan et al. 2004, 2012.

Table 3—Total harvest for California's leading timber harvest counties, 1976–2016

County	Volume[a]	Total	County	Volume[a]	Total
	Million board feet	*Percent*		*Million board feet*	*Percent*
1976:			1994:		
Humboldt	1,073.3	22.7	Humboldt	559.6	19.7
Mendocino	489.2	10.3	Plumas	163.5	5.8
Shasta	359.3	7.6	Shasta	147.5	5.2
Siskiyou	337.1	7.1	Lassen	123.3	4.3
Del Norte	236.4	5.0	Trinity	117.2	4.1
Total county	2,495.3	52.7	Total county	1,111.1	39.1
California total	4,731.0		California total	2,839.0	
1982:			2000:		
Humboldt	456.2	18.3	Humboldt	435.3	19.3
Mendocino	448.1	17.9	Siskiyou	209.7	9.3
Plumas	164.7	6.6	Shasta	194.3	8.6
Trinity	161.2	6.5	Plumas	193.8	8.6
Tehama	148.3	5.9	Mendocino	193.5	8.6
Total county	1,378.5	55.2	Total county	1,226.6	54.5
California total	2,497.0		California total	2,249.7	
1985:			2006:		
Humboldt	608.1	15.0	Humboldt	345.7	20.0
Mendocino	435.1	10.7	Shasta	209.0	12.1
Shasta	204.1	5.0	Siskiyou	196.0	11.3
Plumas	202.2	5.0	Mendocino	123.1	7.1
Siskiyou	201.8	5.0	Plumas	122.4	7.1
Total county	1,651.3	40.7	Total county	996.2	57.5
California total	4,056.0		California total	1,733.1	
1988:			2012:		
Humboldt	769.0	15.9	Shasta	229.1	16.1
Mendocino	499.1	10.3	Humboldt	215.1	15.1
Siskiyou	295.6	6.1	Siskiyou	147.9	10.4
Trinity	272.1	5.6	Mendocino	108.8	7.6
Plumas	271.5	5.6	Lassen	83.8	5.9
Total county	2,107.3	43.5	Total county	784.7	55.1
California total	4,840.0		California total	1,425.4	
1992:			2016:		
Humboldt	502.2	15.6	Shasta	208.0	13.2
Mendocino	271.6	8.5	Humboldt	177.9	11.3
El Dorado	195.1	6.1	Siskiyou	170.8	10.9
Lassen	158.8	4.9	Mendocino	106.6	6.8
Shasta	142.9	4.4	Plumas	96.0	6.1
Total county	1,270.6	39.5	Total county	759.3	48.3
California total	3,214.0		California total	1,571.5	

[a] Volume in Scribner log rule.

Sources: Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995, 1997.

Harvest by Species

During 2016, true firs, Douglas-fir, ponderosa pine, redwood, and sugar pine were the most commonly harvested tree species, accounting for nearly 95 percent of California's total harvest volume.

During 2016, true firs, Douglas-fir, ponderosa pine, redwood, and sugar pine were the most commonly harvested tree species, accounting for nearly 95 percent of California's total harvest volume (table 4). These species have historically dominated California's harvest, consistently accounting for 87 percent or more of the total volume (table 5). Over the years, Douglas-fir and true firs have been the highest volume species. Douglas-fir provided the top timber harvest volume in 2012, while true firs were the leading species harvested in 2016, accounting for more than 27 percent (429 MMBF) of the volume harvested. From 2012 to 2016, the combined percentage provided by ponderosa pine and sugar pine has increased (30 percent of total harvest), while the redwood percentage of the total harvest decreased. These changes are in line with other long-term trends demonstrating a proportionate decrease in the volume of redwood and increases in the volume of true firs harvested, with pines maintaining a relatively consistent share of California's state timber harvest (McIver et al. 2015; Morgan et al. 2004, 2012).

Tree mortality, while occurring naturally in all forests, can increase as a result of natural disturbances such as wildfire, pest outbreaks, windthrow, and drought (Christensen et al. 2017). Substantial tree mortality associated with several years of severe drought has been observed in California. On average, between 2001 and 2016, there were 10 billion live trees in California, of which 187 million died each year with the highest mortality rates occurring on national forest

Table 4—California's timber harvest by species, 2016

Species	Volume[a]	Total
	Million board feet	*Percent*
True firs	428.9	27.3
Douglas-fir	370.7	23.6
Ponderosa pine	359.0	22.8
Redwood	218.4	13.9
Sugar pine	112.9	7.2
Incense cedar	54.4	3.5
Lodgepole	14.2	0.9
Other softwoods[b]	7.8	0.5
Western hemlock	2.9	0.2
Hardwoods	2.3	0.1
All species	1,571.5	100

[a] Volume in Scribner log rule.
[b] Other softwoods include Jeffrey pine, spruces, giant sequoia, and other coniferous species.

Table 5—Percentage of California's timber harvest by species, 1968–2016[a]

Species	1968	1972	1976	1982	1985	1988	1992	1994	2000	2006	2012	2016
	Percent											
True firs	22.4	21.8	19.9	21.1	22.0	23.0	22.9	25.6	19.0	28.3	26.7	27.3
Douglas-fir	32.2	26.9	27.4	22.9	24.1	26.5	23.2	26.7	27.6	24.2	28.4	23.6
Ponderosa and sugar pine	23.7	25.3	25.4	27.0	26.3	26.9	23.4	22.0	23.8	23.1	23.7	30.0
Redwood	18.2	18.7	19.5	24.3	22.6	18.2	24.9	21.9	16.7	14.3	14.7	13.9
Other softwoods[c]	3.3	3.0	3.6	0.5	1.4	1.3	1.3	1.3	7.7	5.4	1.5	1.6
Incense cedar	[b]	4.1	4.1	3.9	3.0	3.7	4.3	2.4	4.7	4.8	4.9	3.5
Hardwoods	0.2	0.2	0.2	0.4	0.5	0.5	[d]	[d]	0.5	[d]	[d]	0.1
Total	100	100	100	100	100	100	100	100	100	100	100	100

[a] Harvest for years prior to 2000 does not include timber delivered to out-of-state mills.
[b] Included in "Other softwoods."
[c] Other softwoods include western hemlock, lodgepole pine, spruces, and other coniferous species.
[d] Less than 0.05 percent.
Source: Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995, 1997.

land (Christensen et al. 2017). Measurement of FIA plots from 2001–2005 and 2011–2015 provided estimates of average annual growth, removals, and mortality in California's forests. Mean annual gross growth was 1.99 million ft^3 per year and mean annual mortality was 903 thousand ft^3 per year (Brodie and Palmer 2020). Although mortality across all ownerships was relatively high (45 percent of growth), mortality rates on national forests (70 percent of growth) were dramatically greater than on all private ownership (20 percent of growth) (Brodie and Palmer 2020). Despite these mortality rates, net change in California's forest land was positive during this period.

Tree mortality during 2015 and 2016 is reflected in the more than 207 MMBF Scribner of reported dead timber harvest volume (table 6). Although the dead timber volume reported during the 2012 survey accounted for only 2 percent of the timber harvest in California, the dead volume reported in 2016 accounts for 13 percent of the state's total harvest. Ponderosa pine—one of the species heavily affected by the bark beetle epidemic—saw a 16 percent increase in dead volume since 2012. Some of the species with high proportions of dead volume (e.g., Jeffrey pine and sugar pine) do not account for a large proportion of the timber harvested across the state. However, from 2000 to 2016, key timber harvest species such as ponderosa pine, Douglas-fir, and true fir species have seen significant increases in the proportion of reported dead volume. An increased proportion of timber harvest volume reported dead also was observed between 2000 and 2006 in California, with 11 percent of the timber harvest being reported as dead (Morgan et al. 2012).

The dead timber volume reported in 2016 accounts for 13 percent of the state's total harvest. Ponderosa pine—one of the species heavily affected by the bark beetle epidemic—saw a 16 percent increase in dead volume since 2012.

Table 6—Proportion of California's timber harvest by species reported as dead in 2000, 2006, 2012 and 2016

Species	2000	2006	2012	2016
	- - - - - - - Percentage of dead timber - - - - - - -			
Jeffrey pine	*N/A*	*N/A*	40	40
Sugar pine	10	5	6	27
Lodgepole pine	11	4	21	18
Ponderosa pine	8	6	2	18
Cedar[a]	3	9	0	15
Douglas-fir	5	12	3	14
True firs	6	4	2	11
Hardwoods	0	2	0	1
Other softwoods[b]	12	1	0	0
Redwood	1	31	0	0
Total percentage dead	6	11	2	13
Dead volume (MMBF)	129.1	182.8	35.0	207.4
Total harvest volume (MMBF)	2,249.7	1,733.1	1,425.4	1,571.5

MMBF = million board feet. N/A = not applicable.
[a] Includes Port Orford, incense, and western red cedar.
[b] Other softwoods include western white pine, hemlock, spruces, and other coniferous species.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Harvest by Product Type

Products directly manufactured from timber are referred to as primary products—the first stage of wood processing. These products include lumber, plywood, veneer, posts and poles, pilings and timbers, house logs, and log furniture. Products made from chipping or grinding timber, as well as from the mill residuals (e.g., bark, sawdust, and planer shavings) generated in the production of primary products, are also included in this analysis. These reconstituted primary products include particleboard, medium-density fiberboard, hardboard, fuel pellets, and bioenergy. Other primary products made from mill residuals include decorative bark, mulch, soil amendments, and animal bedding.

Timber harvested in California during 2016 falls into four general timber product categories:

- Sawlogs (timber used to produce lumber and other sawn products, as well as logs harvested for export)
- Veneer logs (timber sliced or peeled to make veneer for plywood or laminated veneer lumber)
- Bioenergy (woody biomass burned industrially to generate electricity or steam)

- Other products (including utility poles, house logs, log furniture, firewood, and fiber logs)

These four categories comprise the overall product types represented in California's timber harvest.

Sawlogs accounted for 82 percent (1,292 MMBF) of the harvest in 2016, marking a slightly smaller proportion than in 2012 (83 percent) and thus representing the smallest proportion on record. Historically, sawlogs have accounted for more than 85 percent of the total annual harvest (table 7). Veneer logs accounted for approximately 10 percent of the total harvest through the 1970s; however, since the 1980s, veneer logs have accounted for only 4 to 8 percent of California's annual timber harvest. During 2016, veneer log harvest reached its highest percentage of California's harvest since the mid-1970s with a notable increase to 11 percent of the statewide harvest, up from 8 percent in 2012.

Sawlogs and veneer logs have constituted the vast majority of harvested volume in California, with a relatively small portion of annual harvests used for other timber products. Bioenergy has been an expanding use of California's timber in the past two decades, with a high of 8 percent (116 MMBF) of the harvest volume delivered to bioenergy producers in 2012—a significant increase over 2006 and 2000. However, in 2016, timber harvest volume for bioenergy dropped to about 5 percent (83 MMBF) of the total statewide harvest. During 2016, power purchase agreements between biomass facilities and power companies were nearing expiration, resulting in many bioenergy plants in California becoming idle for a portion

Table 7—Percentage of California's timber harvest by product type, 1968–2016[a]

Product type	1968	1972	1976	1982	1985	1988	1992	1994	2000	2006	2012	2016
	Percent											
Sawlogs[b]	86	86	86	91.2	92	92.5	99.3	92.9	89.8	88.1	82.8	82.2
Veneer logs	10	12	11.5	6.1	5	4.7	[c]	5.2	7.4	8.0	8.4	11.0
Pulpwood	1	1.5	0.1	1.1	0.8	1.1	[d]	[d]	[d]	[d]	—	—
Other[e]	3	0.5	2.4	1.6	2.2	1.7	0.7	1.9	0.4	<0.3	0.6	1.4
Bioenergy	[f]	[f]	[f]	[f]	[f]	[f]	[f]	[f]	2.4	3.6	8.2	5.3
Total	100	100	100	100	100	100	100	100	100	100	100	100

[a] Harvest for years prior to 2000 does not include timber delivered to out-of-state mills.
[b] Includes reported log exports leaving California.
[c] Included in "sawlogs."
[d] Included in "other."
[e] Includes utility poles, house logs, log furniture, firewood and fiber logs; does not include bioenergy.
[f] Not reported prior to 2000.
Source: Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995, 1997.

of 2016 while a resolution was sought (Souza 2016). The timing of these closures coincided with increased supply of dead wood being harvested from the Sierra Nevada Mountains, where drought and bark beetle outbreaks caused large-scale tree mortality in 2015 and 2016. This led Governor Jerry Brown to sign Senate Bill 859 in September 2016, which offered a temporary reprieve for biomass power facilities that use fuel from state-designated high-hazard-zone forests (CBEA 2016). Despite a decrease in the proportion of California's timber harvest used by bioenergy facilities in 2016, the bioenergy sector remains an important part of California's forest products industry.

Pulpwood has historically accounted for less than 2 percent of the annual harvest volume because of the pulp and board sector's heavy reliance on mill residuals. With the closure of California's last remaining pulp mill in 2009, logs are no longer harvested in California to be used as pulp. Although there are no primary pulp or paper-manufacturing facilities in the state, secondary paper products are produced; these products are generally not as closely linked to forest management in California when compared to the primary forest products industry. Logs harvested for other products such as utility poles, house logs, log furniture, firewood, and fiber logs have historically accounted for less than 1 percent of the annual harvest since the mid-1990s. However, in 2016, these "other" timber products accounted for an increased percentage of the statewide harvest, up from 0.6 percent in 2012 to 1.4 percent during 2016.

Product Type by Ownership Class

Most of the volume harvested in California during 2016 came from private timberlands (table 8). Timber used for sawlogs constituted the most harvested category across all ownership groups, both in 2012 and 2016. The sawlog product category increased by 10 percent from 2012 to 2016, up more than 112 MMBF and reversing the change observed between 2006 and 2012. Veneer and other timber products saw the largest increase, with 52 percent (67 MMBF) more volume harvested in 2016. During 2012, a shift away from volume harvested for sawlog products was observed as the bioenergy harvest experienced a dramatic increase of 186 percent (McIver et al. 2015). However, harvest for bioenergy saw a decline from 2012 to 2016, with 29 percent less volume (33 MMBF) in this product category. As general economic recovery has continued after the Great Recession, production of sawlogs and other higher quality wood products have experienced growth in California's forest products industry.

In 2016, industrial lands provided the majority (66 percent) of California's sawlog, veneer, and other log harvest, compared to 72 percent in 2012 and only 54

Table 8—California's timber harvest by ownership class and product type, 2016

Ownership source	Sawlogs[a]	Veneer and other[b]	Bioenergy	All products
		Million board feet[c]		
Private timberlands:	1,030.7	156.7	63.6	1,251.0
Industrial	837.6	143.7	63.3	1,044.5
Nonindustrial and tribal	193.1	13.0	0.3	206.4
Public timberlands:	261.6	39.5	19.5	320.6
National forests	223.3	32.2	10.0	265.5
Other public	38.3	7.3	9.4	55.1
Total	1,292.3	196.2	83.1	1,571.5

[a] Includes log exports.
[b] Other product types include house logs, firewood, furniture logs, fiber logs, and utility poles.
[c] Volume in Scribner log rule.

percent in 2006. Although nonindustrial lands again provided about 13 percent of the sawlog, veneer, and other log harvest in 2016, public lands saw an increased contribution to these product types, from 6 percent in 2012 to 20 percent in 2016. Private lands continue to provide the majority of timber harvest for high-value wood products, while public lands represent an increasing proportion of the saw, veneer, and other log harvest. Industrial lands also contributed 76 percent (63 MMBF) of wood used for bioenergy, which is up proportionally from 55 percent (64 MMBF) in 2012 and 73 percent (45 MMBF) in 2006. Public lands, primarily national forests, made up the remaining volume of wood used for bioenergy, at approximately 19.5 MMBF, or 24 percent—a notable decrease from the 51.9 MMBF (45 percent) contribution during 2012.

In 2016, industrial lands provided the majority (66 percent) of California's sawlog, veneer, and other log harvest, compared to 72 percent in 2012 and only 54 percent in 2006.

Product Type by Species

From 2012 to 2016, total volume harvested by species increased for true firs (up 13 percent), ponderosa pine (up 42 percent), redwood (up 5 percent), and sugar pine (up 31 percent). Although Douglas-fir remained the second most harvested of California's species, it experienced a decline of 8 percent from 2012 to 2016. True firs and Douglas-fir were the species most harvested across all products, followed closely by ponderosa pine (table 9). However, ponderosa pine accounted for more of the sawlog volume than Douglas fir, and true firs and ponderosa pine together accounted for nearly half (48 percent) of all sawlog volume harvested in 2016. The harvest for veneer and other products increased substantially for each of the three leading species categories, with Douglas-fir up 23 percent, true firs up 54 percent, and ponderosa pine harvest for veneer and other products up 135 percent from 2012

Table 9—California's timber harvest by species and product type, 2016

Species	Sawlogs[a]	Veneer and other[b]	Bioenergy	All products
	Million board feet[c]			
True firs	314.9	85.5	29.4	429.8
Douglas-fir	288.2	63.6	19.4	371.2
Ponderosa pine	311.1	32.0	14.1	357.2
Redwood	218.2	0.2	—	218.4
Sugar pine	97.4	9.6	5.9	113.0
Incense-cedar	48.5	1.1	4.9	54.4
Other softwoods[d]	10.9	2.2	9.3	22.3
Western hemlock	2.9	—	—	2.9
Hardwoods	0.1	2.2	—	2.3
All species	1,292.3	196.2	83.1	1,571.5

— = zero.
[a] Includes log exports.
[b] Other product types include house logs, firewood, furniture logs, fiber logs, and utility poles.
[c] Volume in Scribner log rule.
[d] Includes lodgepole pine, Jeffrey pine, giant sequoia, and western white pine.

to 2016. True firs, Douglas-fir, and ponderosa pine accounted for the majority (76 percent) of the harvest for bioenergy in 2016. This represents a decrease both in volume and in proportional contribution from 2012. Similar to 2006 and 2012, hardwoods comprised very little (less than 0.5 percent) of the 2016 harvest. However, in 2016, hardwoods were used mostly for veneer and other wood products, compared to 2012 when hardwoods were primarily used for bioenergy.

Timber Flow

This section briefly details the movement of timber among California's wood-producing regions, geographic resource areas, and individual counties, as well as between California and other states and countries. As a result of tracking the flow of timber into and out of the state, there are slight differences in the volume estimates of timber harvested in California versus timber received by facilities in the state.

In 2016, California's sawmill, veneer, and other wood-processing facilities received 1,538 MMBF Scribner of logs (table 10). Of that volume, 79 percent came from private timberlands, about 17 percent from national forests, and about 4 percent from other public ownerships. Bioenergy facilities in California received about 83 MMBF of timber, in addition to mill residuals. Although veneer and other products saw an increase in total volume received, the contributions by ownership class remained fairly stable. National forests contributed 17 percent of the sawlog

Table 10—Timber volume received by California facilities by ownership and product, 2016

Ownership source	Sawlogs[a]	Veneer and other[b]	Bioenergy	All products
	Million board feet[c]			
Private timberlands:				
Industrial	831.4	133.1	63.3	1,027.8
Nonindustrial and tribal	184.7	8.2	0.3	193.3
	1,016.2	141.4	63.6	1,221.1
Public timberlands:				
National forests	223.6	28.2	10.0	261.9
Other public	38.4	7.4	9.4	55.3
	262.0	35.7	19.5	317.2
Total	1,278.2	177.0	83.1	1,538.3

[a] Includes log exports.
[b] Other product types include house logs, firewood, furniture logs, fiber logs, and utility poles.
[c] Volume in Scribner log rule.

timber volume received in 2016, up from the 2012 contribution of 12 percent. There was a similar increase in the volume received from national forest land for veneer and other products. Seventy-six percent of timber volume received by bioenergy facilities came from industrial private timberlands, 12 percent from national forests, and another 12 percent from nonindustrial and other public sources. This represented a notable shift from 2012, when 37 percent of timber received by bioenergy facilities originated from national forests and only 8 percent came from other public and nonindustrial sources. Unlike during the 2012 California mill census, the residual-utilizing sector (i.e., reconstituted board and decorative bark facilities) did receive timber inputs for raw material owing in part to resource availability, processing capability, and market conditions. However, this sector continues to rely primarily on mill residuals for most feedstock.

Timber flow trends during 2016 were similar to those in both 2012 and 2006. Most (99 percent) of the timber used by California's primary wood products industry was harvested from within the state. California timber-processing facilities received 1,538 MMBF Scribner of timber in 2016 (table 10). Wood-processing facilities received approximately 145 MMBF more in 2016 than in 2012, an increase of about 10 percent. In 2016, slightly more than 11 MMBF, or less than 1 percent, of timber processed in California came from outside the state. This represents an increase over 2012, when less than 4 MMBF (0.5 percent) of timber processed in California originated from other states. The log in-flow to California during 2016

was still well below the 126.5 MMBF of timber imported from other states a decade ago. On the other hand, 44.8 MMBF (3 percent) of California's timber harvest was shipped out of state to be processed (table 11). This constituted an increase over 2012, though the percentage of the total remained the same. It is also about half the log flow that left the state in 2006. All the timber that flowed into California, as well as all the volume that flowed out, was in the form of sawlogs and veneer logs. These volumes do not include logs exported internationally from California's customs districts (see the "International and interstate timber flows" section for discussion).

Table 11—Interstate timber flow into and out of California to processing facilities,[a] 2016

Timber products	Log flow into California	Log flow out of California	Net imports (net exports)
	- - - - - - - - - *Million board feet*[b] - - - - - - - - -		
Saw and veneer logs	11.5	44.8	(33.2)
Total	11.5	44.8	(33.2)

[a] Does not include international log exports or imports.
[b] Volume in Scribner log rule.

Intrastate timber flow—

This section briefly examines the flow of California timber to mills within the state. The number of timber-processing facilities in several California counties is so low that reporting county-level data would require disclosure of firm-level information. To avoid disclosing information, geographic resource areas are used to illustrate intrastate timber flow (table 12). Harvest and receiving areas reflect six multicounty geographic resource areas (fig. 3) where counties have been combined where necessary to conceal individual mill information.

In 2012, weak lumber markets in the wake of the Great Recession limited the flow of timber from California to other states as well as the importation of timber into California. However, between 2012 and 2016, log flow into California increased more than threefold to 11.5 MMBF, while log flow out of California increased by almost 24 percent. During 2016, 40 percent of harvested timber was processed in its county of harvest, and about 80 percent was processed in the geographic resource area of harvest. Timber traveled farther for primary processing in 2016 than in 2012, when nearly 50 percent of harvested timber was processed in its county of harvest and approximately 87 percent was processed in the resource area of harvest. Although 2012 saw an increase in the percentage of timber remaining in the same geographical location for processing post-harvest, 2016 was more in line with the trends observed

During 2016, 40 percent of harvested timber was processed in its county of harvest, and about 80 percent was processed in the geographic resource area of harvest.

Table 12—California intrastate timber flow by geographic resource area, 2016

Harvest area	Receiving area					
	North Coast and Central Coast[a]	Northern Interior[b]	Sacramento[c]	San Joaquin[d] and Southern California[e]	Out of state[f]	Total harvest
	Million board feet Scribner					
North Coast and Central Coast[a]	302.9	38.0	0.1	—	8.5	349.5
Northern Interior[b]	—	444.1	77.2	0	35.8	557.1
Sacramento[c]	17.4	81.5	355.4	5.5	0.5	460.3
San Joaquin[d]	—	—	35.8	160.6	—	196.4
Southern California[e]	—	—	—	8.3	—	8.3
Out of state[f]	—	8.3	3.2	0.1	N/A	11.5
Total received	320.3	571.9	471.6	174.5	44.8	

— = zero.; N/A = not applicable.
[a] North Coast and Central Coast regions are combined to avoid disclosure; North Coast includes Del Norte, Humboldt, Mendocino, and Sonoma Counties and Central Coast includes Napa, Solano, Marin, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Santa Cruz, San Benito, and Monterey Counties.
[b] Northern Interior region includes Lassen, Modoc, Siskiyou, Shasta, and Trinity Counties.
[c] Sacramento region includes Butte, Colusa, El Dorado, Glenn, Lake, Nevada, Placer, Plumas, Sacramento, Sierra, Sutter, Tehama, Yolo, and Yuba Counties.
[d] San Joaquin region Includes Alpine, Amador, Calaveras, Fresno, Kern, Kings, Madera, Mariposa, Merced, Mono, San Joaquin, Stanislaus, Tulare, and Tuolumne Counties.
[e] Southern California region includes Imperial, Inyo, Los Angeles, Orange, San Luis Obispo, Riverside, San Bernardino, San Diego, Santa Barbara, and Ventura Counties.
[f] Out-of-state region includes Oregon, and Nevada. They do not capture logs exported internationally.

through 2006 when the percentage of timber processed within its county of harvest declined (Barrette et al. 1970, McIver et al. 2015, Morgan et al. 2012).

The remaining timber harvest volume was processed outside of its county or geographic resource area, flowing to another county, area, or state. Timber harvest volume not processed within its county or resource area of origin has tended to be delivered to mills in the north or western part of California or to Oregon. This trend continued in 2016 with the Northern Interior resource area shipping the largest volume of timber to be processed out-of-area, mostly to Oregon and the Sacramento resource area. Although the volume sent from the Northern Interior to the Sacramento resource area stayed fairly constant from 2012, more than three times the amount of volume was sent to Oregon from this resource area in 2016.

International and interstate timber flows—
Interstate and international timber flow trends have changed since the 2012 mill census. As in 2012, mills that participated in the 2016 survey did not report using foreign timber, whereas during 2006, California timber-processing facilities used 60 MMBF of timber from Canada. Despite some increases in the distance traveled by California timber during 2016, the flow of Canadian logs to California has not

resumed. Currently, there is no indication of increasing amounts of timber entering California from international sources, and the small amount of timber coming from other states is nowhere near the levels observed from the late 1960s through the 1990s (Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1991; Ward 1995, 1997).

International softwood log exports from California have seen an increase over the past two decades. According to Zhou and Daniels (2018), the U.S. International Trade Commission (USITC), and other sources, California's log exports were at a low starting in 1999 and lasting through the Great Recession. Recovery and increases across multiple sectors of the international forest product markets were observed from 2008 through 2012, with approximately 49 MMBF of softwood logs leaving California ports in 2012 (McIver et al. 2015). To identify changing trends in softwood log exports, data from the USITC were analyzed along with the most recent resource bulletin published on Pacific Northwest log exports from Zhou and Daniels (2018). The export data supplied by USITC reflected the forest product volumes and values that were exported **through** California customs districts. These custom districts encompass selected ports in their surrounding regions. What is not known is how much of these forest product volumes and values originated from timber harvested or products manufactured in California. Log export volume information was collected during the FIDACS census of California's forest products industry when possible. However, the volumes and trends in this section rely on USITC export data and are discussed separately from FIDACS mill census data.

During 2016, softwood log exports through California ports totaled approximately 55 MMBF, representing a 13 percent increase from 2012 (fig. 4) (USDC ITC 2018). Softwood log exports during 2016 represented a 164 percent increase over the low export levels reported from 2006 through 2009. Nearly 48 MMBF of the softwood log volume were exported by the San Francisco customs district, with the remaining 7 MMBF leaving from the San Diego and Los Angeles districts. In 2010, China began to significantly outpace other countries as the primary importer for California's softwood logs. In 2016, 97 percent of softwood log exports from California were sent to China, with both Japan and Mexico each receiving another 1 percent. While Japan received about 75 percent of the log exports from California during 1996, its percentage continued to decrease over time as China emerged as the dominant international recipient of log exports. Ponderosa pine accounted for about 55 percent of California's softwood log exports in 2016, while Douglas-fir constituted close to 11 percent. Total international softwood log exports through California's customs districts during 2016 represented a volume equivalent to 3.5 percent of California's total timber harvest.

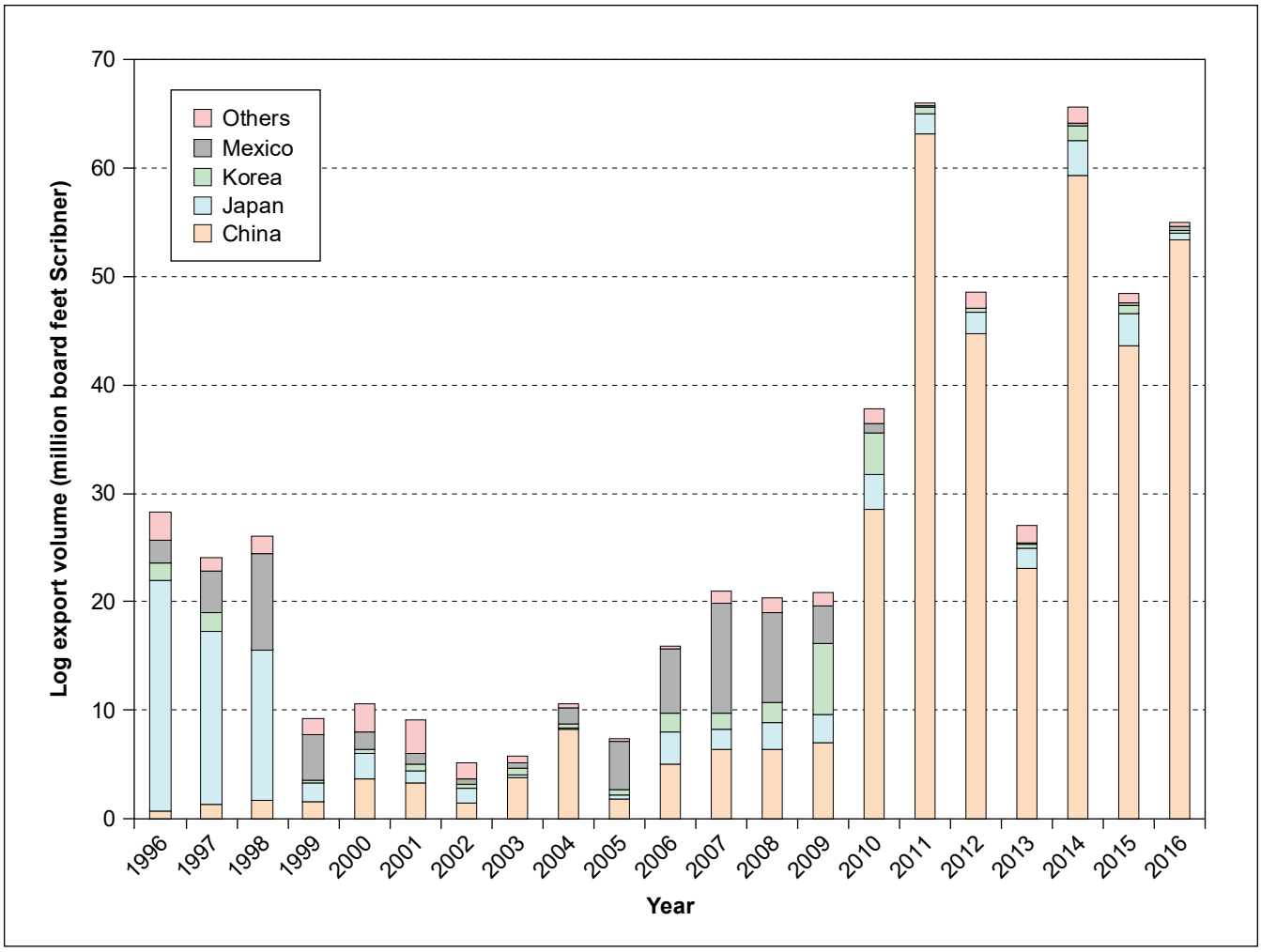

Figure 4—Volume of California's softwood log exports in million board feet Scribner by destination country, 1996–2016.

End Uses of California's 2016 Timber Harvest

This section traces California's timber harvest through the various primary processing sectors. Timber, primary wood products, and mill residuals from manufacturing are commonly quantified in different units of measure. Timber inputs are generally reported in board feet Scribner west-side or east-side log rule. Volumes of mill outputs are provided in the measurement unit common to each product, such as board feet lumber tally or square feet of plywood ⅜-inch basis. Mill residuals are commonly reported in bone-dry units (BDU) or bone-dry tons. In this section, all volumes are expressed in cubic feet because expressing input, output, and residual volumes in a common unit of measure allows for more complete accounting of wood fiber from harvest through primary processing.

In this report, 1 BDU of residual is assumed to contain 96 ft^3 of wood, and each thousand board feet (MBF) lumber tally is assumed to contain approximately 60 $ft^3$of wood; board foot Scribner to cubic conversions for timber differ by timber product type, which reflect log size and quality. See Keegan et al. (2010a, 2010b) for more detail on the conversions and relationships of timber, lumber, and mill residual volumes.

The following conversion factors were developed using log size specifications as well as product and residual recovery information developed from the 2016 mill survey in California:

- 5.32 board feet Scribner per cubic foot for sawlogs and export logs
- 4.92 board feet Scribner per cubic foot for veneer logs
- 4.29 board feet Scribner per cubic foot for reconstituted board and other logs
- 1.0 board foot Scribner per cubic foot for wood used for bioenergy

To help clarify how board feet are related to cubic feet in the context of milling operations, consider this example:

Examining California's sawmill sector, the estimated recovery of board feet lumber tally per board foot Scribner achieved by California sawmills in 2016 was 1.64. Based on this recovery, a thousand board feet (1 MBF) Scribner of logs would yield 1,640 board feet lumber tally of dry planed lumber. Assuming 1 MBF of lumber contains 60 ft^3 (57.5 ft^3 of lumber and 2.5 ft^3 lost to shrinkage during drying), 1.64 MBF lumber tally would contain $1.64 \times 60 = 98.4$ ft^3 of solid wood. The remainder of the log inside bark would be in various forms of mill residual (excluding bark). The average for all sawmills in California during 2016 was 0.57 BDU of mill residual in the form of sawdust, planer shavings, and chippable residual. A BDU of residual is 2,400 lbs of oven-dry wood and contains 96 $ft^3$of solid wood fiber. A recovery of 1.64 MBF of lumber generates $1.64 \times 0.57 \times 96 = 90$ ft^3 of total residual. The residual and the green lumber together account for all the wood fiber in the thousand board feet Scribner of logs used to produce lumber. There are 188.1 ft^3 of solid wood in the average sawlog processed in California, yielding 1,000/188.1 = 5.32 board feet Scribner per cubic foot of logs processed into lumber. This board foot/cubic foot ratio was used to calculate the volume of cubic feet in California's sawlog harvest. See Keegan et al. (2010a) for more detail on the calculation of cubic feet in a given board foot volume of logs.

Figure 5 outlines timber flows of wood fiber by sector beginning with total statewide harvest and ending with finished primary products. Owing to the important role of bark in California's forest products industry, figure 6 outlines by sector the flow and utilization of bark generated through timber harvest. California's 2016

timber harvest was approximately 367 million cubic feet (MMCF) of bole (wood) and 57 MMCF of bark that went to timber-processing and residual-utilizing facilities both within and outside the state. Of the total harvest volume, approximately 233 MMCF (63 percent of bole volume) went to sawmills and was processed into lumber and other sawn products, and about 35 MMCF (nearly 10 percent of bole volume) went to veneer production (fig. 5). Only 5.6 MMCF (2 percent of bole volume) went directly to facilities that produce reconstituted board, posts, utility poles, log home kits, furniture, firewood, or bark products. In addition, reconstituted board facilities in California, Oregon, and Washington received 21 MMCF of residuals from California's sawmill, veneer, and other sectors. Bioenergy plants producing electricity received 83 MMCF of timber directly and 40 MMCF of wood mill residuals from other plants processing California timber, accounting for 33 percent of total cubic bole volume harvested. An additional 34 MMCF of residuals from sawmills and other primary processing facilities was utilized onsite for heat and steam generation, while nearly 31 MMCF of wood residuals went to other uses, including landscaping, mulch, pellets, and animal bedding.

Of the 233 MMCF of timber received by sawmills, 116 MMCF (50 percent of bole volume) became finished lumber, and about 5.5 MMCF were lost to lumber shrinkage during drying. Approximately 111 MCF of wood residuals were produced by the sawmill sector in California during 2016. Most of the wood mill residuals generated by sawmills were used to produce energy, both internally (32 MMCF) and at bioenergy facilities (35 MMCF). Nearly 30 MMCF of wood residuals were sold to other manufactures of landscaping, mulch, pellets, and animal bedding. A very small amount, less than 0.2 MMCF, of wood residuals from processing California timber into lumber was unused in 2016.

Most of the wood mill residuals generated by sawmills were used to produce energy, both internally (32 MMCF) and at bioenergy facilities (35 MMCF).

In addition to the 367 MMCF of harvested wood, bark was used by various industry sectors. Of the total bark that went to timber-processing facilities in California, the majority flowed to roundwood-processing facilities along with the wood bole (fig. 6). Decorative bark and landscaping facilities in California received an estimated 22 MMCF of bark residuals from wood-processing facilities in 2016. Bark residual was also used to generate heat, both internally (16 MMCF) and at bioenergy facilities (19 MMCF). Similarly to wood residuals, a very small amount of bark went unutilized in California during 2016.

Figure 7a demonstrates the final disposition of wood fiber harvested in California during 2016 (excluding bark), and figure 7b demonstrates the final disposition of mill residuals generated by California's primary wood products sector (including bark).

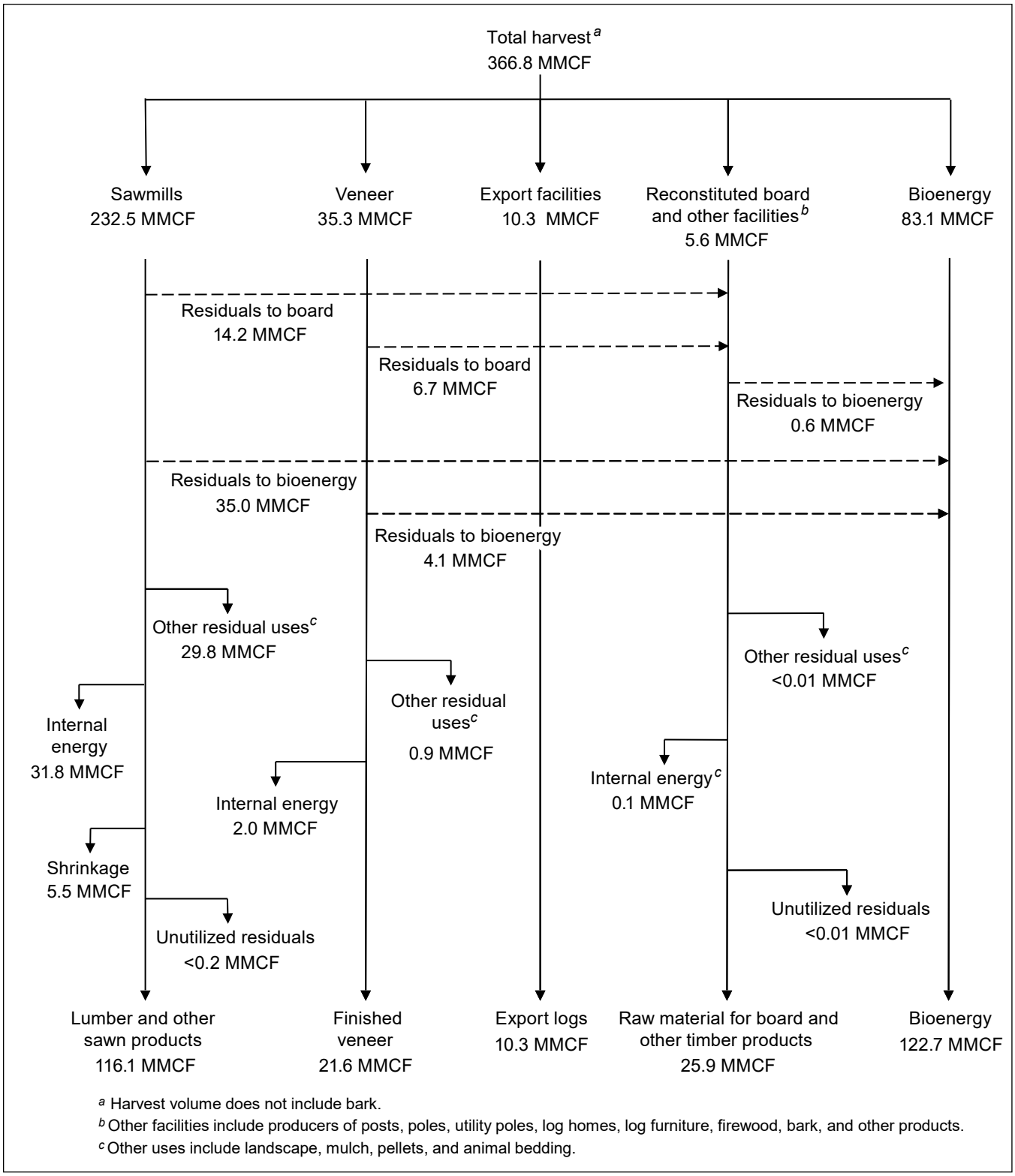

Figure 5—Utilization of California's timber harvest, 2016 (MMCF = million cubic feet).

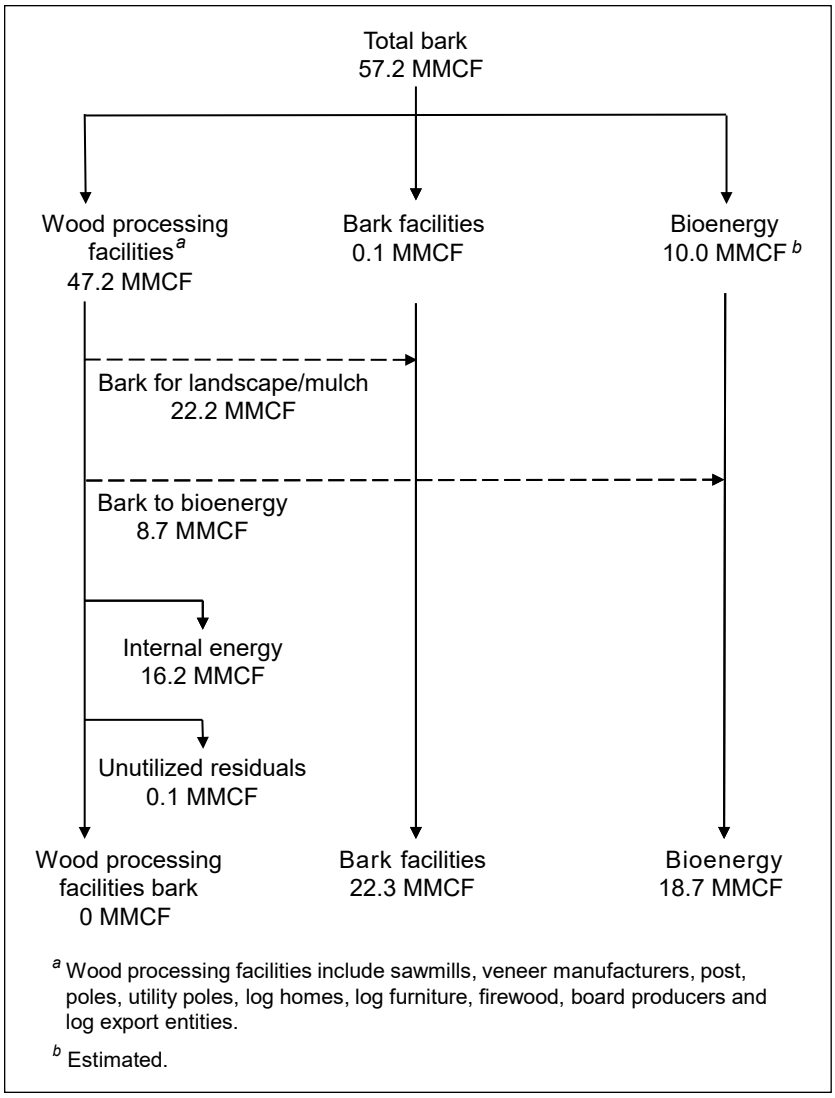

Figure 6—Utilization of bark and bark residuals generated from California's 2016 timber harvest.

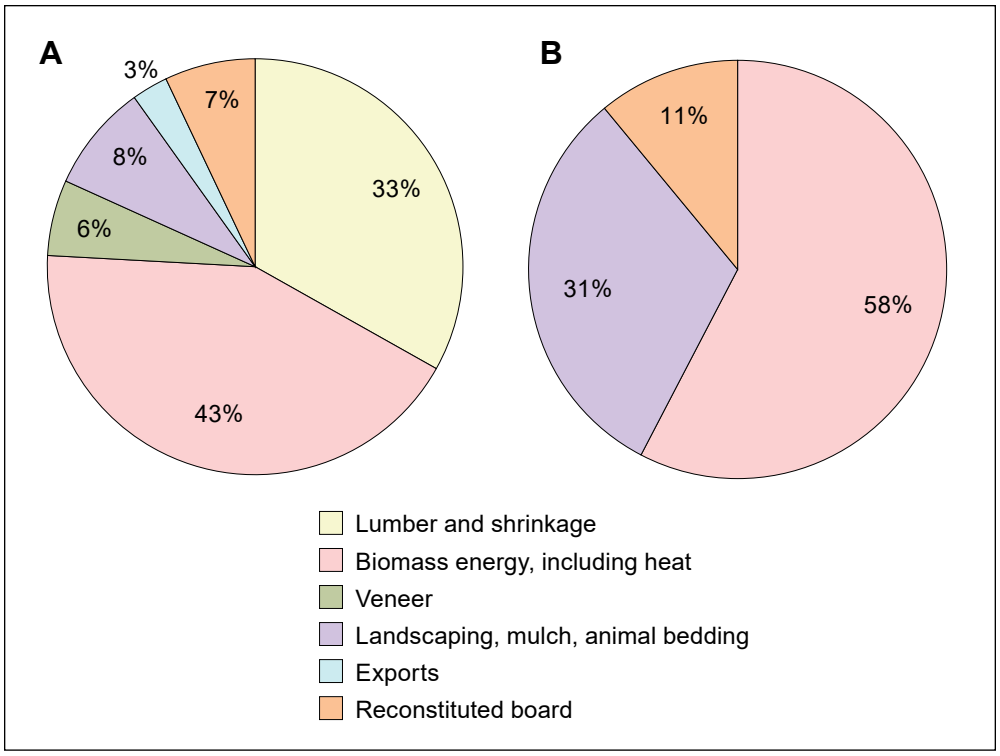

Figure 7—(A) Final disposition of wood harvested in California by industry sector, 2016 (excludes bark); (B) Final disposition of mill residuals in California, 2016 (includes bark).

California's Forest Products Industry

The 2016 FIDACS census identified 80 active primary wood products facilities in California, up from 77 manufacturers identified in both 2012 and 2006.

The 2016 FIDACS census identified 80 active primary wood products facilities in California, up from 77 manufacturers identified in both 2012 and 2006, but significantly lower than the 262 operational facilities in 1968 (fig. 8, table 13). Over the past 50 years, most of these infrastructure losses have occurred in the lumber-producing (i.e., sawmill), veneer and plywood, and pulp and board sectors. Conversely, there has been an increase in the bioenergy, decorative bark, and other sectors owing in part to diversified markets, changes in resource utilization and availability, and advancements in manufacturing technology. Since the 2012 mill census, California gained two sawmills, one decorative bark facility, and three facilities in the "other" category, while losing three bioenergy facilities. In the case of bioenergy operations, the facilities remain intact, but were not active during the 2016 census. More detail on individual sectors is provided in the subsequent discussion.

The higher number of timber-processing facilities in 2000 versus the 1994 survey was due primarily to the inclusion of the bioenergy and decorative bark sectors in the 2000 census, offsetting declines in the number of sawmill and pulp and board

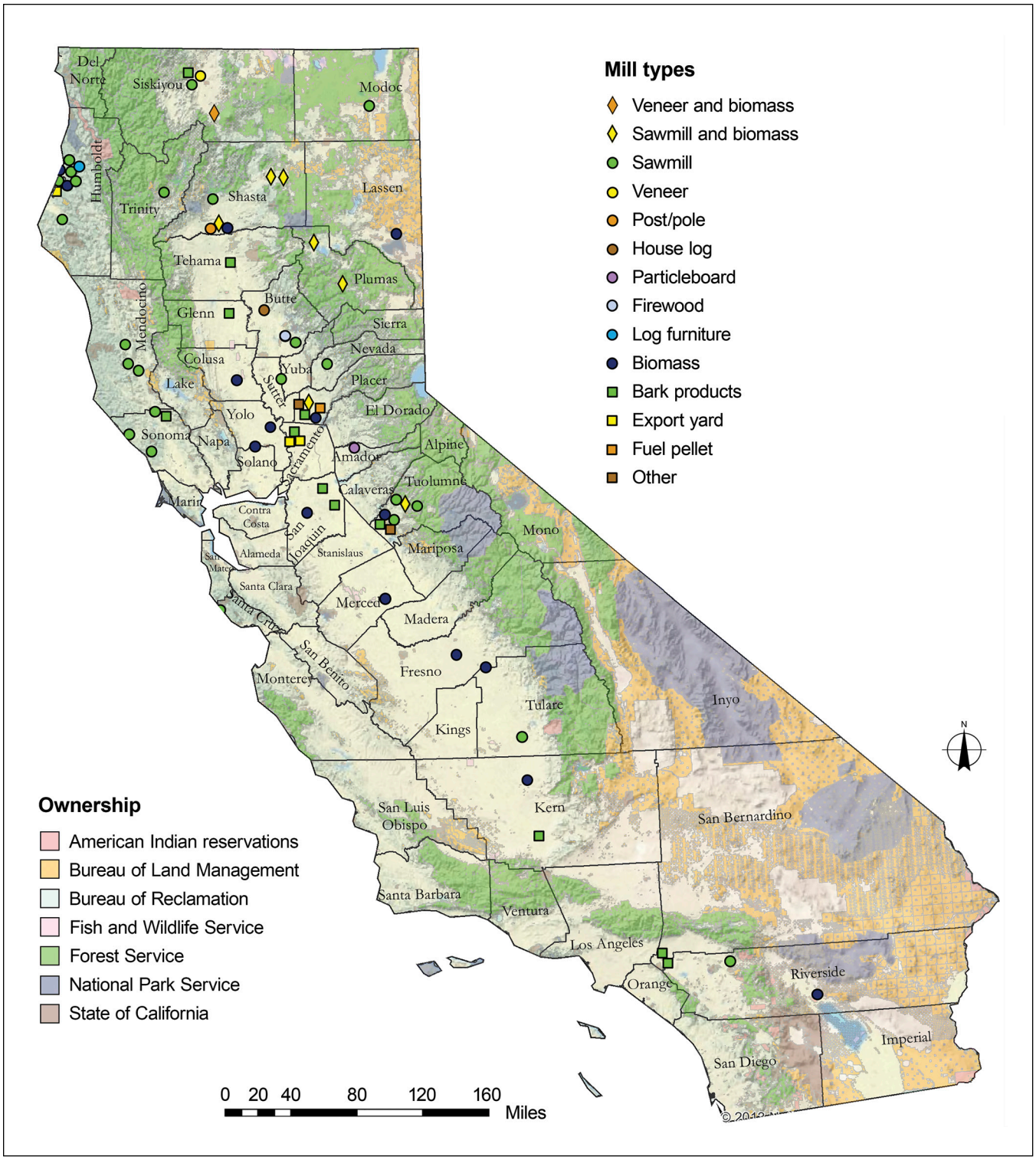

Figure 8—California's active timber-processing and residual-utilizing facilities, 2016.

Table 13—Active California primary wood products facilities by sector, 1968–2016

Industry sector	1968	1972	1976	1982	1985	1988	1992	1994	2000	2006	2012	2016
Sawmills	216	176	142	101	89	93	56	53	47	33	30	32
Veneer and plywood	26	25	21	10	6	6	3	4	2	2	2	2
Pulp and board	17	18	7	10	11	11	9	12	7	4	1	1
Bioenergy	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	25	25	26	23
Decorative bark	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]	10	10	11	12
Other[a]	3	13	13	9	9	9	5	6	2	3	7	10
Total	262	232	183	130	115	119	73	75	93	77	77	80

[a] "Other" includes log home producers, firewood producers, log furniture makers, fuel pellet facilities, and export entities, as well as utility pole manufacturers.
[b] Data unavailable for bioenergy and decorative bark sectors for 1968–1994.
Source: Barrette et al. 1970; Hiserote and Howard 1978; Howard 1974, 1984; Howard and Ward 1988, 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995, 1997.

facilities (Morgan et al. 2004, Ward 1997). Additional changes resulted from efforts to conduct a more comprehensive census of the industry starting in 2000, thus capturing more small sawmills and other facilities. Although this change in research protocol may have resulted in finding more mills, the downward trends continue in the number of facilities, volume of timber processed, and capacity—mirroring industry trends in other Western states (Hayes and Morgan 2017, Simmons and Morgan 2017, Simmons et al. 2016).

The downward trends associated with the forest products industry across the West can be attributed to several factors:

1. A steep reduction in available timber, primarily due to reduced harvest levels on federal and nonindustrial private lands.
2. A prescriptive regulatory environment combined with reduced social acceptability of timber harvest that has challenged forest management and industry operations.
3. Unfavorable market conditions associated with severe recessions in 1980 and 2007.
4. Concentration of production into large, capital-intensive, high-efficiency mills.

Additional factors affecting the structure and size of California's forest products industry are discussed in more detail in the "Trends and Capacity by Sector" section.

Wood product manufacturing facilities operated in 28 of California's 58 counties during 2016.

Industry Concentrations

Wood product manufacturing facilities operated in 28 of California's 58 counties during calendar year 2016 (fig. 8; table 14). There were nine active primary timber-processing facilities in Humboldt County in 2016, down from 12 active facilities during 2012. Shasta County also had nine active facilities during 2016, down from

Table 14—Active California primary wood products facilities by county and sector, 2016

County	Sawmills	Veneer	Medium-density fiberboard and particleboard	Bioenergy	Decorative bark	Other[a]	Total
Amador	—	—	1	—	—	—	1
Butte	2	—	—	—	—	2	4
Colusa	—	—	—	1	—	—	1
Del Norte	—	—	—	—	—	—	0
El Dorado	—	—	—	—	—	—	0
Fresno	—	—	—	2	—	—	2
Glenn	—	—	—	—	1	—	1
Humboldt	5	—	—	2	—	2	9
Kern	—	—	—	1	1	—	2
Lassen	—	—	—	1	—	—	1
Madera	—	—	—	—	—	—	0
Mendocino	2	—	—	—	—	—	2
Merced	—	—	—	1	—	—	1
Modoc	1	—	—	—	—	—	1
Nevada	1	—	—	—	—	—	1
Placer	1	—	—	2	1	2	6
Plumas	2	—	—	2	—	—	4
Riverside	1	—	—	1	1	—	3
Sacramento	—	—	—	—	1	2	3
San Bernardino	—	—	—	—	1	—	1
San Joaquin	—	—	—	1	2	—	3
Santa Cruz	1	—	—	—	—	—	1
Shasta	4	—	—	4	—	1	9
Sierra	—	—	—	—	—	—	0
Siskiyou	1	2	—	1	1	—	5
Sonoma	4	—	—	—	1	—	5
Sutter	1	—	—	—	—	—	1
Tehama	—	—	—	—	1	—	1
Trinity	1	—	—	—	—	—	1
Tulare	1	—	—	—	—	—	1
Tuolumne	4	—	—	2	1	1	8
Yolo	—	—	—	2	—	—	2
Yuba	—	—	—	—	—	—	0
2016 total	32	2	1	23	12	10	80
2012 total	30	2	1	26	11	7	77
2006 total	33	2	4	25	10	3	77
2000 total	47	2	5	25	10	4	93

— = zero.

[a] "Other" includes log home producers, firewood, log furniture facilities, export entities, animal bedding, fuel pellets, and utility pole manufacturers.

10 operational facilities identified in both 2012 and 2006. Tuolumne County had eight processing facilities, one more than in 2012; Butte County had four facilities in 2016 versus two in 2012. Siskiyou and Sonoma Counties each had five operational facilities in 2016 compared with four during 2012. Tulare County had only one active processing facility identified in 2016, down from the four operational facilities in 2012. Although no active facilities were identified during 2012, Colusa, Merced, Modoc, Nevada, and Sutter Counties all contained an operational primary wood-processing facility during 2016. Conversely, El Dorado, Madera, and Yuba Counties had lost their operational facilities since 2012 and contained none during the 2016 census.

Sales Value, Product Markets, and Market Areas

California's primary forest products manufacturers reported about $1.5 billion in total sales value in 2016. This is an $82 million increase compared to 2012, but a $289 million decrease from 2006 and $1.5 billion decrease from 2000, in constant 2016 dollars.

The total sales value reported by California's primary forest products manufacturers in 2016 was about $1.5 billion. Although this represents an increase of more than $82 million over the 2012 total sales value, it is down $289 million from 2006 and $1.5 billion from 2000, in constant 2016 dollars. Table 15 shows that product sales were led by the sawmill sector at $984 million, followed by bioenergy, residual-utilizing, and veneer and other primary wood products sectors. Sales values increased across all industries from 2012 with the exception of the bioenergy sector, which decreased by 21 percent. The economic impacts of each sector are discussed more thoroughly in subsequent sections.

Sales value and geographic destination by product type for California's primary finished wood products in 2016 are shown in table 16 and figure 9. Mills usually distribute their products either through their own distribution channels or through independent wholesalers and selling agents. Because of subsequent transactions, the geographic destination reported here may not reflect final delivery points of shipments.

Table 15—Sales value of California's primary wood products, 2000–2016

Product	2000	2006	2012	2016[a]
	Thousand 2016 dollars			
Lumber, timbers, and associated products	2,002,204	1,159,524	921,692	984,380
Bioenergy	349,180	237,156	344,385	273,542
Residual-utilizing sector[b]	622,577	302,999	129,116	133,416
Veneer and other primary wood products[c]	103,377	113,387	46,619	132,935
Total	3,077,338	1,813,066	1,441,813	1,524,273

[a] Sales value from export logs included in 2016 total.
[b] Residual-utilizing sector includes pulp, paper, and board manufacturers, animal bedding producers, fuel pellet manufacturers, and decorative bark.
[c] Veneer and other products include log home accents, peeler cores, posts, poles, pilings, log furniture, firewood, exports (2016), and veneer.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Table 16—Geographic destination and value of California's primary wood products sales, 2016

Product	California	Far West	Rockies	North Central	Northeast	South	Other[a]	Total
	Thousand 2016 dollars							
Lumber, timbers, and associated products	742,619	34,025	71,116	65,248	12,691	51,594	7,087	984,380
Bioenergy	273,542	—	—	—	—	—	—	273,542
Residual-utilizing sector[b]	115,521	5,201	7,428	1,930	1,494	1,708	133	133,416
Veneer and other primary wood products[c]	3,231	73,421	2,119	48	24	24	54,068	132,935
2016 All primary wood products[d]	1,134,912	112,648	80,663	67,226	14,209	53,326	61,289	1,524,273
2012 All primary wood products	1,111,181	81,703	87,719	71,784	12,194	60,070	17,162	1,441,813
2006 All primary wood products	1,263,715	179,075	98,287	79,923	35,356	26,249	130,46	1,813,066
2000 All primary wood products	1,903,053	353,796	237,619	286,183	112,677	80,095	103,915	3,077,338
	Percentage of 2016 sales							
Lumber, timbers, and associated products	48.7	2.2	4.7	4.3	0.8	3.4	0.5	64.6
Bioenergy	17.9	—	—	—	—	—	—	17.9
Residual-utilizing sectorb	7.6	0.3	0.5	0.1	0.1	0.1	—	8.8
Veneer and other primary wood productsc	0.2	4.8	0.1	0	0	0	3.5	8.7
All primary wood products	74.5	7.4	5.3	4.4	0.9	3.5	4.0	100.0

[a] Other destinations include Pacific Rim and Canada.
[b] Residual-utilizing sector includes facilities that use residues from the manufacture of lumber and other products, including pulp mills, board facilities, fuel pellet producers and bark plants.
[c] Veneer and other primary wood products include log home accents, peeler cores, animal bedding, utility poles, firewood, furniture, exports (2016), and veneer.
[d] Sales value from export logs included in 2016 total.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Sales of lumber and sawn products accounted for 65 percent of total sales in 2016. Bioenergy sales made up 19 percent ($273.5 million), the residual-utilizing sector accounted for 9 percent ($133.4 million), and veneer and other primary products made up the remaining 9 percent ($133 million). Although lumber and other sawn products as well as the residual-utilizing sector both saw increased sales values from 2012 to 2016, the veneer and other products sector experienced a dramatic increase in overall sales value. Note that export logs are included in the 2016 total sales value. However, even if export logs are removed, the veneer and other products sector experienced a 70 percent increase (in constant 2016 dollars) in overall sales value between 2012 and 2016. Bioenergy was the only sector to have 2016 sales that exceeded pre-recession 2006 sales.

At more than $1.1 billion and more than 74 percent of total sales, California is its own largest market for primary wood products. Most of the lumber (75 percent),

as well as all the energy and electricity produced by the bioenergy sector, are used in state. The veneer and other primary wood products category is the only one to generate greater sales value in out-of-state markets. After dropping by nearly 60 percent between 2006 and 2012, sales value from the residuals-utilizing sector increased by 3 percent in 2016. Following similar trends noted during 2012 as a result of the closure of California's last pulp facility and reduction in out-of-state flow of residuals output, approximately 87 percent of the sales value of California's residual-utilizing sector was used in state.

Veneer and other primary wood products manufactured in California were primarily sold out of state in 2016, with just 2 percent of veneer and other products sold in state, and 55 percent sold to Far West states, followed by other market areas (41 percent) and the Rocky Mountain states (2 percent). International log exports from California to Pacific Rim countries in 2016 drove the sale of primary wood products to other market areas. The proportion of veneer and other primary wood products sold in California during 2016 constituted a drop in in-state sales since 2012, when about 10 percent of veneer and other products were sold in California. Veneer being sold to plywood and laminated veneer lumber mills in Oregon accounted for much of this trend.

The distribution of California's primary wood products has changed since previous years. The value of sales to the Far West and Northeast states and international markets increased between 2012 and 2016, whereas the value of sales to states in the other regions decreased. The Far West states (fig. 9) constituted the largest out-of-state market for California primary wood products in 2016, at 7 percent of total sales value. The Rocky Mountain states accounted for the second-largest percentage of out-of-state sales value, at $80 million or 5 percent of 2016 sales, primarily through lumber and residual-utilizing product sales. The North Central states yielded about 4 percent of total sales value at more than $67 million, with nearly all of it (97 percent) as lumber. Sales to the South were approximately $53 million, roughly 3 percent, while the Northeast totaled $14 million, or 1 percent of California's total primary wood product sales. Sales to Northeast states increased 17 percent from 2012 to 2016.

International product exports reported by participating mills constituted a similar percentage of California's total primary wood products sales in 2016 relative to previous years. An estimated $61 million in products went to Canada and Pacific Rim countries, about 4 percent of total sales. This compares to $17 million or 1 percent in 2012, and $130 million or 7 percent in 2006 (in constant 2016 dollars). In 2016, the majority of sales (88 percent) to foreign countries was from the veneer and other products sector, driven primarily by log exports, with most of the rest coming from the sawmill sector. By comparison, the bulk of sales to other countries during 2006 was generated from the residual-utilizing sector.

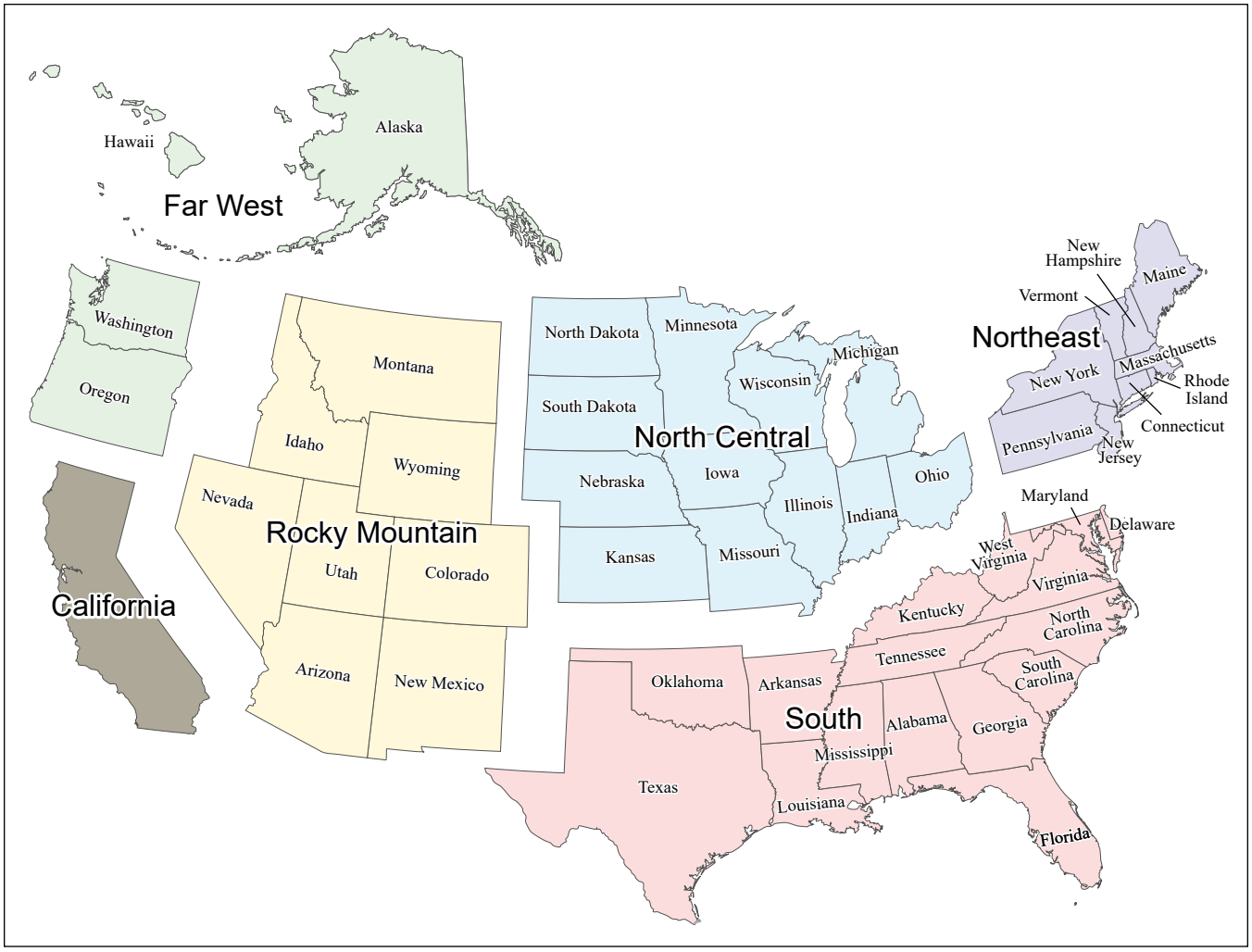

Figure 9—Domestic shipment destinations of California's primary wood products, 2016.

Trends and Capacity by Sector

Sawmill Sector

The sawmill sector continues to be the largest component of California's primary forest products industry in terms of sales value (tables 15 and 16) and volume of timber processed (table 10). The 32 sawmills operating in California during 2016 produced more than 2,000 MMBF of lumber, accounting for more than 6 percent of U.S. domestic softwood lumber production and just over 4 percent of U.S. lumber consumption (WWPA 1964–2016).

Lumber production in California peaked in the late 1950s and has generally been declining since (fig. 10), following trends similar to those experienced in other Western states over the course of the 20th century (Morgan et al. 2012). Lumber production and prices have been volatile since 2000, when production dropped to

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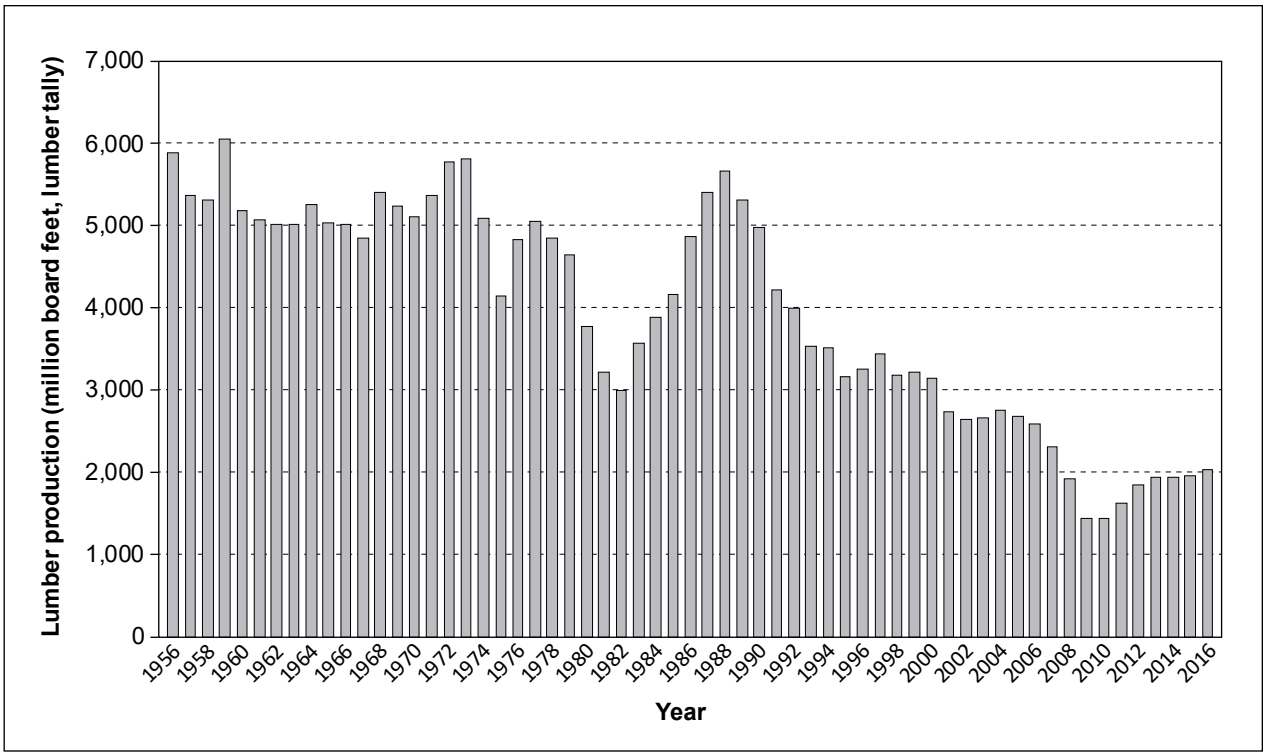

Figure 10—California's lumber production, 1956–2016 (source: WWPA 1964–2016).

3,100 MMBF, with a sales value of $1.8 billion. The declines continued into the first decade of the 21st century; despite very strong housing and lumber markets in 2004 and 2005, output and sales value were below 2000 levels. With weakening markets in 2009 and 2010, output fell to about 1,500 MMBF, and lumber sales were less than $1.0 billion (WWPA 1964–2016) (fig. 11). The industry began a slow recovery starting in 2010. By 2012, California produced 1,800 MMBF of lumber with sales of $756 million, and in 2016, the state produced more than 2,000 MMBF of lumber with sales of $833 million. Lumber production and associated sales in 2016 represent a 60-percent increase over the lowest point of the Great Recession in 2009, but 48 percent less than pre-recession (2004) sales.

Veneer and Plywood Sector

Currently, there are no plywood plants in California and only two plants producing veneer for further manufacture into plywood and laminated-veneer lumber by mills located in Oregon. The plywood sector was relatively short lived in California. It emerged and almost completely disappeared over the course of 60 years (Morgan et al. 2004). With strong wood markets and the development of technology to make quality plywood out of abundant large-diameter Douglas-fir timber, California

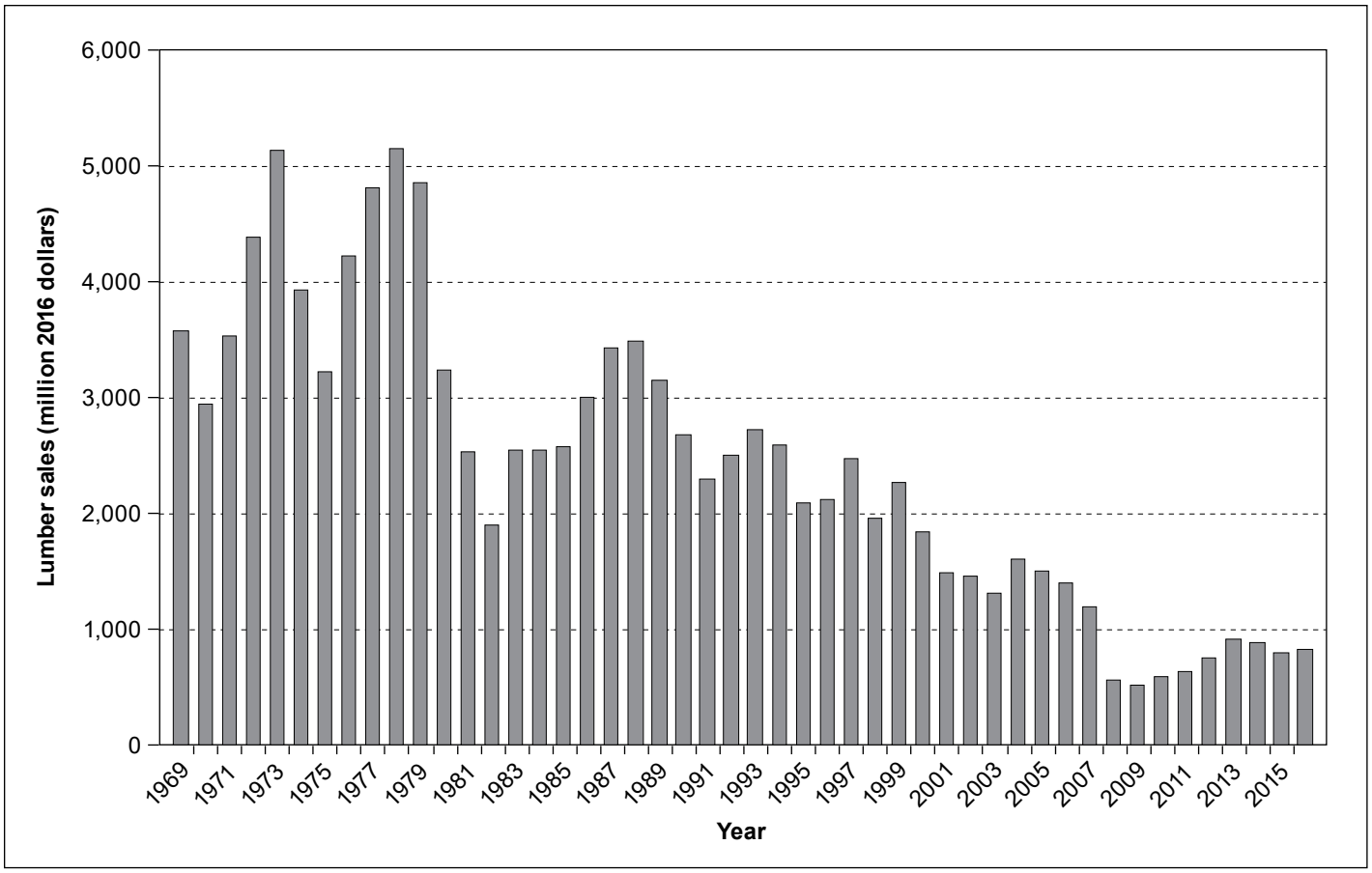

Figure 11—California's inflation-adjusted lumber sales, 1969–2016 (source: WWPA 1964–2016).

plywood production grew rapidly in the 1950s and early 1960s, peaking in 1964 at 1,300 million ft^2 (3/8-inch basis). A number of factors have accounted for the decline and near disappearance of California's plywood and veneer industry. Howard (1974) pointed out that large-diameter Douglas-fir logs became less available. At the same time, spikes in log exports in the late 1960s and early 1970s brought increased competition for logs (Morgan et al. 2004). More recently, substitute products such as oriented strand board captured large portions of construction markets once dominated by plywood. The veneer and plywood sector comprises a small proportion of California's total forest products industry, but sales value in the sector increased by 70 percent from 2012 to 2016, and the percentage of timber harvested for veneer logs increased from slightly more than 8 percent to 11 percent. To maintain confidentiality and protect firm-level information, additional details regarding California's current plywood and veneer sector cannot be disclosed.

Residual-Utilizing Sector

In 2016, there were 16 facilities in California manufacturing products from the mill residuals generated at sawmills and other plants that process timber into products. These included two animal bedding facilities, one particleboard facility, one fuel pellet producer, and 12 bark plants producing landscaping products such as decorative bark and mulch. From 2000 to 2012, the number of manufacturers using mill residuals declined from 17 to 15. In 2016, the residual-utilizing sector gained one new bark facility. The composition of the sector has remained relatively unchanged since the last survey, with many of the same facilities still utilizing mill residuals to generate products such as particleboard, decorative bark, mulch, shavings for animal bedding, and fuel pellets.

California's 2016 timber harvest included slightly more than 57 MMCF of bark, of which roughly 35 MMCF was used to produce energy and about 22 MMCF was used for other products such as mulch and landscaping. As with other wood mill residuals in California during 2016, only a very small amount (less than 0.1 MMCF) of bark was not used.

Prior to the early 1970s, the bark removed from timber during the production of lumber and other primary products was usually burned onsite for fuel, buried in landfills, or burned as waste (Barrette et al. 1970). A market developed by the nursery and gardening industry led to the establishment of three decorative bark producers in California by 1975 (Hiserote and Howard 1978); this number grew to 10 by 2000 (Morgan et al. 2004) and by 2016 was up to 12. Sales for residual-utilizing manufacturers totaled more than $133 million in 2016, up $4.3 million (3 percent) from 2012. The increase in sales resulted from the addition of one bark facility as well as increased output across the residual-utilizing sector during 2016.

Bioenergy Sector

While other sectors of the forest industry in California have declined over the past 100 years, the bioenergy sector saw steady growth through 2012. Although 2016 represented a decrease in bioenergy activity, the sector remains important to California's forest products industry. The state's bioenergy sector consists of a variety of facilities. Cogeneration plants at timber-processing facilities such as sawmills produce steam and electricity, whereas stand-alone facilities use various mixes of urban and agricultural waste, sawmill residuals, and timber to produce electricity. A total of 23 bioenergy facilities used some type of wood fiber, including timber, forest chips (i.e., trees or slash chipped in the forest), sawmill residuals, and agricultural or urban waste (i.e., orchard clippings, fruit pits or nutshells, and construction and demolition waste). Seven facilities operated exclusively on sawmill

residuals, the same as during 2012 and more than the two operating during 2006; four facilities used a mixture of forest chips and sawmill residuals; 10 facilities used a mixture of agricultural waste, urban waste, and sawmill residuals; and two facilities used forest chips, sawmill residuals, and urban and agricultural waste (down from four during 2012). The diversity of facilities and inputs in the bioenergy sector reflect the increasing emphasis put on alternative energy sources in California through state and federal energy and pollution policies (e.g., California's AB 32 and Renewable Energy Standard), as well as advancements in technology.

The energy-producing capacity of the 23 active bioenergy facilities that used wood fiber in 2016 totaled 510 megawatts (MW) (Woody Biomass Utilization Group 2019), down from 551 MW in 2012 but higher than the 485 MW of capacity recorded in 2006. Several facilities with a history of using forest or mill residuals were idle during 2016 as power purchase agreements between biomass facilities and power companies neared the end of their contracts. California's active bioenergy producers sold slightly more than 3 million megawatt-hours (MWh) of power in 2016. By comparison, the 26 bioenergy facilities active in 2012 produced 3.4 million MWh and the 25 bioenergy facilities active during 2006 produced 3.1 million MWh. One MWh can power an average California home for up to 2 months (USDE EIA 2018). All the energy produced was sold within the state of California, with a total sales value of $273.5 million (table 16). The sales value of electricity produced by bioenergy facilities decreased by 21 percent over 2012 sales, which was a combination of decreased production as well as a 15 percent decrease in the price paid per kilowatt-hour, from $0.1015 in 2012 to $0.0867 in 2016 (constant 2016 dollars).

The energy-producing capacity of the 23 active bioenergy facilities that used wood fiber in 2016 totaled 510 megawatts (MW), down from 551 MW in 2012 but higher than the 485 MW of capacity recorded in 2006.

Measured in cubic feet, the bioenergy sector used about 33 percent of the wood fiber (excluding bark) from California's timber harvest, as well as approximately 33 percent of the bark residuals produced. This includes more than 83 MMCF of timber harvested for bioenergy and approximately 48 MMCF (including bark) from other primary processing facilities. A dramatic reduction in the flow of bark residuals from wood-processing facilities to bioenergy facilities was observed between 2012 and 2016, as bark residual streams shifted more toward decorative landscaping bark entities and internal energy production.

California's bioenergy sector faced several challenges during 2016, contributing to an overall reduction in activity across the sector. Biomass energy production continues to be faced with relatively high production cost, and other renewable energy sources, including solar and wind generated power have lower costs as a result of available subsidies, tax exemptions, smaller workforce requirements, and generally fewer operating expenses (Lofthouse et al. 2015). Biomass energy is made more economical through power purchase agreements between biomass

facilities and power companies, incentivizing the use of renewable energy generated from woody biomass under California's Green Building Action Plan (Executive Order B-18-12). However, many power purchase agreements faced expiration deadlines during 2016, causing many facilities to be idle for parts of the year in anticipation of widespread closures (Benda 2016, Langley 2017). Concern over large-scale tree mortality and industry capacity to utilize harvested dead material led Governor Jerry Brown to sign Senate Bill 859 in September of 2016, which offered a temporary reprieve for biomass power facilities that use fuel from state-designated high-hazard zone forests. The bill and resulting Biofuel Renewable Auction Mechanism (BioRAM) program required electricity retailers to enter into 5-year contracts with biomass facilities that would source 80 percent of their feedstock from state-designated high-hazard-zone forests. In addition, the Bioenergy Market Adjusting Tariff (BioMAT) program, a feed-in tariff program for small bioenergy plants, requires state utility companies to purchase 50 MW from sustainable forest management (Simet 2017).

Other Sectors

The remaining primary wood products manufacturers identified in 2016 included three log export operations, one utility pole producer, one house log facility, one commercial firewood operation, and one log furniture producer. The number and types of facilities comprising California's other wood product manufacturers have varied throughout the years. Historical information on their operations is somewhat limited, and given the changing nature of the "other" sector it is difficult to make meaningful comparisons over time. Some of these producers are small operations that come and go with demand for their products, making it challenging to determine the total number of facilities operating and obtain information from them. Because of the limited number of facilities, no production data for these firms can be reported, and sales data are included with the veneer sector.

Input and Output Capacity

This section focuses on two measures of capacity—input (timber-processing) capacity and output (production) capacity—from 1988 through 2016 and the proportion of that capacity used by the forest industry. Output capacity is the most commonly used measure of capacity, measuring the volume of finished product a mill could produce in a given time frame, generally per shift or per year. However, finished products are measured in a variety of units: board feet lumber tally (lumber), thousand square feet (plywood, veneer), lineal feet (house logs), etc., which makes it difficult to express the total capacity of the industry as a whole. Another way of expressing capacity is in input capacity, often measured as timber-processing

capacity, which is a measure of the volume of raw logs that a mill can process in a given time frame, generally per year and measured in board feet Scribner. Capacity for 2016 was developed from the FIDACS census of California's forest products industry. Capacity for years preceding 2016 was either estimated from previous industry censuses (Howard and Ward 1991; McIver et al. 2015; Morgan et al. 2004, 2012; Ward 1995) or, for intervening years between periodic surveys, based on reported mill closures, openings, and expansions (Ehinger 2012, Random Lengths 1976–2016, Spelter et al. 2009).

Sawtimber-processing capacity—
California's sawtimber-processing plants include sawmills, veneer mills, house log facilities, and utility pole plants. Through the FIDACS census, California mills were asked for their 8-hour shift and annual production capacities given sufficient supplies of raw materials and firm market demand for their products. Large sawmills and veneer plants expressed annual production capacity equal to two to three 8-hour shifts daily for 240 to 300 operating days per year. Smaller mills generally reported annual capacity as only one shift per day, for not more than 250 days per year.

To combine capacity figures for the state's sawtimber users and to estimate the industry's total capacity to process sawtimber, capacity was expressed in units of raw material input (MMBF of timber Scribner Decimal C) and was called processing capacity. Sawmill capacity figures were adjusted to million board feet of timber Scribner Decimal C log scale by dividing production capacity in lumber tally by the mill's calculated lumber recovery per board foot Scribner. For veneer plants, production capacity in square feet of ⅜-inch veneer was divided by each mill's calculated veneer recovery figure. Capacities for utility pole plants were adjusted to thousand board feet Scribner by multiplying capacity in lineal feet by an average calculated using the average volume of a log that would be used for that product. The resulting pole volumes, quantified as pieces, were comparable in size to veneer and sawlogs.

California's capacity to process timber in 2016 was an estimated 1,900 MMBF Scribner, of which 73 percent was used by mills processing nearly 1,400 MMBF Scribner (fig. 12). A slight increase in total capacity for processing sawtimber and capacity utilized was observed from 2012 to 2016; in 2012, total capacity was estimated at 1,800 MMBF and mills processed approximately 1,300 MMBF. There has been a 69 percent drop in capacity to process sawtimber in California since 1988, when capacity was 6,000 MMBF Scribner of log input and mills processed about 4,000 MMBF of timber. The major decline in capacity took place from 1988 to 1999 with a fall from 6,000 to 2,800 MMBF (Morgan et al. 2004). The capacity decline in the 1990s resulted primarily from the decline of roughly 2,000 MMBF

California's capacity to process timber in 2016 was an estimated 1,900 MMBF Scribner, of which 73 percent was used by mills processing nearly 1,400 MMBF Scribner.

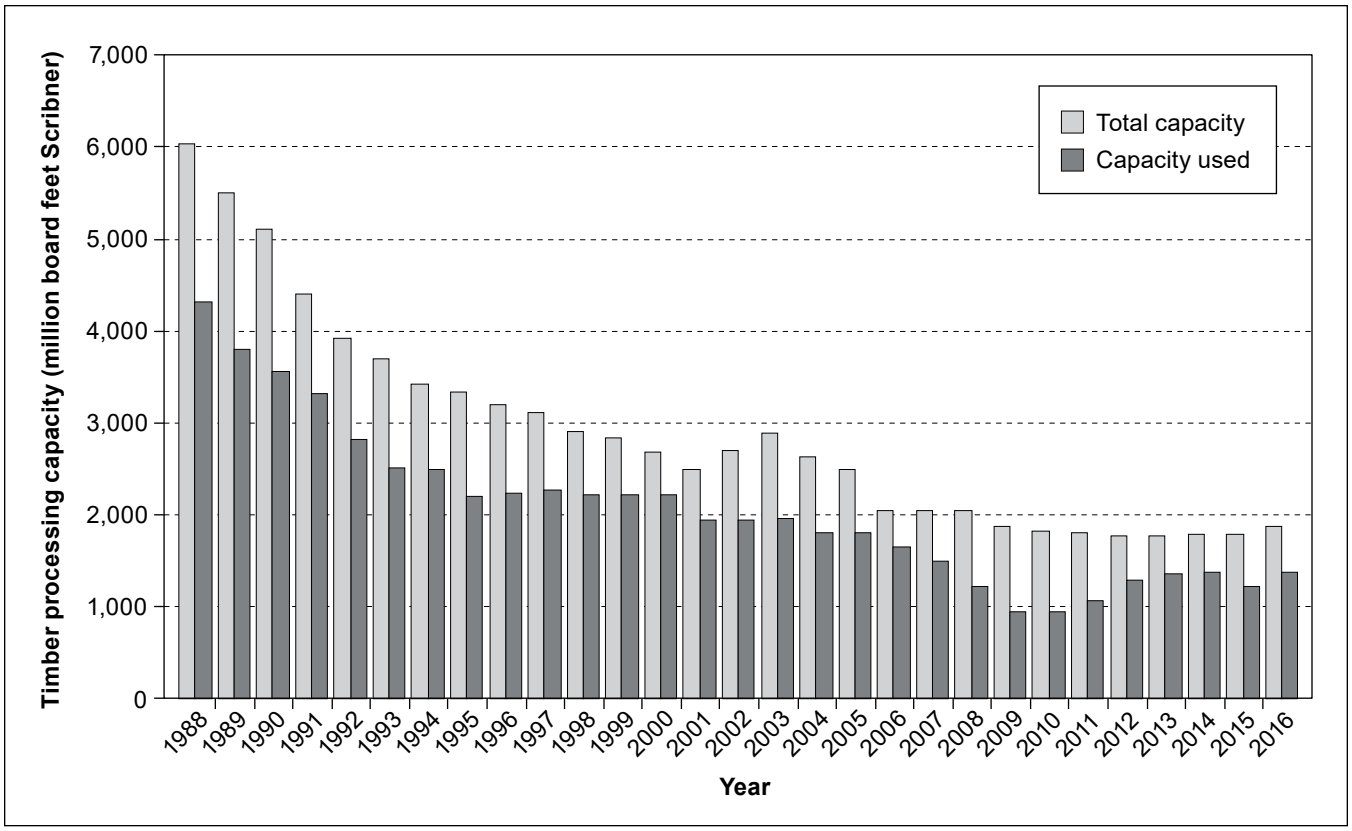

Figure 12—California's capacity for processing sawtimber, 1988–2016.

Scribner in federal timber sale offerings from national forests. Increased state regulations of timber harvest activities reduced the available private timber volume, as did increased costs of removal (Thompson and Dicus 2005). Additional changes in the use of private lands, including development, urbanization, or purchases and set-asides for parks or old-growth preservation, also contributed to reduced timber harvest across private forest lands. The Great Recession led to poor market conditions, and the portion of capacity used fell more dramatically than total capacity, with capacity used declining from around 80 percent during the 2000 to 2006 period to an estimated 50 percent in 2009 (Keegan et al. 2011; McIver et al. 2015). As markets have continued to rebound and slowly recover, production and capacity utilization increased to 73 percent in 2016.

Lumber production capacity—
Capacity to produce lumber varies widely among California's 32 sawmills, and the proportion of capacity utilized appears to increase as mill size increases (table 17). Total lumber produced by sawmills during 2016 was 2,022 MMBF, while production capacity was more than 2,296 MMBF lumber tally. Thus, approximately 88 percent

of California's annual lumber-producing capacity was utilized, up from 78 percent in 2012 and 80 percent in 2006. The majority, 1,697 MMBF (nearly 74 percent) of lumber-producing capacity, was concentrated in the 11 largest mills, each with over 100 MMBF annual capacity. There was a slight increase in the number of mills with 10 to 50 MMBF annual capacity as well as increases in their production capacity and their proportional contribution to state total capacity. Owing to some mill closures, a 7 percent decrease in overall sawmill production capacity was observed from 2012 to 2016, although there was a 6 percent increase in actual production.

The degree of concentration of capacity among the largest mills increased from 2000, when 58 percent of capacity was in the size class of more than 100 MMBF capacity. During 2016, these largest mills accounted for more than 75 percent (1,528 MMBF) of lumber production in California and utilized on average 90 percent of their lumber-producing capacity, up significantly from 78 percent in 2012 and 85 percent in 2006. Mills with capacities of 50 to 100 MMBF accounted for 415 MMBF (18 percent) of total capacity—producing almost 348 MMBF (17 percent) of the state's lumber—and utilized on average almost 84 percent of their capacity. While two more sawmills were active during 2016 than in 2012, some shifting between size classes occurred as new mills were added and some closed. The smallest 16 sawmills—with 50 MMBF production capacity or less—accounted for 8 percent (184 MMBF) of California's lumber-producing capacity and about 7 percent (147 MMBF) of the state's lumber production. Mills in the smallest size class utilized a lower percentage of their available capacity than mills in the larger size classes. However, the small mills still used nearly 80 percent of their production capacity during 2016. For comparison, the 12 sawmills with processing capacity of 50 MMBF or less utilized about 71 percent of their available capacity in 2012.

Table 17—Number of active California sawmills, capacity, production, and proportion of capacity utilized by capacity size class, 2016

Production capacity size class	Number of mills	Production capacity	Percentage of total capacity	Average capacity per mill	Production	Percentage of total production	Average production per mill	Capacity utilized
		MMBF[a]	*Percent*	*MMBF*[a]	*MMBF*[a]	*Percent*	*MMBF*[a]	*Percent*
10 MMBF or less	10	18.1	0.8	1.8	8.7	0.4	0.9	48.3
10 to 50 MMBF	6	166.4	7.2	27.7	138.3	6.8	23.1	83.1
50 to 100 MMBF	5	415.0	18.1	83.0	347.5	17.2	69.5	83.7
More than 100 MMBF	11	1,697.0	73.9	154.3	1,527.9	75.5	138.9	90.0
2016 Total	32	2,296.5	100.0	71.8	2,022.5	100.0	63.2	88.1
2012 Total	30	2,467.5	100.0	82.2	1,917.0	100.0	63.9	77.7
2006 Total	33	3,067.2	100.0	92.9	2,453.3	100.0	74.3	80.0
2000 Total	47	3,878.5	100.0	82.5	3,137.7	100.0	66.8	80.9

MMBF = million board feet.
[a] Volume in million board feet lumber tally.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Lumber Recovery Factors and Overrun

Product recovery ratios, or the volume of output per unit of input, are reported for California's sawmills as lumber recovery factors (LRFs) and overrun. The LRF is the lumber output (in board feet lumber tally) divided by the timber input (in cubic feet). Overrun is the volume of lumber (in board feet lumber tally) obtained from a log in excess of the estimated volume based on log scale (board feet Scribner). Both overrun and LRF are measures of mill efficiency. Although overrun is the more common measure, it is not as useful as LRF because of the weakness of the Scribner scale as a measure of log input. The average size of logs processed in California has decreased over the past 50 years. As log diameters decrease, the Scribner log rule underestimates by an increasing amount the volume of lumber that can be recovered from a log, thus leading to increased overrun.

The statewide lumber recovery factor for California sawmills in 2016 was 8.72 board feet of lumber output per cubic foot of log input, a 10 percent increase since 2000 and a 2 percent decrease since 2012.

The volume of sawtimber used by California's sawmills in 2016 was approximately 232 MMCF (fig. 5) and lumber production was 2,022 MMBF lumber tally. Thus the statewide LRF for California sawmills in 2016 was 8.72 board feet of lumber output per cubic foot of log input, a 10 percent increase since 2000 (Morgan et al. 2004, 2012) and a 2 percent decrease since 2012 (McIver et al. 2015).

Increases in LRF are attributable primarily to improvements in processing technology. Technological improvements have made California mills more efficient in numerous ways. For example, log size (diameter and length) sensing capabilities linked to computers determine the best sawing pattern for logs to recover either the greatest volume or greatest value from each log. Improved sawing accuracies have reduced the amount of size variation in sawn lumber, reducing the need for planing and increasing solid wood recovery. Thinner kerf saws reduce the percentage of the log that becomes sawdust, and curved sawing technology has increased recovery from logs with sweep and crook (Keegan et al. 2010a). Small deviations up or down in LRF from year to year are not unusual and can be caused by an array of factors, including the number, size, and type of sawmills in operation during a given year.

During 2016, California sawmills produced 2,022 MMBF lumber tally by processing 1,235 MMBF, Scribner Decimal C, of logs yielding an overrun of 64 percent or 1.64 board feet of lumber per board foot Scribner of log input. A comparison of California sawmill overrun and LRF for various years is shown in figure 13. Though variations can be observed from year to year, both overrun and LRF for California sawmills has trended in an upward direction since 1968.

Despite the long-term trend toward smaller logs discussed above, the average log size processed by California sawmills increased slightly from 2012 to 2016 (table 18). During 2016, 78 percent of logs processed by sawmills had a small-end diameter greater than 10 inches. This represents an increase over the 75 percent of logs with small-end diameters of more than 10 inches in 2012 (McIver et al. 2015) and the 72 percent in 2006 (Morgan et al. 2012).

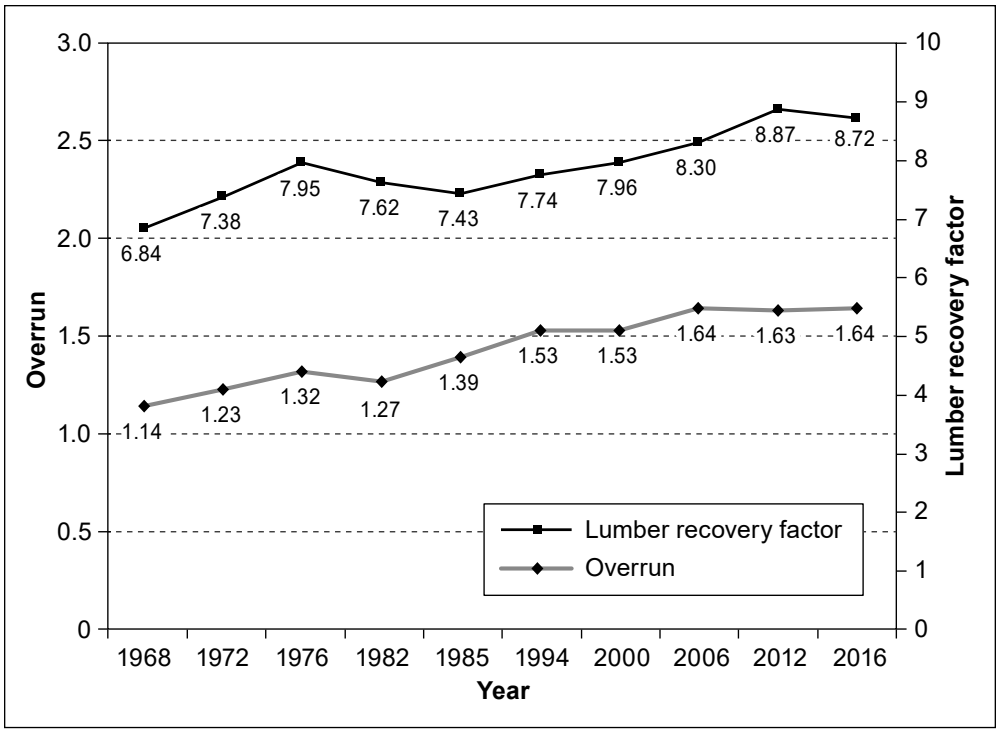

Figure 13—Lumber recovery factor and overrun in California sawmills, various years.

Table 18—Proportion of logs processed by sawmills by small-end diameter

Small-end diameter	2006	2012	2016
Inches		*Percent*	
<7	9	7	7
7–10	19	18	0.15
Total <10	28	25	22
10–24	51	52	58
>24	21	23	20
Total >10	72	75	78

Mill Residuals: Quantity, Type, and Use

In 2016, roughly 50 percent of the total fiber (wood and bark) processed by primary wood manufacturing facilities ended up as mill residuals, down from 56 percent in 2012 and 60 percent in 2006 (McIver et al. 2015, Morgan et al. 2012). These residuals can present difficult and expensive disposal problems or they can be used to create additional products or energy to generate revenue. California's substantial bioenergy industry is the largest consumer of the wood residual generated in the state, whereas sawmills are the largest residual producers. Facilities producing landscaping mulch, decorative bark, and animal bedding products are also large users of mill residuals in California.

Roughly 50 percent of the total fiber (wood and bark) processed by primary wood manufacturing facilities ended up as mill residuals, down from 56 percent in 2012 and 60 percent in 2006.

Three types of wood residuals are created by California's primary wood products industry: coarse or chippable residuals consisting of slabs, edging, trim, log ends, and pieces of veneer; fine residuals consisting primarily of planer shavings and sawdust; and bark. The 2016 census gathered information on volumes and uses of mill residuals. Actual residual volumes, reported in BDU, were obtained from facilities that sold all or most of their residuals. One BDU is the equivalent of 2,400 lbs of oven-dry wood. All mills reported, on a percentage basis, how their residuals were used.

Residual volume factors, which express mill residuals generated per unit of output produced, were derived from production and residual output volumes reported by mills. California's sawmills produce residuals during their normal production process. Residual factors for 2000, 2006, 2012, and 2016 as shown in table 19 represent statewide averages. During 2016, sawmills in California produced a similar amount of residuals per thousand board feet of lumber as in 2012, producing a slightly higher amount of planer shavings and slightly less bark. The 2016 and 2012 sawmill residual factors indicate lower residual production than during 2000 and 2006. Several factors can contribute to changes in mill residual production. In general, changes in the size and species mix of logs received and products produced by sawmills can cause residual factors to change (Keegan et al. 2010a, 2010b). Improved milling technology and increases in average log size tend to reduce the amount of planer shavings, sawdust, and coarse residual generated per unit of lumber.

In 2016, California sawmills generated 1.58 million BDU of mill residuals, accounting for 90 percent of all mill residuals generated that year (table 20). Veneer plants, a utility pole facility, a log home accent plant, and a log furniture facility accounted for the remaining 9 percent of mill residuals produced during 2016. Coarse residual accounted for the largest proportion of residuals at approximately

Table 19—California's sawmill residual factors, 2000–2016

Type of residual	2000	2006	2012	2016
	Bone-dry units per MBF[a]			
Coarse	0.41	0.37	0.33	0.33
Sawdust	0.15	0.15	0.14	0.14
Planer shavings	0.13	0.11	0.08	0.10
Bark	0.23	0.21	0.22	0.21
Total	0.92	0.85	0.77	0.78

[a] Bone-dry units (2,400 lbs of oven-dry wood) of the various residual types generated for every thousand board feet (MBF) of lumber manufactured.
Source: McIver et al. 2015; Morgan et al. 2004, 2012.

Table 20—Volume of wood residuals generated by California's sawmills, 2016

Residual type	Wood residuals			Percentage of type		
	Used	Unused	Total	Used	Unused	Total
	Bone-dry units[a]			*Percent*		
Coarse	664,937	65	665,002	99.99	0.01	42.01
Fine						
Sawdust	276,012	1,488	277,500	99.46	0.54	17.53
Planer shavings	211,693	29	211,722	99.99	0.01	13.37
Bark	427,881	877	428,758	99.80	0.20	27.09
All residuals	1,580,523	2,458	1,582,981	99.84	0.16	100

[a] One bone-dry unit = 2,400 lbs of oven-dry wood.

42 percent, with bark accounting for 27 percent. More than 99 percent of residuals generated by sawmills during 2016 was utilized, either internally by the mill or sold for other products.

More than 1.75 million BDU of wood products residuals were generated during 2016, which is 7 percent more than in 2012. Coarse residuals were the largest component of wood products residuals in the state (table 21). Facilities in California produced 754,214 BDU of coarse residuals, and only 80 BDU were not used. Sixty-two percent of coarse residuals was used to produce energy, 21 percent was used by reconstituted board plants, and 16 percent was sold and used for other products.

Fine residuals—sawdust and planer shavings—made up 29 percent of residuals (505,216 BDU) in 2016. Fine residuals increased 22 percent from 2012 to 2016. Sawdust composed 57 percent and planer shavings 43 percent of fine residuals.

More than 99 percent of residuals generated by sawmills during 2016 was utilized, either internally by the mill or sold for other products.

Table 21—California's production and disposition of wood products residuals, 2016

Type of residual[a]	Total utilized	Reconstituted board	Energy	Landscape products, animal bedding, and other uses	Unutilized	Total produced
			Bone-dry units[b]			
Coarse	754,134	160,450	470,734	122,951	80	754,214
Fine						
Sawdust	287,770	16,559	221,259	49,952	1,488	289,258
Planer shavings	215,929	15,172	56,475	144,282	29	215,958
Bark	490,416	—	259,355	231,061	1,177	491,593
All residuals	1,748,249	192,181	1,007,822	548,246	2,773	1,751,022

— = zero.
[a] Includes residuals from the manufacture of lumber, veneer, utility poles, log furniture, firewood, export logs, and house logs.
[b] One bone-dry unit = 2,400 lbs of oven-dry wood.

Nearly 100 percent of fine residuals were utilized, with less than 1 percent left unutilized, most of which was sawdust. Fine residuals were primarily used as fuel in the production of energy (277,734 BDU or 55 percent) or for landscaping and other products (194,234 BDU or 38 percent). In 2016, California timber-processing facilities generated 491,593 BDU of bark—practically all of which was used by other sectors. Fifty-three percent of bark (259,355 BDU) was used for bioenergy and 47 percent (231,061 BDU) was used as landscaping or soil additives.

Forest Industry Employment and Earnings

Data reported in the FIDACS mill census were used in conjunction with employment and earnings data from the U.S. Department of Commerce (USDC) Regional Economic Information System to identify employment and labor income for California's primary and secondary forest products industry. Although the U.S. government changed the way it reported economic data and classified employment by sector in 2001, the USDC Bureau of Economic Analysis (BEA) has made state-level personal income information available from 1998 through the present. This period formed the basis of the analysis in this section. For further reading on changes in government reporting systems for economic data, see Morgan et al. (2012).

Primary forest products manufacturers are just one component of the broader forest industry in California. The classification of forest industries used here follows the North American Industry Classification System (NAICS) available online on the BEA website. The forest products industry shows up in four categories:

- NAICS 113—forestry and logging
- NAICS 1153—forestry support activities
- NAICS 321—wood products manufacturing
- NAICS 322—paper manufacturing (secondary)

These categories include employees who work in both the primary and secondary wood products and paper-manufacturing sector. Given the absence of primary paper manufacturing in California, all figures mentioned pertain solely to recycled paper or secondary paper manufacturing. Note that the four NAICS categories used to characterize the forest industry likely underestimate total employment because they do not include log hauling (trucking) companies, lumber and construction material wholesalers, road construction and maintenance contractors, and forest management services performed by government agencies or nonprofit organizations. Data from the Quarterly Census of Employment and Wages, a product of the U.S. Department of Labor Bureau of Labor Statistics, were combined with BEA data to estimate employment and labor income associated with forestry support activities. These publicly available data sources provide a point of comparison for

estimates of employees and labor income for the primary forest products manufacturers as well as additional information on the larger forest industry.

In 2016, total employment in the forest industry in California was an estimated 57,890 full- and part-time workers (USDC BEA 2018a; USDL BLS 2017). Of these, approximately 28,680 workers were employed in the manufacturing of primary and secondary wood products. In addition, we estimate that nearly 5,200 were employed in forestry and logging and 1,595 provided supporting activities for forestry operations. An additional 22,340 workers manufactured secondary paper products in California during 2016 (fig. 14).

In 2016, total employment in the forest industry in California was an estimated 57,890 full- and part-time workers.

Although 2009 is considered the end of the Great Recession, 2011 and 2012 had the lowest levels of total forest industry employment for California in the past two decades. Wood products manufacturing in California experienced the most dramatic decline over the past 15 years, with all employment sectors seeing decreases

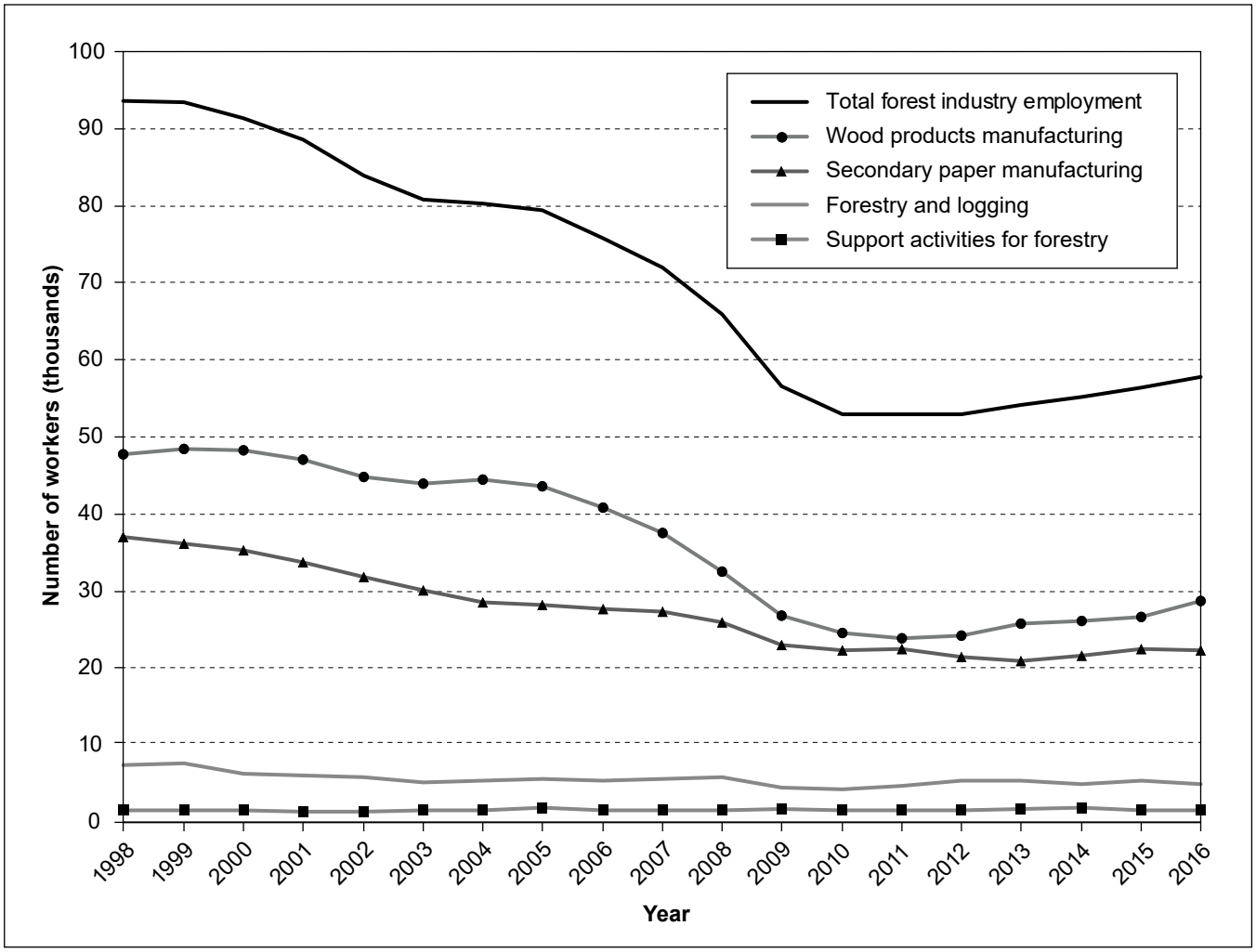

Figure 14—Employment in California's forest industry, 1998–2016.

beginning in 2003 and lasting for nearly a decade. The Great Recession contributed to weak demand for wood products, and mill closures and curtailments were observed across all Western states. Recovery has been slow, but employment in California's forest industry has experienced growth during recent years. Since 2012, total employment in the forest industry has been on an upward trend. The 9 percent growth in total forest industry employment from 2012 to 2016 was led by wood products manufacturing, which increased by 18 percent. Although forestry and logging employment decreased by 2 percent from 2012 to 2016, secondary paper manufacturing employment increased by 4 percent and forestry support activities by 2 percent over the same period.

Workers in the forest industry earned more than $3.6 billion in labor income or worker earnings in 2016.

Workers in the forest industry earned more than $3.6 billion in labor income or worker earnings in 2016 (USDC BEA 2018b; USDL BLS 2017) (fig. 15), with the average employee across all sectors of the forest industry making $60,500 annually. Labor income includes wages and salaries, some benefits, and earnings of the self-employed. Labor income growth for the forest industry as a whole (14 percent) between 2012 and 2016 exceeded total forest industry employment growth (9 percent) over the same period. Since 2012, inflation-adjusted earnings in the wood products manufacturing sector increased by 22 percent, slightly outpacing employment growth in that sector. The average wood products manufacturing employee earned approximately $48,000 in 2016. Despite decreasing employment in forestry and logging between 2012 and 2016, labor income for these employees grew by 30 percent over the same period. Labor income for forestry support activities and secondary paper manufacturing increased between 2012 and 2016 by 2 and 7 percent, respectively—amounts that are similar to the employment growth in each sector over the same period.

Wage growth outpacing employment could be attributed to a variety of factors, including general wage increases across forest industry sectors and efforts toward employee retention, as well as the inclusion of both full- and part-time workers in BEA employment estimates. For example, when wages grow faster than employment, it may point to employees who were previously working part time adding more hours or days, which increases wages paid by businesses but does not change the overall employment estimate. Although nearly every sector of the forest industry has experienced increasing labor income levels since 2012, income levels generally declined across the industry after 2006 (a 23 percent decrease), with the exception of support activities for forestry.

Support activities for forestry (NAICS 1153) encompasses a variety of activities, including wildfire suppression and prevention activities, tree thinning and planting, and pest management. The employment and wage growth experienced in

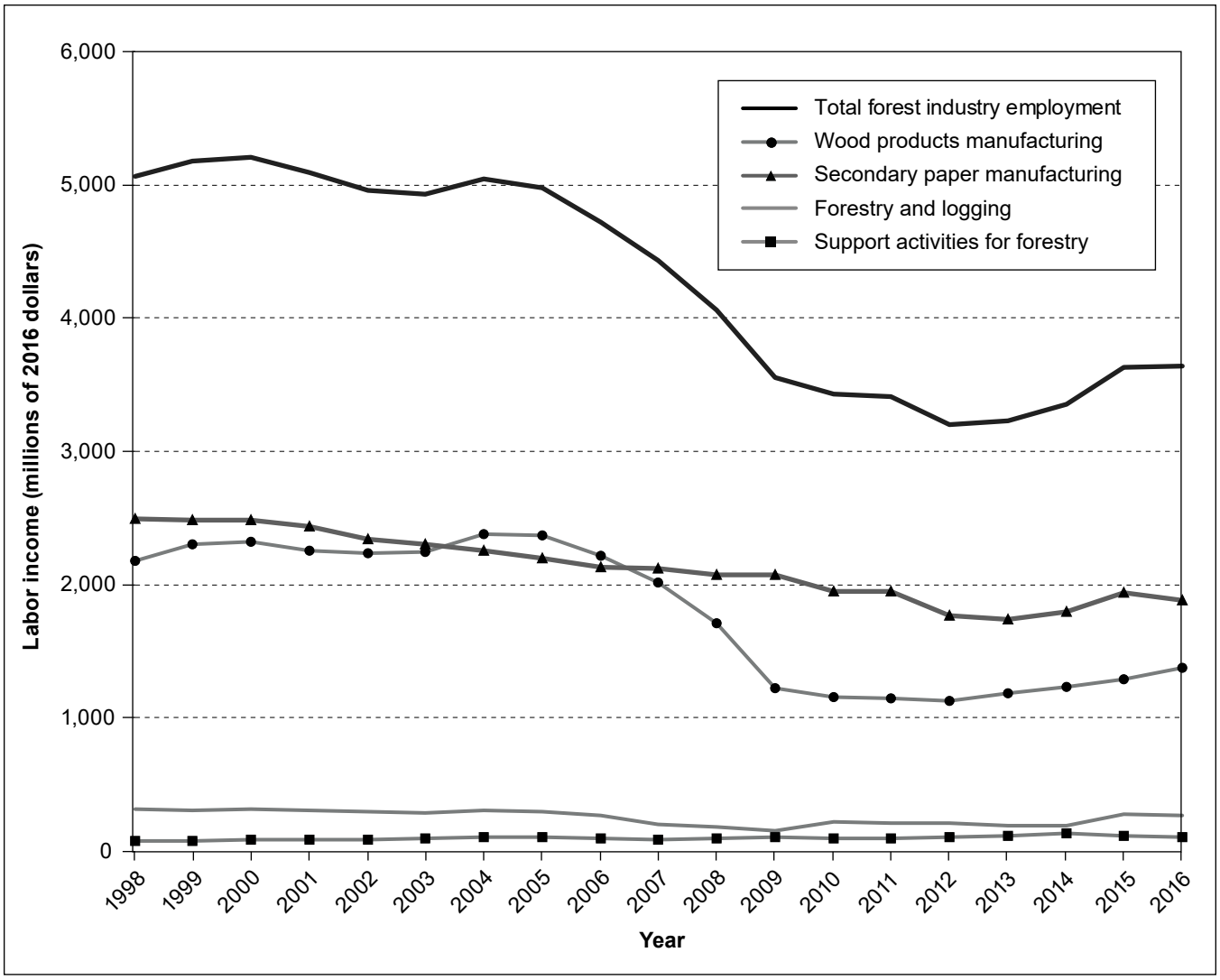

Figure 15—Inflation-adjusted earnings in California's forest industry, 1998–2016.

this category may be explained by a number of interrelated factors. First, the timing of the upward trend (2009–2010) coincides with federal investments in infrastructure made through the American Reinvestment and Recovery Act. Second, as timber harvest levels have declined, businesses previously involved in commercial timber harvesting have diversified into noncommercial thinning, fuels reduction, and wildfire suppression activities, thus causing these businesses to be reclassified from forestry and logging to support activities for forestry. Finally, investments in noncommercial forest management activities likely increased in Western states, including California, during this time because of extensive mortality resulting from the mountain pine beetle epidemic and severe drought conditions.

Economic Contribution of California's Forest Industry

Economic contribution analyses measure gross changes in economic activity in an existing regional economy that can be associated with an industry, event, or policy (Watson et al. 2007). For this report, we assessed the contribution of California's forest industry as dollars spent on intermediate inputs, taxes, and labor and, in turn, by households. All these expenditures generate economic opportunities as they cycle through the state's economy.

The wood products and secondary paper manufacturers, forestry and logging workers, and forestry support firms that constitute California's forest industry directly contributed approximately 57,891 jobs and $3.6 billion dollars in labor income to the state. The activity associated with this direct employment generated additional economic opportunities, as they rely on other industries' intermediate inputs and services, thus indirectly supporting employment and wages in additional sectors.

For every wood products manufacturing job in the state, another 1.3 jobs were supported in related sectors, and for every $1 dollar paid in labor income by wood products manufacturers, another $1.50 is paid in supporting sectors.

Using regional data and existing linkages within California's economy represented by the BEA's RIMS II multipliers (USDC BEA 2016), we estimated that the wood products manufacturing sector alone supported more than 66,000 full- and part-time jobs and an associated $3.4 billion dollars in labor income in 2016 (table 22). In other words, for every wood products manufacturing job in the state, another 1.3 jobs were supported in related sectors, and for every $1 dollar paid in labor income by wood products manufacturers, another $1.50 is paid in supporting sectors, including forestry and logging, forestry support, trucking, wholesale trade, and management.

Likewise, we estimated that the 5,266 people employed in the forestry and logging sector support an additional 6,824 full- and part-time jobs along with more than $250 million dollars in labor income in supporting sectors, such as equipment sales and repair. Note that we intentionally do not aggregate sectors nor provide estimates of the total employment and labor income contribution for the entire forest industry. Doing so would result in double-counting, as some employment and labor income feature as both direct contribution of one sector and indirect or induced contributions of another sector. For example, some or all of direct employment and labor income in the forestry and logging sector would be included as indirect and induced contributions of the wood products manufacturing sector because these manufacturers rely upon forestry and logging businesses to supply their raw material inputs.

Wood products and paper manufacturing represent both primary and secondary employment and labor income estimates. California's secondary wood and paper products industries are concentrated near population centers in the state's southern and central counties. The primary forest products industry is concentrated in the northern

counties, closer to where timber harvesting occurs. The primary portion of the industry is integrally linked to forest management practices in the state, while the link is not as pronounced with the secondary industry. Consequently, statewide policies and legislation, whether related to the environment, labor, or forest products industry, will generally have larger impacts on the residents of the northern counties than the state's population as a whole.

Since 2012, the California State Legislature has been interested in wood utilization and increasing forest industry processing capacity in response to severe wildfires and tree mortality. Several state bills, policies, and key reports have indicated the need to increase wood-processing capacity across all sectors of the forest industry, including assembly bills about mass timber and innovative forest products (AB2518 and AB1823); the BioRAM and BioMAT programs for biomass energy facilities; the AB1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory; and other regional or local efforts. Forest industry processing capacity in California continues to be challenged by many issues such as the high cost of doing business in California, labor shortage, lack of appropriate workforce skills, and the high cost or limited supply of raw materials. Despite these challenges, new opportunities and emerging markets for wood products, including low-value wood for biomass energy, may help increase the financial viability of ecosystem restoration goals and play a role in forest management efforts in response to beetle kill, drought, extreme weather conditions, and population expansion affecting California forests.

Acknowledgments

We thank all the participating wood products facility owners, managers, and staff who provided detailed information about their operations. In addition, we are grateful for the comments and input provided by Steve Brink, California Forestry Association; Larry Swan and Helena Murray, USDA Forest Service State and Private Forestry; Bill Stewart, University of California, Berkeley; Nadia Tase, California Department of Forestry and Fire Protection; the USDA Forest Service, Forest Inventory and Analysis program; and all the reviewers of the manuscript and summary data tables.

Table 22—Average annual employment and labor income contributions from California's forest industry, 2016

Sector	Direct employment	Indirect and induced employment	Total employment contribution[a]	Direct labor income	Indirect and induced labor income	Total labor income contribution[a]
	Number of jobs			*Thousand 2016 dollars*		
Wood product manufacturing	28,685	37,534	66,219	1,374,406	2,061,265	3,435,671
Forestry and logging	5,266	6,824	12,090	273,460	251,200	524,660
Forestry support activities	1,595	627	2,222	105,093	53,009	158,102
Secondary paper manufacturing	22,345	58,573	80,918	1,886,131	2,834,289	4,720,420
Total forest industry	57,891	*a*	*a*	3,639,090	*a*	*a*

[a] Indirect and induced employment and labor income should not be summed for multiple sectors because some employment and income shows up as both direct contributions to their sector and indirect contributions to other sectors.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet (ft)	0.3048	Meters
Square feet (ft^2)	0.0929	Square meters
Acre (ac)	0.404	Hectare
Cubic feet (ft^3)	0.0283	Cubic meters
Cubic feet per acre (ft^3/ac)	0.06997	Cubic meters per hectare
Pounds (lbs)	0.3732	Kilogram

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