California Logging Utilization: 2004

Todd A. Morgan and Timothy P. Spoelma

ABSTRACT

A study of logging activities conducted during 2004 provided utilization data and information on timber harvesting operations in California. A nested and stratified sampling scheme was used to produce a sample of felled trees with distributions of geographic area, ownership class, tree species, and tree size representative of California's recent sawlog and veneer log harvest. Results of the study indicated that about 50% of the harvested trees were less than 16.5-in.dbh, but these trees produced just 15% of the volume. About 50% of the harvested volume came from trees less than 24.5-in. dbh, and about two-thirds of the volume was from trees less than 30-in. dbh. Removals factors, quantifying impacts on growing stock, revealed that 1,051.4 ft^3 of growing-stock volume was removed for every thousand cubic feet delivered to mills, with just 61.5 ft^3 left in the forest as logging residue. Periodic reevaluations of logging utilization in California would make it possible to evaluate impacts of technology, market conditions, and policy changes on logging operations and utilization factors in the state.

Keywords: growing-stock removals, logging residue, removals factors, timber harvest

Up-to-date information on timber harvesting activities is an essential element of well-informed forest management decisions. Information on the condition and changes in California's timber resource comes from three main sources: (1) statewide multiresource inventory, which quantifies existing conditions and changes due to land exchanges, timber harvest, mortality, and growth (Waddell and Bassett 1996, 1997a–1997d); (2) mill surveys, which characterize timber-processing facilities and quantify the volume of timber products delivered to primary wood products facilities (Howard and Ward 1988, Ward 1995, 1997, Morgan et al. 2004); and (3) logging utilization studies, which characterize harvest operations and determine what proportion of timber harvested actually is used.

Prior logging utilization studies likely were conducted in California; however, no published information from California studies with comparable methods and results has been identified. Substantial changes in California's wood products industry over the past 20 years—changes in volume and ownership source of harvest, harvesting and milling techniques, and numbers and types of mills operating (Morgan et al. 2004)—have necessitated a logging utilization study to reflect the effects of contemporary timber harvesting on forest inventory. Information provided by logging utilization studies includes volumes of growing stock (i.e., live trees 5.0-in. dbh or more measured from a 1-ft stump height to a 4-in. top diameter outside bark [dob]), sawtimber (i.e., growing-stock trees with dbh 9 in. or more for softwoods or dbh 11 in. or more for hardwoods), and nonsawlog portions of sawtimber trees (i.e., below the 1-ft stump or above the 7-in. top dob for softwoods or 9-in. dob for hardwoods) left in the forest as logging residue, as well as the diameter distribution of harvested trees and descriptions of harvesting techniques and equipment currently used by loggers.

In 2004, the authors undertook a study of logging utilization in California in cooperation with the US Forest Service, Pacific Northwest Forest Inventory and Analysis Program. The overall goal of this study was to acquire and analyze logging utilization data for timber harvests in California. The specific objectives toward this end were to

1. Characterize California's timber harvest by tree size.
2. Characterize harvest operations.
3. Provide removals factors to convert volumes received by primary wood processors into estimates of product volume removed from growing stock, product volume from nongrowing-stock sources, growing-stock logging residue, and total removals from growing stock.
4. Provide removals factors to convert volumes received by primary wood processors into estimates of product volume removed from sawtimber, product volume from nonsawlog portions of sawtimber trees, sawtimber logging residue, and total removals from sawtimber.

Methods

In California, there are more than a dozen commercially harvested tree species spread across 17.9 million acres of timberland (Smith et al. 2001), and recent annual harvest volumes have ranged from 1.6 to 2.2 billion board feet (bbf) (California State Board of Equalization 2000–2003, Morgan et al. 2004). Conducting a comprehensive logging utilization study in California presented numerous methodological and logistic challenges. Ideally, the population of logging operations expected to occur in the state during the year of analysis would be listed and stratified by important variables, and then a random sample of appropriate size from each strata would be

Received August 1, 2006; accepted December 3, 2006.

Todd A. Morgan (todd.morgan@business.umt.edu), and Timothy P. Spoelma (tim.spoelma@business.umt.edu), The University of Montana–Missoula, Bureau of Business and Economic Research, Gallagher Business Building, Missoula, MT 59812-6840. *The authors thank Brian Steele of the Mathematics Department at the University of Montana for assistance with the sampling design and statistical analysis; Tony Johnson, James Bentley, and Mike Thompson of the Forest Inventory and Analysis Program for assistance with fieldwork; Shana Jones of the California Department of Forestry and Fire Protection for Timber Harvest Plan information; and the private landowners, consultants, mills, and agency personnel for access to logging sites in California. This research was funded by the US Forest Service, Pacific Northwest Forest Inventory and Analysis Program in Portland, Oregon.*

selected and measurements taken at each operation. Given the nature of timber harvesting, it is not possible to establish far in advance precisely when, where, how, or even how much logging will take place. Harvest volumes and characteristics vary annually. Weather often causes managers to postpone or accelerate logging operations, changing markets may lead to a substantial shift in the quantity or kind of timber demanded by mills, and litigation may delay a scheduled harvest or stop one currently in progress. Thus, the demographics of recent harvests are the best predictors of current and future logging activities.

For this study, published timber harvest accounts and expert opinion of timber harvest professionals were used to develop an appropriate statewide sample that would capture the range in variability among different logging sites and among the harvested trees within sites. Morgan et al. (2004) summarized the volume of California's 2000 timber harvest in various ways, including by timber product type, ownership class, and county. The California State Board of Equalization produces annual summaries of the state's timber harvest by county and public versus private ownership classes (California State Board of Equalization 2000–2003), and the California Department of Forestry and Fire Protection keeps detailed records on each timber harvest plan submitted by private landowners planning a commercial timber harvest within the state (California Department of Forestry and Fire Protection 2005). This background information provided a means of defining the population of logging sites by timber product type and allowed for the volume-based stratification of potential logging sites by geographic location and landownership class.

Approximately 2.2 bbf, Scribner, were harvested during 2000 (Morgan et al. 2004). Green (live) timber accounted for 95.3% of the total harvest, and sawlogs and veneer logs accounted for 99.6% of the state's total harvest. Historically, sawlogs and veneer logs combined accounted for 96% or more of all timber harvested in California. The majority of the volume for other products (e.g., pulpwood, bioenergy, or posts) comes as secondary or tertiary products from saw or veneer log harvests or is sufficiently small in volume as to have only a minor impact on inventory relative to sawlogs and veneer logs. Therefore, the population of interest for this logging utilization study was logging operations where green sawlogs and/or veneer logs were the primary product. Previous logging utilization studies conducted by the Southern Research Station in the Southeast United States (Bentley and Johnson 2004, Johnson and Bentley 2004, Zarnoch et al. 2004) and by research foresters in Montana (Morgan et al. 2005) suggested that a sample of 30–50 logging sites with 20–35 felled trees measured at each site would be sufficient to determine state-level utilization factors for sawlogs and veneer logs in California.

Site Stratification and Selection

Three levels of sampling units were used in this study. The sample was nested on all levels. It was stratified on the first level and a random process was assumed on the second and third levels. The primary sampling units were forest resource areas. California has been divided historically into six forest resource areas each with four or more counties. Stratification was done by resource area, assigning the target number of logging sites to be measured in each resource area in proportion to the recent harvest volume from the resource area. From 2000 through 2003, about 99.9% of California's timber harvest has come from five of these forest resource areas: North Coast (31.3%), Northern Interior (29.7%), Sacramento (29.1%), San Joaquin (8.8%), and Central Coast (1.0%). For this study, the North Coast and Central Coast resource areas were combined into one area, Coastal, and stratification was done by the four resource areas (Figure 1).

The secondary sampling units were logging sites within each resource area. Sites were not chosen randomly but were assumed to be representative of the areas in which they were located. Two to 3 weeks in advance of field crews deploying to California, mills and/or agencies were contacted and asked to provide a list of sites within one or two adjacent resource areas from which they planned to harvest timber. Then, the landowners or unit managers were contacted to get permission for researchers to access the sites. The logging contractors were typically contacted a few days in advance, and a time was arranged for field crews to safely measure felled trees on the sites.

The tertiary sampling units were the felled trees on each site. Trees were randomly selected within each site independent of species, diameter, or form. For utilization analysis, it was necessary for the researchers to track and measure all components of a tree's main stem after felling. Each measurement tree had to be alive before harvest, at least 5.0-in. dbh, to qualify as a growing-stock tree (Figure 2), and it had to have all its bole available for measurement. Trees meeting these requirements were found lying throughout the harvest unit or accumulated in piles for skidding, depending on the operator and equipment being used. In cases where accumulating harvesting heads were used, it was assumed that placement of trees within a pile and among piles was random, and researchers selected as many trees in each pile that could be measured safely and precisely before moving to subsequent piles. Typically, no more than three trees could be measured in an individual pile because portions of the bole would be obscured by other trees in the pile.

Landownership class was used as a sampling constraint to further ensure a representative sample of statewide logging operations. Morgan et al. (2004) reported that about 47% of California's sawlog and veneer log harvest in 2000 came from industrial ownership, 36% came from nonindustrial private, 15% came from national forests, 1% came from other public ownerships, and less than 1% came from Tribal lands. Subsequent California State Board of Equalization (2001–2003) harvest reports indicated the proportion of public harvest was between 8 and 10% of annual harvest volume. Thus, the target number of logging operations measured on public lands was limited to a minimum of 5% and a maximum of 15% of all sites measured. Because of differences in the geographic distribution of available logging operations and public lands, this proportion of sites by ownership class was not maintained in each of the individual forest resource areas.

This sampling scheme, determining the number of measured sites based on geographic area and constrained by ownership class with approximately the same number of trees measured at each site, was anticipated to produce a sample of felled trees with distributions of geographic area, ownership class, tree species, and tree size that were representative of California's sawlog and veneer log harvest during recent years.

Data Collection

At each harvesting site, loggers provided information regarding the tree species, products being merchandised, and the preferred and acceptable log lengths to be sent to receiving mill(s). Researchers

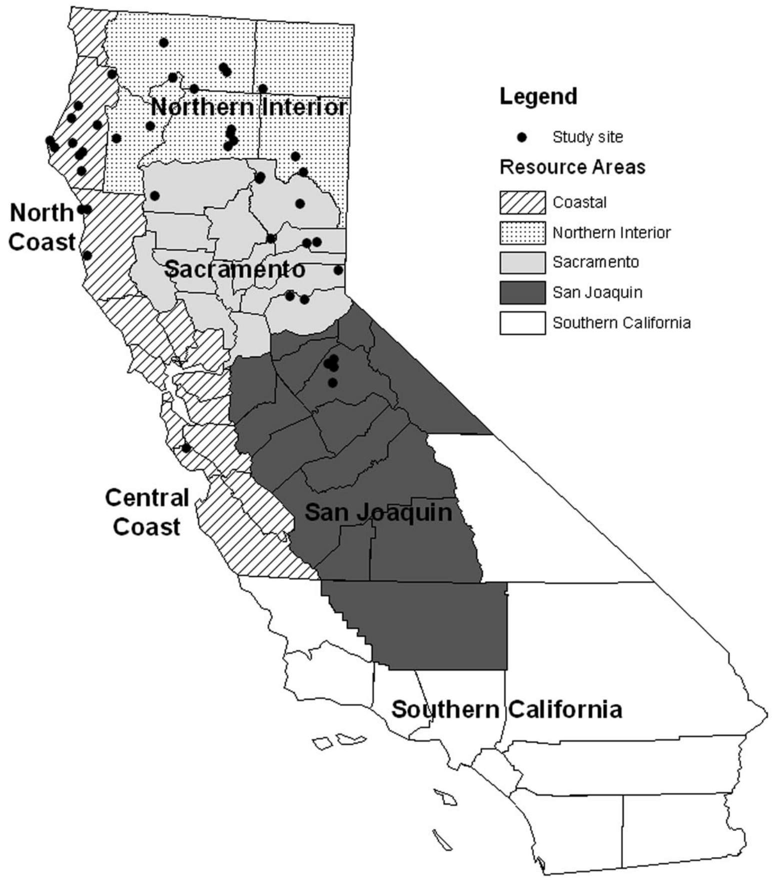

Figure 1. California logging utilization study sites.

recorded this information along with the date, county, landownership class, felling method, yarding/skidding method, log merchandising location and method, operator, equipment in use, and receiving mill(s).

For each measurement tree, a unique identification number was assigned, and species, dbh, primary product, bole length, and percent cubic cull were recorded. Diameter and section length measurements were taken at the cut stump height, at 1 ft aboveground level (uphill side of the tree), at breast height (4.5 ft aboveground on uphill side), at the 7.0-in. dob point, at the 4.0-in. dob point, and at the end-of-utilization point. Diameter and section length measurements were also taken along the bole on intervals corresponding to the lengths and sizes specified by the loggers, with a maximum section length of 16 ft. Thus, for each bole section, lower and upper dob and length were recorded. The percent cubic cull in each section was recorded also, and each bole section was identified as used (sent to a mill) or unused (left on-site).

Data Analysis

Individual section data for each tree were entered and checked, section volumes were calculated using Smalian's formula (Avery and Burkhart 1994), and data were combined into a master file with all trees from all sites in the state. The master data file was processed to develop utilization factors for each resource area, sample variances, and 95% confidence intervals according to the ratio of means method (Zarnoch et al. 2004). State-level utilization factors, sample variances, and 95% confidence intervals were then calculated as the means of the resource area factors weighted by the resource area's percentage of total sites. Data also were summarized by tree dbh, species, landownership class, and various characteristics of the harvest operations.

Results

Characteristics of Logging Operations

Between May 3 and Sept. 28, 2004, 42 logging operations in California were sampled. Harvesting operations were measured throughout the forest resource areas in California in four general ownership groups: industrial, nonindustrial private forestland, national forest, and state. The distributions of sampled sites by resource area and by ownership class closely matched the harvest proportions from Morgan et al. (2004), with the Costal and Northern Interior areas each accounting for one-third of the sites and public lands accounting for 14.3% of sampled sites (Table 1).

Logging operations included hand and mechanical felling methods as well as sites with a mix of the two methods, ground skidding and cable yarding systems, and hand and mechanical merchandising (Table 2). Mechanical felling methods included the use of accumulating heads such as a feller-buncher, as well as cut-to-length harvesting heads. Ground-based skidding included the use of skidders or dozers, which had either a grapple or a winch with chokers, as well as forwarding systems where material was stacked on a bunk that was unloaded at a landing or transferred directly onto a log truck. Mechanical merchandising methods included the use of stroke (slide-boom) delimbers and cut-to-length harvesting heads.

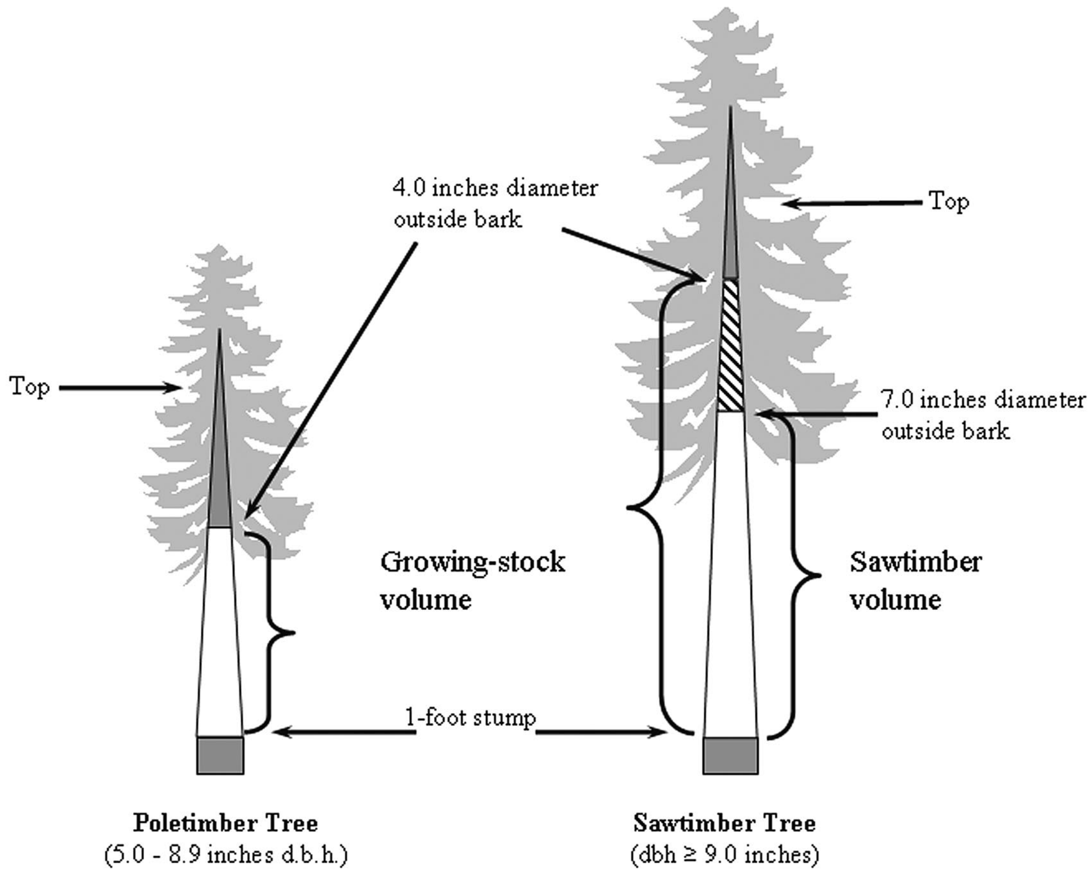

Figure 2. Stem sections of softwood pole-timber and sawtimber trees. Growing-stock volume is between the 1-ft stump and 4-in. dob of sawtimber and pole-timber trees. Sawtimber volume is between the 1-ft stump and 7-in. dob of sawtimber trees. Products from the tops, limbs, and stumps (shaded) are nongrowing-stock product volume. Products from sawtimber trees between the 7- and 4-in. dob (cross-hatched) are nonsawlog product volume.

Table 1. Number and percentage of California logging operations sampled by resource area and land ownership class, 2004.

Resource area	Ownership class				
	Industrial	NIPF	National forest	State	All owners
Coastal	6	7	1	—	14
Sacramento	5	2	3	—	10
Northern Interior	7	5	1	1	14
San Joaquin	4	—	—	—	4
All areas	22	14	5	1	42
	Percentage of sites				
Coastal	14.3	16.7	2.4	—	33.3
Sacramento	11.9	4.8	7.1	—	23.8
Northern Interior	16.7	11.9	2.4	2.4	33.3
San Joaquin	9.5	—	—	—	9.5
All areas	52.4%	33.3%	11.9%	2.4%	100%

NIPF, nonindustrial private forestland.

Hand felling and merchandising still is quite common in California, particularly in the Coastal resource area, where larger trees and steeper terrain limit the operability of mechanical felling and merchandising systems. In-woods merchandising, subsequently, is much more common than merchandising at landings, with merchandised (i.e., log-length) material being yarded or skidded to landings more frequently than tree-length material. However, at several sites, where tops and limbs were being used for biomass energy production, tree-length material was being brought to landings to minimize fuel loads in the forest and to facilitate the more efficient collection and loading of material for transport to biomass energy facilities.

Characteristics of Felled Trees

A total of 1,230 felled trees were measured for this study, ranging from 5.1- to 53.7-in. dbh (Table 3). About one-half (50.2%) of the felled trees had a dbh of less than 16.4 in. Results indicate that 0.4% of volume harvested for saw and veneer logs came from pole-timber trees (dbh, 5.0–8.9 in.), and about 65.5% came from sawtimber trees with a dbh of less than 29.0 in. Trees with a dbh 39.0 in. or more accounted for just 9.8% of volume delivered to mills for lumber, veneer, or plywood production during 2004. The volume-weighted median tree dbh was 24.3 in. The size distribution of total growing-stock removals (mill-delivered volume and logging residue

Table 2. Characterization of California logging operations by landownership class, felling method, yarding method, merchandising location, and merchandising method, 2004.

		Ownership		Felling			Yarding		Merchandising location		Merchandising method	
		Public	Private	Hand	Mechanical	Mixed	Ground	Cable	In-woods	Landing	Hand	Mechanical
Ownership	Public	6										
	Private	—	36									
Felling	Hand	2	27	29								
	Mechanical	4	4	—	8							
	Mixed	—	5	—	—	5						
Yarding	Ground	5	28	20	8	5	33					
	Cable	1	8	9	—	—	—	9				
Merchandising location	In-woods	3	30	27	2	4	25	8	33			
	Landing	3	6	2	6	1	8	1	—	9		
Merchandising method	Hand	2	31	29	—	4	24	9	31	2	33	
	Mechanical	4	5	—	8	1	9	—	2	7	—	9

Table 3. Distribution of felled trees, mill-delivered volume, growing-stock removals, and logging residue by tree diameter at dbh—California, 2004.

Tree dbh class	Percentage of felled trees	Percentage of mill-delivered volume (cubic basis)	Percentage of growing-stock removals (cubic basis)	Percentage of logging residue (cubic basis)
6	1.8	0.0	0.1	0.9
8	4.9	0.3	0.4	2.6
10	11.8	1.9	2.1	6.2
12	11.8	3.4	3.4	5.7
14	12.3	5.0	5.1	6.6
16	11.1	6.6	6.6	7.9
18	12.4	10.0	10.0	9.2
20	8.5	8.7	8.6	6.7
22	5.9	7.5	7.5	6.5
24	5.3	8.5	8.5	8.1
26	3.7	7.3	7.3	6.6
28	2.7	6.5	6.5	6.0
30	1.9	5.4	5.3	3.2
32	2.2	7.0	6.9	5.8
34	1.1	4.5	4.4	2.8
36	1.0	4.6	4.6	3.0
38	0.5	2.8	2.7	1.7
40	0.4	2.2	2.2	1.9
42	0.5	3.8	3.8	3.4
44	0.3	2.5	2.5	3.2
46	0.1	0.7	0.7	0.1
48	0.0	0.0	0.0	0.0
50+	0.1	0.7	0.8	1.8
All sizes	100%	100%	100%	100%

combined) was quite similar to mill-delivered volume. Logging residue (growing-stock volume cut or killed but not delivered to a mill) came from the small- to intermediate-sized trees in relatively greater proportions, with 3.5% of logging residue from pole-timber trees and 69.5% of residue volume from sawtimber trees with a dbh of less than 29.0 in.

The species composition of the 2004 felled trees (Table 4) was similar to the 2000 harvest (Morgan et al. 2004) for many of the softwood species. However, no record of the 2004 timber harvest by species has been published for a within-year comparison. True firs accounted for 34.2% of mill-delivered volume among the felled trees; Douglas-fir accounted for 26.7%, redwood accounted for 14.5%, and ponderosa pine accounted 14.0% of mill-delivered volume among felled trees. Hardwoods accounted for less than 0.1% of the felled tree volume, with only one hardwood tree measured.

The timber product mix of the 2004 felled trees (Table 5) was similar to the 2000 harvest (Morgan et al. 2004). However, individual trees measured in this logging utilization study were coded by the primary timber product derived from the tree. Volumes by product type reported by Morgan et al. (2004) were total mill-delivered volumes and included portions of trees (e.g., tops and limbs) that may have been used for a different purpose than the main stem or bole. Thus, one would expect the proportions of the felled trees to be lower than the total mill-delivered volumes for secondary or tertiary harvested products (i.e., posts and fuelwood).

Removals Factors

Removals factors quantify the amount of growing stock (Table 6) or sawtimber (Table 7) volume that is cut and either delivered to the mill or left in the forest during the process of harvesting timber. Removals factors are presented per thousand cubic feet (MCF) of green timber delivered to mills, thus allowing expansion of mill receipts to reflect the net impacts of timber product harvest on growing stock and sawtimber inventory.

During 2004, 10.1 ft^3 (F1) of every 1,000 ft^3 of green timber harvested in California and delivered to mills came from nongrowing-stock material (i.e., "overutilized" stumps and tops—stumps cut shorter than 1.0 ft, and tops smaller than 4.0-in. dob) on

Table 4. Distribution of felled trees, mill-delivered volume, growing-stock removals, and logging residue by tree species—California, 2004.

Tree species	Percentage of felled trees	Percentage of mill-delivered volume (cubic basis)	Percentage of growing-stock removals (cubic basis)	Percentage of logging residue (cubic basis)
True firs	35.8	34.2	34.0	31.9
Douglas-fir	23.8	26.7	26.9	27.8
Redwood	15.0	14.5	14.7	17.9
Ponderosa pine	12.5	14.0	13.8	11.2
Incense-cedar	5.7	2.5	2.6	4.5
Sugar pine	4.4	5.0	4.9	4.0
Other softwoods	2.8	3.0	3.0	2.6
Hardwoods	0.1	0.0	0.0	0.0
All species	100%	100%	100%	100%

Table 5. Distribution of felled trees, mill-delivered volume, growing-stock removals, and logging residue by timber product—California, 2004.

Timber product	Percentage of felled trees	Percentage of mill-delivered volume (cubic basis)	Percentage of growing-stock removals (cubic basis)	Percentage of logging residue (cubic basis)
Sawlogs	91.7	97.0	97.0	95.3
Veneer logs	5.3	2.5	2.5	3.6
Utility poles	1.7	0.4	0.4	0.9
Posts	0.3	0.0	0.0	0.2
Fuelwood	1.0	0.1	0.1	0.0
All products	100%	100%	100%	100%

Table 6. California growing-stock removals factors for each cubic foot of green material delivered to mills from growing-stock trees, 2004.

Growing-stock removals factor	Lower bound (95% CI)	Estimate	Upper bound (95% CI)
(F1) Nongrowing-stock product delivered to mills	0.0062	0.0101	0.0140
(F2) Growing-stock product delivered to mills	0.9860	0.9899	0.9938
(F3) Growing-stock logging residue	0.0501	0.0615	0.0730
(F4) Removals from growing stock	1.0435	1.0514	1.0594

Table 7. California sawtimber removals factors for each cubic foot of green material delivered to mills from sawtimber-sized trees, 2004.

Sawtimber removals factor	Lower bound (95% CI)	Estimate	Upper bound (95% CI)
(F5) Nonsawlog product delivered to mills	0.0126	0.0221	0.0316
(F6) Sawlog product delivered to mills	0.9684	0.9779	0.9874
(F7) Sawlog logging residue	0.0240	0.0302	0.0363
(F8) Sawlog removals from sawtimber	0.9930	1.0081	1.0232

growing-stock trees and 989.9 ft^3 (F2) came from the growing-stock portion of those trees (Table 6). Every 1,000 ft^3 delivered to mills resulted in 1,051.4 ft^3 (F4) being removed from growing-stock inventory. Of the 1,051.4 ft^3 removed from growing-stock inventory, 989.9 ft^3 were growing-stock product delivered to mills, and 61.5 ft^3 (F3) were logging residue left in the forest. Logging residue includes not only growing-stock portions of trees that are not used during the processing of a tree into logs, but residue also includes entire growing-stock trees that may be cut down or otherwise killed and left on-site.

For every 1,000 ft^3 of green timber delivered to the mills from sawtimber trees (Table 7), 22.1 ft^3 (F5) came from nonsawlog portions of sawtimber trees, and 977.9 ft^3 (F6) came from the sawlog portions. For every 1,000 ft^3 delivered to mills, 1,008.1 ft^3 (F8) were removed from sawlog inventory, with 30.2 ft^3 (F7) remaining in the forest as sawlog logging residue, and 977.9 ft^3 going to mills.

Conclusions

The sampling design used in this study succeeded at capturing the range in variability among logging sites and among harvested trees within sites. The geographic stratification of sites provided a representative sample of harvested volume when compared with harvest records by resource area, ownership class, and timber product. The design also did fairly well at capturing the more frequently harvested species, but not as well with the very infrequently harvested species, particularly hardwoods. Future studies could be improved by incorporating constraints on species composition to ensure sufficient representation of hardwood harvest while avoiding the oversampling of certain softwood species.

Results of the California logging utilization study illustrate several important points: loggers in California still use a variety of harvesting and merchandising techniques, including traditional hand felling and bucking of logs, as well as highly mechanized systems; a substantial portion, about two-thirds, of California's timber harvest volume comes from trees less than 30-in. dbh; and logging residue accounts for very little of the material removed from growing stock during timber harvesting. For example, California's 2000 harvest volume of saw and veneer logs was 419 million cubic feet (MMCF), exclusive of bark (Morgan et al. 2004). With 95.3% of that harvest coming from live trees and the growing-stock removals factors calculated in this report (Table 6), the total impact to growing stock in 2000 was about 420 MMCF, and only 25 MMCF of growing-stock material was left in the forest as logging residue.

Periodic reevaluations of logging utilization in California would make it possible to evaluate impacts of technology, market conditions, and policy changes on logging operations and utilization factors in the state. For example, remeasurements of logging utilization in Montana on an approximately 20-year basis have shown dramatic reductions in the size of trees harvested and the amount of growing-stock residue left in the forest as a result of logging activities (Morgan et al. 2005). Although historic logging utilization studies for California are unavailable, future studies like this one can help provide the data needed to analyze these trends. Understanding how California's timber harvest continues to change will benefit those with an ongoing interest in sound forest management and wood fiber utilization.

Literature Cited

AVERY, T.E., AND H.E. BURKHART. 1994. *Forest measurements*, 4th Ed. McGraw-Hill, Inc., New York. 408 p.

BENTLEY, J.W., AND T.G. JOHNSON. 2004. *Eastern Texas harvest and utilization study, 2003.* US For. Serv. Resourc. Bull. SRS-97, Southern Res. Stn., Asheville, NC. 28 p.

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION. 2005. *Resource management-forest practice.* Available online at www.fire.ca.gov/php/rsrc-mgt_forestpractice.php; last accessed July 26, 2006.

CALIFORNIA STATE BOARD OF EQUALIZATION. 2000–2003. *California timber harvests by county. Timber Yield Tax Program.* Available online at www.boe.ca.gov/proptaxes/timbertax.htm; last accessed July 26, 2006.

HOWARD, J.O., AND F.R. WARD. 1988. *California's forest products industry: 1985.* US For. Serv. Resourc. Bull. PNW-RB-150, Pacific Northwest Res. Stn., Portland, OR. 72 p.

JOHNSON, T.G., AND J. BENTLEY. 2004. *Personal consultation with Timber Product Output Foresters.* Southern Res. Stn., Forest Inventory and Analysis, Knoxville, TN. Personal communication.

MORGAN, T.A., C.E. KEEGAN III, T. DILLON, A.L. CHASE, J.S. FRIED, AND M.N. WEBER. 2004. *California's forest products industry: A descriptive analysis.* US For. Serv. Gen. Tech. Rep. PNW-GTR-615, Pacific Northwest Res. Stn., Portland, OR. 55 p.

MORGAN, T.A., T.P. SPOELMA, C.E. KEEGAN III, A.L. CHASE, AND M.T. THOMPSON. 2005. *Montana logging utilization, 2002.* US For. Serv. Res. Pap. RMRS-RP-52, Rocky Mountain Res. Stn., Fort Collins, CO. 12 p.

SMITH, W.B., J.S. VISSAGE, D.R. DARR, AND R. SHEFFIELD. 2001. *Forest resources of the United States, 1997.* US For. Serv. Gen. Tech. Rep. NC-219, North Central Res. Stn., St. Paul, MN. 191 p.

WADDELL, K.L., AND P.M. BASSETT. 1996. *Timber resource statistics for the North Coast Resource Area of California, 1994.* US For. Serv. Resourc. Bull. PNW-RB-214, Pacific Northwest Res. Stn., Portland, OR. 50 p.

WADDELL, K.L., AND P.M. BASSETT. 1997a. *Timber resource statistics for the Sacramento Resource Area of California.* US For. Serv. Resourc. Bull. PNW-RB-220, Pacific Northwest Res. Stn., Portland, OR. 50 p.

WADDELL, K.L., AND P.M. BASSETT. 1997b. *Timber resource statistics for the Central Coast Resource Area of California.* US For. Serv. Resourc. Bull. PNW-RB-221, Pacific Northwest Res. Stn., Portland, OR. 45 p.

WADDELL, K.L., AND P.M. BASSETT. 1997c. *Timber resource statistics for the North Interior Resource Area of California.* US For. Serv. Resourc. Bull. PNW-RB-222, Pacific Northwest Res. Stn., Portland, OR. 49 p.

WADDELL, K.L., AND P.M. BASSETT. 1997d. *Timber resource statistics for the San Joaquin and Southern Resource Area of California.* US For. Serv. Resourc. Bull. PNW-RB-224, Pacific Northwest Res. Stn., Portland, OR. 51 p.

WARD, F.R. 1995. *California's forest products industry: 1992.* US For. Serv. Resourc. Bull. PNW-RB-206, Pacific Northwest Res. Stn., Portland, OR. 68 p.

WARD, F.R. 1997. *California's forest products industry: 1994.* US For. Serv. Resourc. Bull. PNW-RB-217, Pacific Northwest Res. Stn., Portland, OR. 60 p.

ZARNOCH, S.J., J.W. BENTLEY, AND T.G. JOHNSON. 2004. *Determining sample size for tree utilization surveys.* US For. Serv. Res. Pap. SRS-34, Southern Res. Stn., Asheville, NC. 11 p.