

# California Black Oak—From Firewood to Lumber, the Lumber Recovery Story<sup>1</sup>

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**Abstract:** Interest in use of local western hardwoods is increasing, especially among secondary manufacturers. In the case of black oak, trees have traditionally been sold for firewood, but a better economic use of this material would be to manufacture products such as furniture or flooring. Questions regarding the quality of black oak (*Quercus kelloggii*) for these products have been raised. This study sampled 140 black oak trees to determine lumber volume recovery and value recovery by tree and log grade. Two types of mills, a portable sawmill and a mill that typically saws softwoods, manufactured the lumber for this study. Volume recovery differed between mills, and differences were found between both tree and log grades in terms of value.

As opportunities for the commercial use of the softwood resource in California become limited because of environmental pressures and land-use restrictions, there is an increased interest in the utilization potential of hardwoods. Much hardwood lumber from the eastern United States is used by manufacturers producing value-added products. Questions and concerns about the quantity of hardwoods in California and their quality for wood products have been raised. Answers to these questions are critical to developing a hardwood industry in California.

A combined effort of state and local agencies to evaluate the hardwood resource in five counties (Amador, El Dorado, Nevada, Placer, and Sierra Counties) was undertaken in 1989. The resulting publication, *Hardwood Resource, Assessment, and Management* (McCaskill 1990), examined the hardwood resources on private land in the five counties and developed a tree-grading system to describe the quality of the hardwood resource. It is estimated that the five counties contain approximately 548,000 acres of hardwood woodland or commercial timberland outside National Forests (Bolsinger 1988) and that California harvests less than 5 percent of the annual hardwood growth (Smith 1986). At that level of harvest, the volume of hardwood resource will increase, with much of the small amounts harvested going primarily for firewood, an underutilization of its economic potential.

The High Sierra Resource Conservation and Development Area Council (High Sierra RC&D) wanted to supplement this inventory information with product recovery information. Their primary interest is in California black oak (*Quercus kelloggii*) which grows abundantly on the west side of the Sierra Nevada. It is also found in the northern Coast Range of California. This species grows in a wide elevation range (400-7000 feet) and is associated with six forest cover types. Black oak is primarily found in mixed conifer stands and is not a major component of the Canyon Live Oak Type (Burns and Honkala 1990) or other oak types found at low elevations.

Godden, Stanley, and Huber (1993) selected black oak trees from one site in the Sierra Nevada and performed a lumber recovery study on logs from these trees using a portable (Mobile Dimension) sawmill. The USDA Forest Service Pacific Northwest Research Station (PNW) Timber Quality Research (TQR) Team was contacted by the High Sierra RC&D to conduct a larger scale study using trees from a broader geographic area and to observe differences in lumber

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recovery between a portable mill and a conventional sawmill. In addition to the High Sierra RC&D and PNW, cooperators for this study included USDA Forest Service Region 5, California Department of Forestry and Fire Protection, University of California Blodgett Research Forest, Sierra Pacific Industries, California Hardwood Producers Co-op, Inc. and Willits Redwood.

This study was designed to provide baseline lumber volume recovery of black oak by log diameter, analyze differences in value between tree grades, and note differences between two different types of sawmill operations.

Methods

Sample

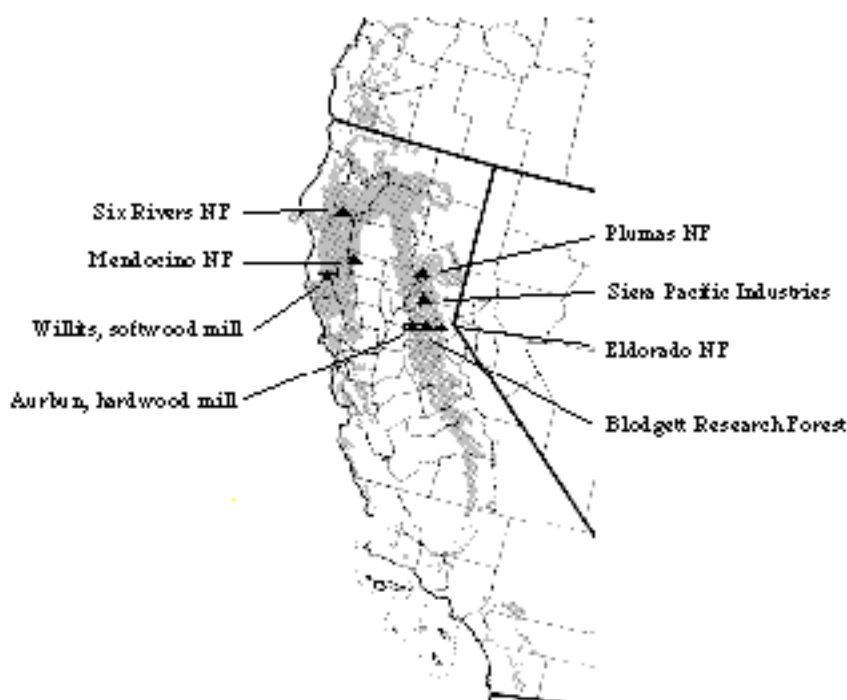
To determine baseline recovery for black oak, the sample was designed to cover the diameter and quality (tree grade) range of merchantable black oak trees. The sampling matrix was 2-inch dbh (diameter at breast height) class (10 to 36+ inches, a total of 14 classes) by tree grades (grades 1, 2, and 3). Trees were graded according to eastern hardwood tree grades developed by Hanks (1976). A target of seven trees for each dbh class/tree grade combination was set, resulting in a desired sample size of 294 trees for the study. Limitations in the available sample made it impossible to fill all combinations. Finding large-diameter trees of lower grades proved difficult because quality of the butt log generally increases as tree diameter increases. Conversely, locating high-grade, small-diameter trees was not always possible. Minimum log diameters established by the grading rules also prevented filling some of the high-grade, small-diameter sample cells. Personnel with some experience in hardwood tree grading were asked to assist during the sampling phase of the study. The final sample included 140 trees distributed by tree grade and processing site (*table 1*).

Table 1—Tree grade and dbh (diameter at breast height) summary of the black oak study trees

| Tree grade | Softwood mill          |                    |                   | Hardwood mill          |                    |                   |
|------------|------------------------|--------------------|-------------------|------------------------|--------------------|-------------------|
|            | Diameter breast height |                    |                   | Diameter breast height |                    |                   |
|            | No. of trees           | Range              | Mean <sup>1</sup> | No. of trees           | Range              | Mean <sup>1</sup> |
|            |                        | ----- inches ----- |                   |                        | ----- inches ----- |                   |
| 1          | 14                     | 16 - 40            | 26 (1.9)          | 7                      | 17 - 36            | 27 (2.8)          |
| 2          | 38                     | 15 - 36            | 24 (0.9)          | 20                     | 14 - 38            | 24 (1.5)          |
| 3          | 41                     | 12 - 42            | 23 (1.2)          | 20                     | 14 - 41            | 24 (1.7)          |

<sup>1</sup>Numbers in parentheses are standard errors of the mean.

Trees were sought from many ownerships whose managers were interested in the project and willing to cooperate by donating trees. Although much of the hardwood resource is found on private lands, logistics (e.g., few and scattered trees in an area or inaccessibility leading to increased harvesting and transportation costs) favored sampling from the public domain. The final sampling areas included National Forest (NF) lands (Plumas NF, Six Rivers NF, Eldorado NF), University of California Blodgett Research Forest, and Sierra Pacific Industry lands (*fig. 1*).



**Figure 1**—Geographic range of black oak with sample and mill locations identified.

Areas with large concentrations of black oak were identified by local personnel having knowledge of the resource (e.g., District timber staff, company foresters). The sample selection team visited all candidate areas recommended and then chose those that would best fill the sampling matrix. No cell in the sampling matrix was filled with trees from a single area.

### **Logging, Log Scaling, and Log Grading**

Felling black oak requires care to minimize splits in the butt logs. Bucking decisions also influence the value of the end product (Fobes 1960). A bucking consultant worked with the loggers for 1 day to familiarize them with hardwood bucking decisions. Woods-length logs varied from tree length (for hauling purposes) to a minimum of 8 feet. Minimum top diameter was 8 inches. Each log was tagged with a number identifying the tree and its position within the tree.

Logs were hauled to the cooperating mills to be roll-out scaled (individually scaled in the mill yard) by Forest Service scalers. The official rules for the study were cubic (USDA Forest Service 1991) and eastside Scribner (USDA Forest Service 1985). Woods-length logs were bucked in the mill yard and rescaled. Mill-length logs were graded using USDA Forest Service standard grades for hardwood factory lumber logs (Rast and others 1973). *Table 2* shows grades and volumes of the final log sample. Cull logs were removed from the data set and not analyzed separately even though, in most cases, lumber was produced from them.

One-inch, random-width lumber was produced. A random sample of green lumber thicknesses and widths (to the nearest 0.001 inch) was taken. Green lumber thickness averaged 1.174 inches at the softwood mill and 1.147 inches at the hardwood mill. Widths ranged from 2 to 12 inches. Each piece of lumber was labeled to track the tree and log it was cut from. Equipment at the softwood mill included a horizontal band headrig saw, an edger, and a resaw. The hardwood mill consisted of two Wood Mizers, one Mobile Dimension saw for primary breakdown for logs larger than 30-inches, two edgers, and one resaw.

*Table 2—Mill-length log sample summarizing final tally of log grades, log volume, and percent defect*

| Grade             | No. of logs | Diameter        |                   | Gross volume    | Cubic defect |
|-------------------|-------------|-----------------|-------------------|-----------------|--------------|
|                   |             | Range           | Mean <sup>1</sup> |                 |              |
|                   |             | ----- in. ----- |                   | ft <sup>3</sup> | pct          |
| 1                 | 20          | 14-32           | 22.4 (1.2)        | 685.6           | 13           |
| 2                 | 113         | 9-37            | 19.9 (0.5)        | 3374.4          | 14           |
| 3                 | 356         | 8-34            | 15.5 (0.3)        | 5740.9          | 16           |
| Construction      | 36          | 8-29            | 11.8 (0.6)        | 321.9           | 29           |
| Local use         | 20          | 7-19            | 10.8 (0.8)        | 119.1           | 27           |
| Cull <sup>2</sup> | 43          | 8-29            | 15.4 (0.9)        |                 |              |

<sup>1</sup>Numbers in parentheses are standard errors of the mean.

<sup>2</sup>Cull defined by Scribner Eastside rules as being less than 2/3 sound. These logs were removed from the analysis data set.

Lumber from both mills was air-dried at least 3 months to a target moisture content of 20 percent before kiln-drying. All lumber was surfaced on two sides to a thickness of 0.938 inches. Pallet stock was tallied rough green. The grade, length, and width of all other lumber were tallied after planing. Lumber was graded according to National Hardwood Lumber Association (NHLA) grading rules by an NHLA hardwood lumber grader who was hired to assist in this phase of the study.

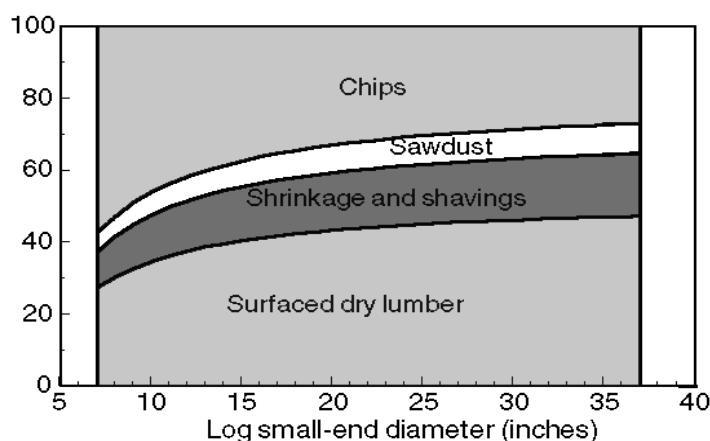
## Results

### Lumber Volume Recovery

One objective of this study was to determine baseline lumber recovery volume of black oak by log diameter. Regression analysis was used to develop a model predicting volume recovery of black oak by log small-end diameter (or some transformation of diameter). The best fitting model for each set of data was selected on the basis of coefficient of determination ( $R^2$ ) and standard error of the estimate. All tests were done at the 0.05 probability level.

The average cubic recovery (cubic volume of green lumber/gross cubic log volume) was the same at both the hardwood and the softwood mill, about 55 percent. However, lumber accounts for only a portion of what is produced when a log is sawn. Chips, sawdust from the headrig and edgers, and shavings from the planer are also produced. Shrinkage in drying also needs to be accounted for in recoverable volume. Cubic recovery (percent volume of components from the total volume of log) is one measure of volume recovery and is shown in *fig. 2* for the softwood mill. A statistical comparison of lumber recovery from the two mills is not possible because the same set of logs cannot be sawn at both mills. Therefore, recovery data for each mill was analyzed separately. Recovery increased with log diameter at the softwood mill (*fig. 2*) but remained constant at the hardwood mill where surfaced, dry lumber accounted for 42 percent of the volume of a log; planer shavings and shrinkage, 14 percent; sawdust, 8 percent; and chips, 36 percent.

Both mills produced boards and low-quality center cants. In addition, the softwood mill produced some double 4/4 pieces which were further broken down on their resaw. All center cants were resawn at the hardwood mill. Only 20 percent of the lumber produced at the softwood mill was in uneven widths compared to 46 percent uneven-width lumber sawn at the hardwood mill.



**Figure 2**—Regression models for cubic volume of products resulting from manufacture of lumber at the softwood mill based on log small-end diameter.

## Lumber Value Recovery

Probably of most interest to landowners is not what a black oak log is worth, but rather what the value of their tree(s) is. The following value and lumber grade recovery data are presented based on tree dbh, rather than on log small-end diameter. The lumber sawn at the softwood mill was not promptly stickered and suffered some degrade from stain. Because the final lumber grade tally reflected this loss, only the sample from the hardwood mill was used to examine differences in lumber value and lumber grade recovery among tree grades.

Dollars per thousand board feet lumber tally (\$/MLT) is the most meaningful monetary measure in evaluating differences in tree (or log) grades because it is the average value of all lumber produced from a tree (or log) and does not include any bias from defect estimation. The lumber volume of all logs (to a small diameter of 8 inches) from a tree was added together to get total volume of lumber sawn from each tree. Dollars per thousand board feet lumber tally is calculated by multiplying the volume in a lumber grade group by its price, summing them, and dividing the total value by the total volume of lumber produced from each tree. Results are strongly tied to the prices used (*table 3*); any change in price relation among grades would influence the results. Value is highly correlated with tree dbh because tree quality tends to increase with tree size and does not include any bias from defect estimation.

**Table 3**—Lumber grades and prices used in analysis

| Lumber grade      | Price <sup>1</sup>  |
|-------------------|---------------------|
|                   | \$/MBF <sup>2</sup> |
| Select and better | 1,285               |
| #1 Common         | 815                 |
| #2 Common         | 560                 |
| #3 Common         | 385                 |

<sup>1</sup>Prices from Hardwood Lumber Producers Coop, Inc., Auburn, CA.

<sup>2</sup>\$/MBF = dollars per thousand board feet

A model predicting \$/MLT based on tree dbh was developed for each tree grade. A comparison of regression lines (testing for differences in slopes and intercepts) was used to determine whether there was a significant difference ( $P \leq 0.05$ ) in value among tree grades. Resulting regression statistics are summarized in *table 4*.

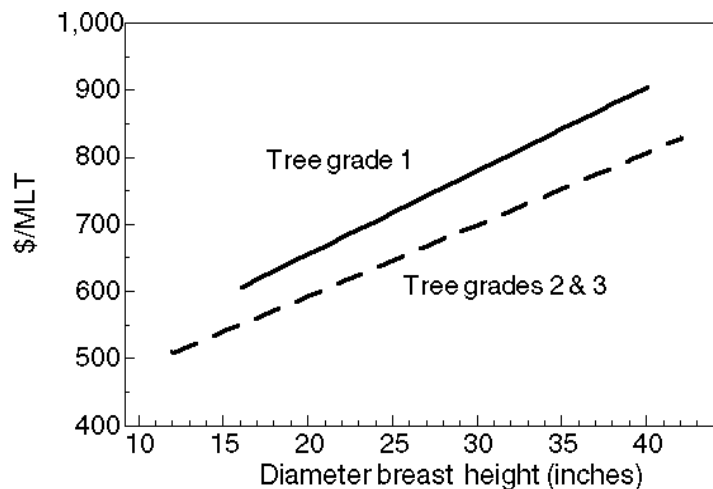
Table 4—Regression equations and statistics for figures 2-5

| Dependent variable                                                        | Equation <sup>1, 2</sup>                  | P      | R <sup>2</sup> |
|---------------------------------------------------------------------------|-------------------------------------------|--------|----------------|
| <b>Cubic recovery (pct)—softwood mill</b>                                 |                                           |        |                |
| Surfaced dry lumber + shrinkage                                           | $R_1 = 52.1 - (170.96 * 1 / SD)$          | 0.0001 | .14            |
| and shavings                                                              | $R_2 = 71.28 - (234.03 * 1 / SD)$         | 0.0001 | .14            |
| Surfaced dry lumber + shrinkage                                           | $R_3 = 80.44 - (262.04 * 1 / SD)$         | 0.0001 | .14            |
| and shavings + sawdust                                                    |                                           |        |                |
| Chips                                                                     | $R_4 = 100 - R_3$                         |        |                |
| <b>\$/MLT<sup>3</sup>—hardwood mill</b>                                   |                                           |        |                |
| Tree grade 1                                                              | $\$/MLT = 410.24 + (12.42 * DBH)$         | 0.0026 | .86            |
| Tree grades 2 & 3                                                         | $\$/MLT = 383.28 + (10.64 * DBH)$         | 0.0001 | .58            |
| <b>Lumber grade recovery (pct) from grade 1 trees—hardwood mill</b>       |                                           |        |                |
| 3 Common                                                                  | $R_5 = 56.85 - (1.15 * DBH)$              | 0.0101 | .76            |
| 2 Common                                                                  | $R_6 = 99.15 - (1.69 * DBH) - R_5$        | 0.0032 | .85            |
| 1 Common                                                                  | $R_7 = 111.16 - (1.30 * DBH) - R_6$       | 0.0123 | .75            |
| Select                                                                    | $R_8 = 119.44 - (1.08 * DBH) - R_7$       | 0.0161 | .72            |
| FAS <sup>4</sup>                                                          | $R_9 = 100 - R_8$                         |        |                |
| <b>Lumber grade recovery (pct) from grade 2 and 3 trees—hardwood mill</b> |                                           |        |                |
| 3 Common                                                                  | $R_{10} = 75.53 - (1.66 * DBH)$           | 0.0001 | .56            |
| 2 Common                                                                  | $R_{11} = 101.55 - (1.44 * DBH) - R_{10}$ | 0.0001 | .55            |
| 1 Common                                                                  | $R_{12} = 108.63 - (.87 * DBH) - R_{11}$  | 0.0001 | .46            |
| Select                                                                    | $R_{13} = 108.07 - (.51 * DBH) - R_{12}$  | 0.0001 | .44            |
| FAS <sup>4</sup>                                                          | $R_{14} = 100 - R_{13}$                   |        |                |

<sup>1</sup> SD = log small-end diameter in inches<sup>2</sup> DBH = diameter breast height in inches<sup>3</sup>\$/MLT = dollars per thousand board feet of lumber tally<sup>4</sup>FAS = First and Seconds

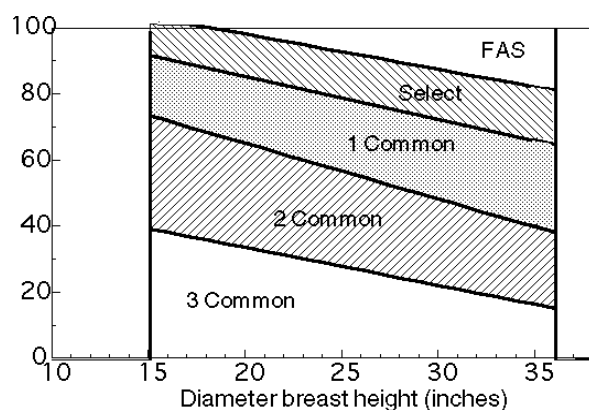
The effect of tree grade and dbh is shown in *fig. 3*. Diameter was significant (*table 4*) for all tree grades. There was no significant difference in the value of lumber produced from trees graded 2 and 3 as is shown by the single regression line in *fig. 3*. The value of grade 1 trees differed significantly from those graded 2 or 3.

**Figure 3**—Difference in dollars per thousand board feet lumber tally (\$/MLT) among tree grades as a function of tree diameter at breast height from the hardwood lumber mill.

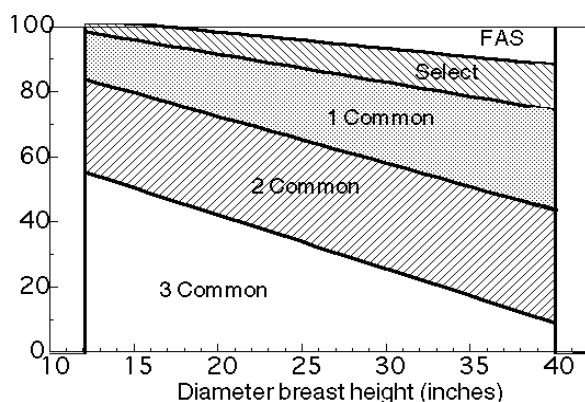


## Lumber Grade Recovery

Of the total 59,500 board feet of lumber sawn, 34 percent (20,000 board feet) was produced at the hardwood mill. *Figures 4 and 5* show the amount of lumber recovered in each lumber grade group. Larger amounts of higher-grade lumber come from larger-diameter trees while smaller-diameter trees tend to yield more lower-grade lumber. For Grade 1 trees (*fig. 4, table 4*), the Select and Better lumber produced ranged from about 9 percent for a 15-inch dbh tree to 36 percent in a 36-inch dbh tree. The amount of higher-grade lumber drops off in tree grades 2 and 3 (*fig. 5, table 4*) to 4 percent Select and Better in a 15-inch tree and to 25 percent in a 36-inch tree. This is the reason the value differed among tree grades.



**Figure 4**—Cumulative percent of lumber grade recovery from the hardwood mill for tree grade 1. FAS is lumber grades First and Seconds.



**Figure 5**—Cumulative percent of lumber grade recovery from the hardwood mill for trees graded 2 and 3. FAS is lumber grades First and Seconds.

## Conclusions

Portable sawmills, such as the Wood Mizer, tend to be more efficient in cubic volume recovery of small-diameter logs (< 15 inches). Recovery from the larger-diameter logs appears to be similar at both types of sawmills. Average lumber volume recovery for both mills was essentially the same; however, distribution of recovery over log diameter differs.

Tree grading rules for eastern hardwood species differentiate the best trees while not seeming to make much distinction between tree grades 2 and 3 in terms of value or lumber grade recovery for the sample sawn at the hardwood mill.

Results from this study provide necessary volume and value recovery data for current and potential hardwood lumber producers such as portable sawmills or small softwood mills looking for an opportunity to diversify their product line. These data provide a basis for evaluating opportunities by small-scale operations to use a local resource, thereby enhancing the economic base of local communities.

## References

- Bolsinger, Charles L. 1988. **The hardwoods of California's timberlands, woodlands, and savanna.** Resour. Bull. PNW-RB-148. Portland, OR: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture; 148 p.
- Burns, Russell M.; Honkala, Barbara H., technical coordinators. 1990. **Silvics of North America.** Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture; 673 p.
- Fobes, E.W. 1960. **Quality-controlled log bucking.** Forest Products Journal. 10(8): 415-418.
- Godden, Randall L.; Stanley, Mark; Huber, Dean. 1993. **California black oak lumber recovery study.** Final report. 17 p. Available from: High Sierra Resource Conservation and Development Area, 251 Auburn Ravine #201, Auburn, CA.
- Hanks, Leland F. 1976. **Hardwood tree grades for factory lumber.** Res. Paper NE-333. Broomall, PA: Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture; 81 p.
- McCaskill, George L. 1990. **Hardwood resource assessment and management.** Sierra Economic Development District EDA Technical Assistance Project Number 07-06-03059; 116 p.
- Rast, Everette D.; Sonderman, David L.; Gammon, Glen L. 1973. **A guide to hardwood log grading (revised).** Gen. Tech. Rep. NE-1. Upper Darby, PA: Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture; 31 p.
- Smith, Z.G. 1986. **California hardwoods: a professional challenge to the resource community.** In: Plumb, Timothy R.; Pillsbury, Norman H., technical coordinators. Proceedings of the symposium on multiple-use management of California's hardwood resources; November 12-14, 1986; San Luis Obispo, CA. Gen. Tech. Rep. PSW-100. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1-4.
- U.S. Department of Agriculture, Forest Service. 1991. **National Forest cubic scaling handbook.** FSH 2409.11a. Amend. 2409.11a-91-1. Washington, DC: U.S. Department of Agriculture, Forest Service.
- U.S. Department of Agriculture, Forest Service. 1985. **National Forest log scaling handbook.** FSH 2409.11. Amend. 6. Washington, DC: U.S. Department of Agriculture, Forest Service.