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Optimal Bucking: Two Trials with Commercial OSU BUCK Software

by

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Cover illustration: A bar-coded log tag.

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Introduction

OSU BUCK Versions 1.1 and 1.2 are software programs recently developed for commercial computer-aided bucking by the Department of Forest Engineering at Oregon State University (OSU). They were designed to optimize the value of a tree under any given market prices and various log-length, diameter, and quality specifications, with consideration also of transportation and logging costs. The software contains features not found in the original optimal-bucking program, BUCK-DEMO (Beaulieu 1988). The technology will help the professional timber faller/bucker produce the combination of log lengths that generates the highest value per tree.

For those unfamiliar with the technology, this publication first describes OSU BUCK, with emphasis on its new features. It then describes the procedures and findings of two commercial trials of optimal bucking at the stump, and finally discusses observations and conclusions drawn from the trials.

How OSU BUCK Works

User Manual

The Applied Optimal Bucking Workshop Manual (College of Forestry, Oregon State University, 1993) is a 123-page user's manual for OSU BUCK. It contains detailed instructions and screen illustrations for using the program. The instructions cover setup, data-entry, and reports. It and program software are available through continuing-education workshops sponsored by the Department of Forest Engineering, College of Forestry, Oregon State University.

Hardware/Software

The commercial versions of OSU BUCK, released in the spring of 1993, will run on any DOS-based computer system. Currently the software will operate on the handheld field computers CMT PC-5, Husky FS/2, Husky Hunter 16, Paravant RHC-44, and Paravant RHC-88. The software is divided into field and office programs. Transfer of information files between the handheld and desktop computers is facilitated by communication software provided by makers of each field computer.

The OSU BUCK program is a decision-making aid for the bucker. Once a tree is "described," the program produces the combination of log lengths that generates the highest possible net value. The bucker or technician need only enter information about the shape and surface quality of a particular tree. After a tree is felled, measurements and quality assessments made to describe the exterior of the tree are entered into the handheld computer. The stem diameter is measured at the butt and along the bole, and the measurements are adjusted to the closest 0.1-inch diameter inside bark. The distance from the butt to the nearest 0.1 foot is noted at each diameter-measurement location so that the program can create taper and form information. The surface quality is categorized by region along the tree length, each category being dependent on the size and frequency of knots. All data input is shown on the handheld computer screen as it is entered, and an entry can be changed at any time during the measurement process.

The final optimal-bucking solution is based on physical attributes of the tree, market condition (including possible mill destinations and related prices for a species), transportation costs to each destination, logging costs expressed as cost per piece, and cost per unit in thousand board feet (mbf), cubic feet, or both. The market prices, which are those paid for logs of various sorts and grades, include specifications for diameter range, acceptable length, and wood-quality.

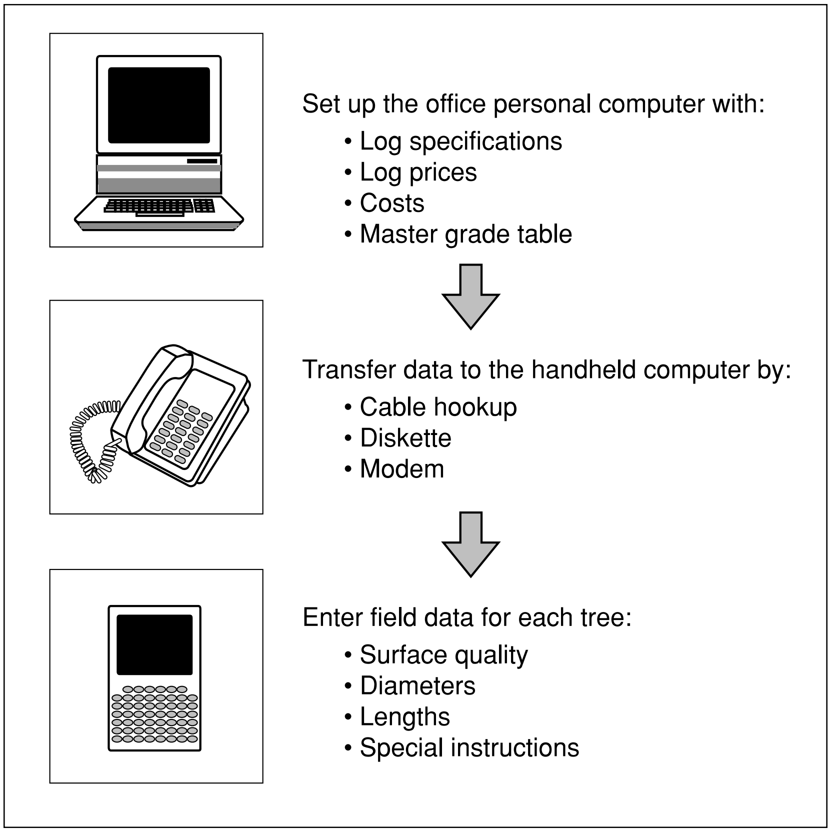


Figure 1. The sequence of data input for the handheld computers.

The program uses a network-based algorithm to search for the combination of logs to be cut from a given tree that will yield the highest net value. Once a solution is generated, the program displays the information in tabular form, listing log lengths as measured from the butt to the top of the stem, predicted diameter at the cut, mill destination, predicted weight, predicted board-foot and cubic-foot volumes, total scale, and total value. Version 1.2 displays the bar code number assigned to each merchantable segment.

The user can control the percentage of logs cut in a given length. A specification from a purchaser such as “average log length must be 35 feet or longer,” is accommodated through manipulation of the price table.

Figure 1 summarizes the sequence of data input that is discussed more fully in the following sections.

The Office-Computer Setup

The office personal computer (PC) can run the same program as the handheld computer. In addition, it is capable of making batch runs for sensitivity analyses of alternative policies.

Grade Information

The office PC contains a master grade table that provides the general specifications for each log sort and grade (Table 1). Each of the sorts in the grade table is cross-referenced with a code number designating minimum surface quality. The table can be used for any timber sale once it is formulated.

Table 1. Sample of a master grade table giving quality-code definitions for computing the optimal bucking solution.[a]

Code	Sort/Grade	Surface characteristics
0	Cull	Breakage or non-merchantable wood. (In OSU BUCK, zero is always a cull.)
1	SM	Knots or knot indicators average less than 1.5 inch in diameter per foot. (Knots and knot indicators less than 0.5 inch diameter are not counted.) Six or more rings per inch. Two oversize knots.
2	J-sort	Six to ten dispersed knots less than 2 inches in diameter. At least 50% of surface clean. (Knots less than 0.5 inch in diameter are not counted.) Twelve rings per inch. No defects; i.e., no rot, stain, scars, burls, or excessive sweep. Two oversize knots.
3	2S	Knots less than 2.5 inches in diameter. Oversize knots: 1 per 8 feet, or all in one-quarter of the stem.[b]
4	3S	Knots less than 3 inches in diameter. Oversize knots: one per 8 feet, or all in one-half of the stem.[b]
5	Utility	Knots less than 3 inches in diameter with or without conk.

[a] Example is for second-growth Douglas-fir stems. It includes the export sort J.

[b] Distributed to permit recovery.

Mill Prices and Specifications

Length, diameter, quality requirements, and prices are entered for each mill. Adjustments are made in the preferred-length prices if a minimum total volume or a minimum average length is required.

Specific Site Costs

Additional items entered for each timber sale are the current costs for stumpage, harvesting (felling, bucking, yarding, loading), and hauling.

The Handheld-Computer Setup

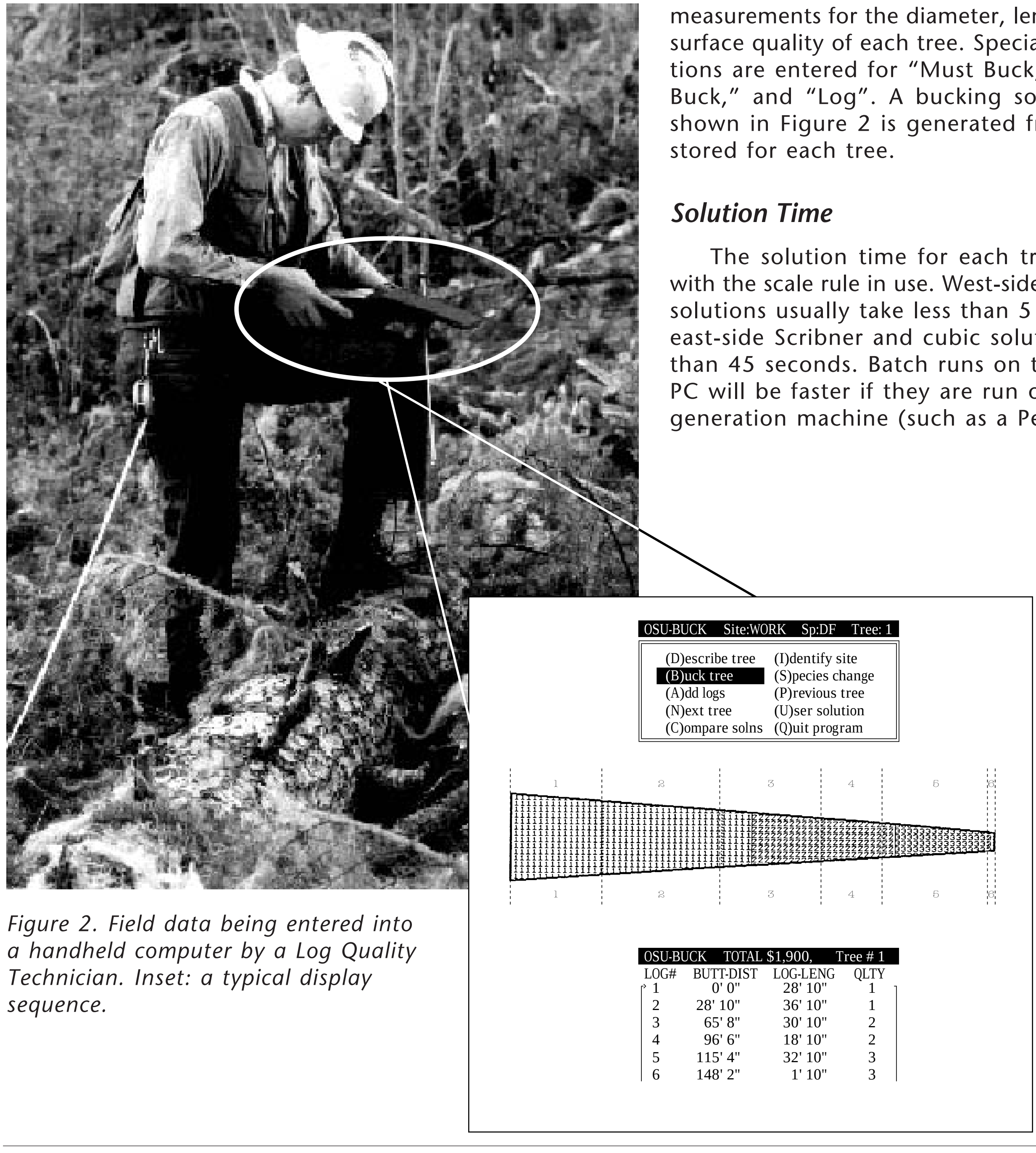
The screen display on the handheld computer can be customized; for example, values can be suppressed. After the display options are chosen, the necessary office PC files are downloaded to the handheld computer.

Field-Data Entry

The field computer deals with different tree species by storing tables that evaluate the specifications of each. The operator selects the species with a two-letter code and then enters the measurements for the diameter, length, and surface quality of each tree. Special instructions are entered for "Must Buck," "Can't Buck," and "Log". A bucking solution as shown in Figure 2 is generated from data stored for each tree.

Solution Time

The solution time for each tree varies with the scale rule in use. West-side Scribner solutions usually take less than 5 seconds, east-side Scribner and cubic solutions less than 45 seconds. Batch runs on the office PC will be faster if they are run on a late-generation machine (such as a Pentium).



```
OSU-BUCK    TOTAL $1,900,      Tree # 1
LOG#    BUTT-DIST    LOG-LENG    QLTY
 1          0' 0"      28' 10"     1
 2         28' 10"     36' 10"     1
 3         65' 8"      30' 10"     2
 4         96' 6"      18' 10"     2
 5        115' 4"      32' 10"     3
 6        148' 2"       1' 10"     3
```

Figure 2. Field data being entered into a handheld computer by a Log Quality Technician. Inset: a typical display sequence.

User-Specified Solutions

A user solution is available whenever the bucker wants to cross-cut in a manner other than the computer choice. For example, the bucker may want to cut a specific log along portions of a tree where breaks have occurred. The optimal solution accepts the user's choice as a given part of the overall solution and includes it in the output. The program can also evaluate a user specification for comparison with the optimal solution, allowing the bucker to make the next best choice when the computer's choice is difficult to accomplish. User and optional solutions are stored automatically.

User Adjustments to Input

The program assumes a straight, perfectly round log with no internal defects. Adjustment for sweep, out-of-round, or internal defects (rot) are made from the bucker's experience. With the "Must Buck" or "Log" options, the bucker predetermines the cross-cut location (or a zone for the crosscut) that will eliminate sweep. This is routinely needed in the butt section. When the tree is out-of-round, the faller takes two diameter measurements and enters the average into the computer. A length of the tree that has internal defects is assigned the cull designation.

Data Output

The ouput sequence is shown in Figure 3. Locations of the optimal bucking cuts are displayed with information on length, diameter, volume, weight, value, and destination of each log. Additions and modifications can be made to the log list. Short logs can be combined, and top logs not already included in the solution can be added. The output log list for each tree is stored in the computer, but because of memory limitations, the information should be transferred to the office computer several times each week. Daily transfers are best for preventing loss of information should the handheld computer malfunction.

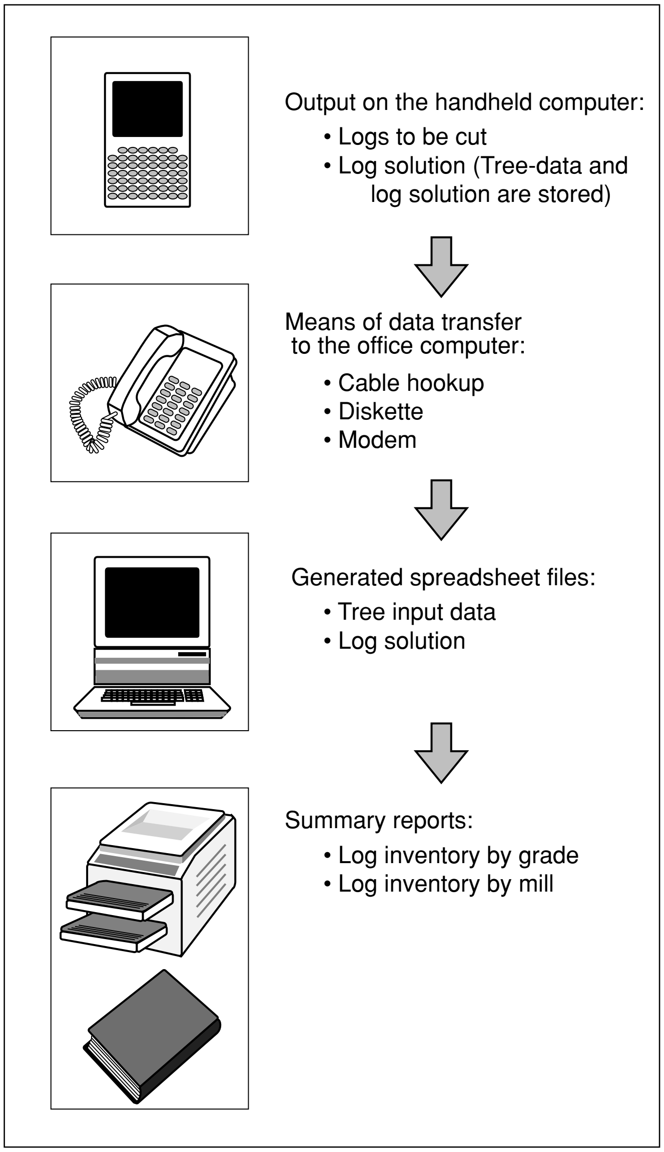


Figure 3. The sequence of data output.

Program Data Files

The office PC creates spreadsheet versions of tree-input and log-output files generated in the field.

Tree and Log Lists

Tree lists and log lists can be sorted and summarized, giving an accurate inventory (see Tables 2 and 3, pages 10 and 11). Spreadsheets

Table 2. Example of tree input data for nine trees.[a] Note the change in species from Douglas-fir (DF) to red cedar (RC).

Bucker ID no.	Working site	Species	Tree no.	Tape break no.	Total (ft)	Tape (ft)	Diameter (in)	Quality	Bucks: Must (1) Can't (2) Log (3)	Zone (ft)
0	WORK	DF	1	1	0	0	30.7	1		
0	WORK	DF	1	1	75	75		2		
0	WORK	DF	1	1	119	119		3		
0	WORK	DF	1	1	150	150	6.4			
0	WORK	DF	2	1	0	0	23	1		
0	WORK	DF	2	1	66	66	18	0		
0	WORK	DF	2	1	70	70	16	3		
0	WORK	DF	2	1	112	112	7			
0	WORK	DF	3	1	0	0	27	1		
0	WORK	DF	3	1	75	75		2		
0	WORK	DF	3	1	123	123	10			
0	WORK	RC	4	1	0	0	25	3		
0	WORK	RC	4	1	134	134	10			
0	WORK	DF	5	1	0	0	24	2		
0	WORK	DF	5	1	13	13			1	
0	WORK	DF	5	1	87	87		3		
0	WORK	DF	5	1	109	109	9			
0	WORK	DF	6	1	0	0	26	2		
0	WORK	DF	6	1	17	17			1	4
0	WORK	DF	6	1	87	87		3		
0	WORK	DF	6	1	109	109	9			
0	WORK	DF	7	1	0	0	27	2		
0	WORK	DF	7	1	68	68			2	4
0	WORK	DF	7	1	87	87		3		
0	WORK	DF	7	1	109	109	9			
0	WORK	DF	8	1	0	0	28	2		
0	WORK	DF	8	1	74	74			3	24
0	WORK	DF	8	1	87	87		3		
0	WORK	DF	8	1	112	112	9			
0	WORK	DF	9	1	0	0	19	1		
0	WORK	DF	9	1	56	56		2		
0	WORK	DF	9	1	72	72	12			
0	WORK	DF	9	2	72	0	12			
0	WORK	DF	9	2	117	45	6			

[a] Computer format slightly modified.

Table 3. Example of log output data with bar-code tag numbers included.[a]

TAG no.	ID no.	Species[b]	Tree no.	Segment no.	Start		Length		Small-end diameter (in)	Quality	Mill[c]	Sort	Net $	Volume	
					(ft)	(in)	Log (ft)	Trim (in)						Board feet	Cubic feet
M13098	2	DF	15	1	0	0	48	10	25	2	OC	2S	1074	1510	213.5
M13067	2	DF	4	1	0	0	48	10	21	2	OC	2S	726	1020	196.5
M13064	2	DF	3	1	0	0	48	10	18	2	OC	2S	527	740	141.5
M13133	2	DF	27	1	0	0	48	10	18	2	OC	2S	527	740	121.4
M13092	2	DF	13	1	0	0	48	10	18	2	OC	2S	527	740	156.3
M13105	2	DF	17	1	0	0	48	10	17	2	OC	2S	455	640	129.7
M12531	1	DF	-28	2	16	10	48	10	17	2	OC	2S	455	640	98.8
M12516	1	DF	-22	1	0	0	48	10	17	2	OC	2S	455	640	116.5
M13071	2	DF	5	1	0	0	48	10	16	2	OC	2S	398	560	105.8
M13084	2	DF	10	1	0	0	48	10	16	2	OC	2S	398	560	105.8
M13082	2	DF	9	2	38	10	48	10	16	2	OC	2S	398	560	111.5
M12488	1	DF	12	1	0	0	48	10	15	2	OC	2S	349	490	101.4
M12498	1	DF	-16	1	0	0	48	10	15	2	OC	2S	349	490	107.6
M12476	1	DF	8	1	0	0	48	10	15	2	OC	2S	349	490	95.5
M13114	2	DF	20	1	0	0	48	10	14	2	OC	2S	292	410	85.8
M12457	1	DF	-1	1	0	0	48	10	14	2	OC	2S	292	410	103.6

[a] Computer format slightly modified.

[b] DF = Douglas-fir.

[c] OC = Oregon Cedar mill.

can be used to analyze bucking results and to reconcile information from the appraisal cruise, scaling tickets, and mill receipts. They can also serve as the basis for auditing log quality and production and for determining incentive payment of crews.

Quotas

The program optimizes each tree separately. It does not impose total volume constraints for each log sort; therefore, if a quota exists, the manager must monitor volume. The volume in each sort can be summarized daily from the spreadsheet records that are automatically generated (Fig. 4, page 12). When a quota is reached, the sort should then be deleted from the log choices stored in the computer.

Figure 4. An example of log output data in spreadsheet format.

Optimal Solution											Optimal Solution			Optimal Solution						Optimal Solution
																Volume				
Bucker ID #	Working site	Species	Tree #	Segment #	Start location (feet)	Start location (inches)	Segment length (feet)	Segment length (inches)	Trim (inches)	Small-end diameter (inches)	Quality	Mill	Sort/ Grade	Net value	Weight (lbs)	Board feet	Cubic feet	Scale rule	Total tree volume	Total tree value
0	WORK	DF	1	1	0	0	28	10	10	26	1	TWP	JSM	854	4959	870	130.5	WEST		
0	WORK	DF	1	2	28	10	36	10	10	20	1	TWP	JSM	617	4330	630	113.9	WEST		
0	WORK	DF	1	3	65	8	30	10	10	15	2	TWP	J	232	2142	270	56.4	WEST		
0	WORK	DF	1	4	96	6	18	10	10	12	2	FPP	2S	55	797	90	21	WEST		
0	WORK	DF	1	5	115	4	32	10	10	6	3	SOH	3S	23	664	50	17.5	WEST		
0	WORK	DF	1	6	148	2	1	10	0	6	3	n/a		0	16	0	0.4	WEST		
																			1910	1781
0	WORK	DF	2	1	0	0	38	10	10	20	1	TWP	JSM	647	3990	660	105	WEST		
0	WORK	DF	2	2	38	10	26	10	10	18	1	TWP	JSM	340	2174	350	57.2	WEST		
0	WORK	DF	2	3	65	8	4	4	0	16	5	n/a		0	304	40	8	WEST		
0	WORK	DF	2	4	70	0	16	10	10	12	3	FPP	2S	49	751	80	19.8	WEST		
0	WORK	DF	2	5	86	10	24	10	10	7	3	SOH	3S	17	550	40	14.5	WEST		
0	WORK	DF	2	6	111	8	0	4	0	7	3	n/a		0	8	0	0.2	WEST		
																			1170	1053

New Features of Commercial OSU BUCK

The following enhancements to previous versions of OSU-BUCK were developed as a result of experience gained from field trials in the past 5 years.

Batch Processing

Input diameters, lengths, and surface quality are stored for each tree. If a manager wishes to see how changing specifications or costs will affect the types of logs cut, the tree file can be run on the office computer as a batch. Such exploratory analysis can be used to establish felling criteria, such as the minimum tree diameter for which optimal bucking is economical.

Setup Options

The optimizing program can be run on either a desk-top or handheld computer. Currently five popular handheld models of the brands Husky, CMT, and Paravant are supported. Customization for other handheld computers is not difficult, mainly requiring adjustment of screen size.

User setup options for the computer program are type of computer; acceptable log lengths (including trim), diameters, and grades; bark-thickness adjustments; and preferred-length constraints.

Lengths are recorded to the nearest 0.1 foot. Acceptable log lengths can be specified in 1-foot or greater increments. Tree diameters are rounded down to the nearest inch. Minimum and maximum diameters and lengths can be designated. Individual trim allowances can be specified for each type of log. The faller can choose to convert diameter outside bark to the inside-bark dimension by giving the appropriate conversion ratio when input specifications are entered, or inside-bark diameters can be entered directly.

The proper proportion of preferred log lengths is achieved by means of trial-and-error price adjustors that favor or inhibit given lengths during optimization. During setup of the computer, a batch of sample trees is used to find the appropriate adjustor values.

Log Tracking

The computer stores information about each log, including whether it was cut according to the optimal solution or according to a user-override solution.

Bar coding

OSU BUCK assigns each log a tag number that is automatically indexed when the computer specifies segmentation of the next tree. The bar-coded labels are attached to the logs when they are bucked, and the following information is generated and stored:

TAG #	Sequential bar-coded label for each log
ID #	Faller identification
SPP	Species
SITE	Name of the unit being harvested
TREE #	Sequential number assigned to the tree
SEG	Segment in the tree (1,2,3,4)
START	Distance from the butt
LOG LEN	Log length
TRIM LEN	Trim added to the log length
S.E. DIA	Small-end inside-bark diameter
QUAL	Numerical code of log surface quality
MILL	Mill destination assigned to the log
SORT	Grade assigned to the log
NET $	Stumpage value of the log
BF VOL	Gross scale for the log in board feet (VOL)
WEIGHT	Estimated weight of the log
CUBIC VOL	Estimated volume in cubic feet
SCALE RULE	Scaling rule being used

Once an initial bar-code number is assigned, the computer automatically numbers each successive log. At the end of each day, the log record can be printed. If bar-code tags have been attached to the logs, each log can then be tracked from the stump to the mill. Upon request, many scaling stations will add the bar-code number to the scale ticket on each log. Electronic summaries of scale-ticket information are available from many scaling stations in the Pacific Northwest.

Bar-code material costs from 5 to 10 cents per tag. A faller normally will buck about 100 logs per day. The time and equipment required to attach the tags to the logs is minimal.

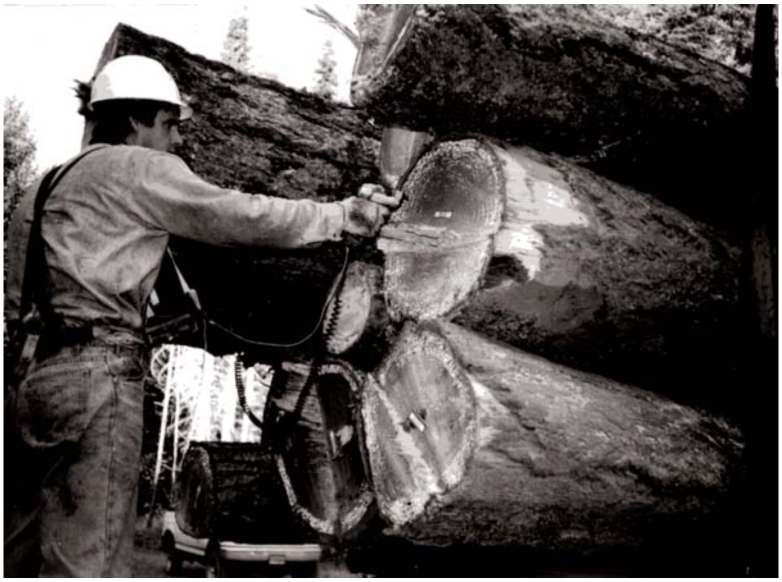


Figure 5. A bar-code scanner being used on a truckload of logs.

Spreadsheet Files

In addition to providing an individual record of each log, the program makes possible summary reports for such items as average log length, log mix, and daily production for each faller. The computer files generated at the scaling station can be reconciled with the OSU BUCK files.

Scanning

With portable scanning equipment, the bar-coded logs can be identified anywhere, such as at landing or sort-yard decks, or on board trucks (Figure 5). Special computer programs can be written to process the scanned information and merge it with other information. (Software has been developed by Bill Selby, Forest Resources Department, College of Forestry, Oregon State University.)

Bark-Thickness Adjustments

Scaling and grading tables are based on diameter inside bark (DIB), which OSU BUCK uses in calculations and analyses. Diameter measurements made in the field are entered into the computer before the tree is bucked. Measurement of diameter outside bark (DOB) is made with calipers. Bark thickness is estimated and mentally subtracted twice (once for each side of the tree) from the DOB measurement, and the result is entered into the program. Thickness can be gauged by notching the bark with a saw, by observing bark thickness during bucking, and by using knowledge gained from experience. But the faller must continually change the estimate with the change in tree species, diameter, and distance from the butt. The bark is typically 3 inches thick or more at the butt of an old-growth tree, gradually decreasing to about one-half inch near a merchantable top (6-inch DIB). The faller usually makes the adjustment in whole inches to simplify the mental mathematics.

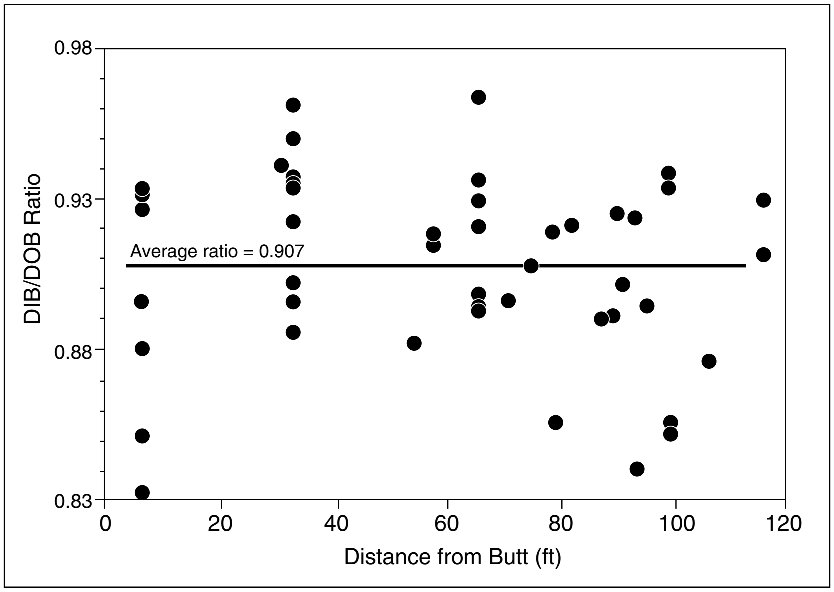


Figure 6. The bark-thickness adjustment ratio of diameter inside bark (DIB) to diameter outside bark (DOB) derived from a representative sample of 10 ponderosa pine trees.

A procedure in which the computer automatically adjusts for bark thickness improves the accuracy of DIB estimates. The program now contains an option that converts DOB to DIB by means of a ratio supplied by the user. The faller enters the DOB measurement and the computer multiplies it by the ratio, such that DOB is displayed as it is entered into the data table for each tree, and DIB is displayed as output data for the logs. The DIB/DOB ratio varies from 0.85 to 0.95 for Pacific Northwest conifers; therefore a ratio must be established for each species at each site by measuring and comparing diameters on a representative sample of 10 or more trees.

The computer ratio equation has the following form:

Ratio = DIB/DOB = A + B x (DIB at butt) + C x (distance from butt),

in which DIB = diameter inside bark in inches to the nearest tenth, distance from the butt is expressed in feet to the nearest tenth, and coefficients B and C may be negative. A sample of 10 ponderosa pine trees is shown in Figure 6. A coefficient, A, was determined to be 0.907. Coefficients for B and C = 0.

Scaling Options

The expanded OSU BUCK also allows the user a choice of scaling rules: west-side Scribner (40 foot segments), east-side Scribner (20 foot segments), and cubic scale (no segment scaling). Any of the three methods can be used on any work site. Official rules of the Northwest Log Rules Advisory Group (1982) and member bureaus have been incorporated into the program. All calculations of log value are based on gross board-foot or cubic-foot volume. Defect in any portion of a tree is assumed to affect the entire cylinder over the length of the specified portion. Defects such as catface, heart rot, shake, and checks, which deduct only part of the cylinder, are not accounted for in the program.

West-Side Scaling

Under west-side scaling rules, OSU BUCK will accept diameters from 1 to 72 inches and log lengths up to 140 feet. Logs from 41 to 80 feet long are scaled as two segments; logs from 81 to 140 feet long are scaled as three segments. There are no special taper allowances for butt logs scaled under west-side rules.

East-Side Scaling

Under east-side scaling rules (Table 4), OSU BUCK will accept diameters from 1 to 72 inches and log lengths up to 40 feet. All butt logs are scaled with special taper and length adjustments. Butt logs from 21 to

Table 4. East-side scaling rules: taper table for multi-segment logs (excluding butt logs). D = small-end diameter.

	Total log length			
Total taper (in)	21-40 ft (2 segments)	41-60 ft (3 segments)	61-80 ft (4 segments)	81-100 ft (5 segments)
1	D+1	D+1+0	D+1+0+0	D+1+0+0+0
2	D+1	D+1+1	D+1+1+0	D+1+1+0+0
3	D+2	D+1+1	D+1+1+1	D+1+1+1+0
4	D+2	D+2+1	D+1+1+1	D+1+1+1+1
5	D+3	D+2+2	D+2+1+1	D+1+1+1+1
6	D+3	D+2+2	D+2+2+1	D+2+1+1+1
7	D+4	D+3+2	D+2+2+2	D+2+2+1+1
8	D+4	D+3+3	D+2+2+2	D+2+2+2+1
9	D+5	D+3+3	D+3+2+2	D+2+2+2+2
10	D+5	D+4+3	D+3+3+2	D+2+2+2+2
11	D+6	D+4+4	D+3+3+3	D+3+2+2+2
12	D+6	D+4+4	D+3+3+3	D+3+3+2+2
13	D+7	D+5+4	D+4+3+3	D+3+3+3+2
14	D+7	D+5+5	D+4+4+3	D+3+3+3+3
15	D+8	D+5+5	D+4+4+4	D+3+3+3+3
16	D+8	D+6+5	D+4+4+4	D+4+3+3+3
17	D+9	D+6+6	D+5+4+4	D+4+4+3+3

(Table 4 continued)

Total taper (in)	Total log length 21-40 ft (2 segments)	41-60 ft (3 segments)	61-80 ft (4 segments)	81-100 ft (5 segments)
18	D+9	D+6+6	D+5+5+4	D+4+4+4+3
19	D+10	D+7+6	D+5+5+5	D+4+4+4+4
20	D+10	D+7+7	D+5+5+5	D+4+4+4+4
21	D+11	D+7+7	D+6+5+5	D+5+4+4+4
22	D+11	D+8+7	D+6+6+5	D+5+5+4+4
23	D+12	D+8+8	D+6+6+6	D+5+5+5+4
24	D+12	D+8+8	D+6+6+6	D+5+5+5+5
25	D+13	D+9+8	D+7+6+6	D+5+5+5+5
26	D+13	D+9+9	D+7+7+6	D+6+5+5+5
27	D+14	D+9+9	D+7+7+7	D+6+6+5+5
28	D+14	D+10+9	D+7+7+7	D+6+6+6+5
29	D+15	D+10+10	D+8+7+7	D+6+6+6+6
30	D+15	D+10+10	D+8+8+7	D+6+6+6+6

Example (see D+6+5+5):	Solution:
Douglas-fir 80 ft	20 ft X 12 in = D
Small-end diameter = 12 in	20 ft X 18 in = + 6 in
Large-end diameter (DL) = 33 in	20 ft X 23 in = + 5 in
Total taper = 21 in	20 ft X 28 in = + 5 in
	DL = 33 in = + 5 in

Source: Northwest Log Rules Advisory Group (1982).

40 feet long are segment-scaled as two logs of as nearly the same length as is possible. If the log cannot be divided equally, the butt segment is considered to be the long segment.

Cubic Scaling

OSU BUCK uses an approved cubic-volume formula (Northwest Log Rules Advisory Group 1982, p. 30-32). One modification has been made in the program in order to maintain acceptable solution times. Whereas long-log cubic volumes are normally calculated by summation of volumes of individual segments, the program assumes a single segment for all logs, regardless of length. The change apparently has little effect on cubic volumes of long logs as it has made no difference in the optimal solutions generated under this scaling rule.

The Field Trials

A workshop in the spring of 1993 was held at OSU to introduce the commercial version of the optimal-bucking program to the public. As a result of interest generated there, a field study was made with OSU BUCK to examine potential gains in log values on the Warm Springs Reservation in east-central Oregon. After a second workshop with OSU Research Staff in 1994, the software was tried in full-production felling and bucking of a clearcut on McDonald-Dunn State Forest in western Oregon.

During the trials, researchers and field personnel evaluated the program for its capability, usefulness, and convenience during office setup and site formulation, field use, and data-file transfer and evaluation. The following features and conditions were tested:

1. Scaling-rule options (west-side Scribner, east-side Scribner, and cubic-foot volume)
2. Processing of multiple species on a given site
3. User input of “Must buck,” “Can’t buck,” and “Log” designations for a tree section (to account for such things as sweep, crook, and rot; and to reduce worker hazard at particular points on the tree)
4. User solutions rather than computer-generated solutions for the bucking pattern
5. Measurement accuracy (within 0.1-inch diameter and 0.1-foot length)
6. Unique trim allowance on logs of different lengths
7. Preferred-length control by temporary (internal) price adjustors
8. Automatic generation of ASCII files (input of tree data and output of log solutions)
9. Batch processing of tree-description data (for refining price adjustors and for marketing analysis)
10. Processing of multiple harvest sites having different costs and specifications

Warm Springs

Warm Springs Forest Industries (WSFPI) commissioned a study to determine the applicability of optimal-bucking technology to their local conditions. WSFPI is a tribal enterprise that processes lumber at its own mill and aggressively sells logs on both the domestic and export markets. It wished to see what gains might be obtained by using optimal-bucking technology on timber harvested on the 650,000-acre Warm Springs Reservation in central Oregon. This was an opportunity for OSU Forest Engineering researchers to investigate industrial implementation of the technology and to test new developments in optimal bucking on multi-species stands with east-side scaling rules as well as on single-species stands with west-side Scribner rules.

Objectives

The study investigated how much of the value increase generated by optimal bucking is due to manipulating scaling volume and how much is due to shifting logs into sorts of higher value. The application also presented the challenge to find bucking solutions that would meet the average-length restrictions imposed by several mills. The new computer-program option that estimates inside-bark diameter from outside bark diameter was field tested on the sites. The outside diameter was entered directly and no mental adjustment was necessary.

The study was conducted by an OSU researcher, a company Logging Quality Coordinator, and fallers working on the reservation. The primary goals were, first, to identify the greatest value increase by species and stand type, and second, to identify the minimum diameter that yielded acceptable value increases within each species and stand type. Most of the trees evaluated had already been felled and bucked. Measurement of length and diameter were entered into the field computer. Bucked trees were evaluated for surface-quality characteristics, and the corresponding values were recorded. Actual log lengths of a given tree were entered as a “user solution.” An optimal-bucking solution was then generated for later comparison.

Procedures

Three sites were studied in order to identify potential benefits under various market conditions for the timber in the Pacific Northwest. Third-quarter 1993 log specifications and log prices were entered into the computer program (Table 5, page 20) before the handheld computer was taken to the sites. At each site approximately 50 sample trees were selected at random. Objectives were to collect an adequate number of trees from each species within the unit, to sample each over the range of diameter classes, and to pick trees from various unit locations so that different fallers would be used in the comparison.

Length and diameter measurements were taken with a log tape and log calipers, respectively. Log lengths and diameters were measured at the existing cuts. Some additional diameter measurements were made midlog. Surface-quality assignments were made on the basis of surface-quality and grade specifications currently used on the reservation. Tree description data, OSU-BUCK log solutions, and the actual log solutions were saved for each tree. The value of each sample tree was determined for logs generated with the OSU-BUCK solution and with the faller’s cutting pattern. The total values were then compared, with consideration of dollar value received for logs delivered at the mill, scaling volume sent to each mill sort, and log lengths.

Site Variations

Site 1, the Redeemed Land Timber Sale in the northwestern portion of the Warm Springs reservation, was typical of many of the high-value old-growth stands of noble-fir and Douglas-fir found there. Approximately 43 percent of the unit volume was comprised of whitewood species, with noble-fir and Douglas-fir accounting for the remaining 28 and 29 percent, respectively. Scattered western white pine and lodgepole pine were not included in the sample. Trees on this unit ranged from 8 inches to more than 50 inches in diameter.

Table 5. Sample timber-sale data: log destination, log specification, and price per thousand board feet (mbf).[a]

		Diameter (in)		Length (ft)		Increment	Trim	
Species[b]	Grade[c]	Min	Max	Min	Max	(ft)	(in)	$/mbf
Destination SUNDIAL (export)								
DF	SB	24	72	26	40	2	10	2450
DF	SM	12	72	26	40	2	10	1150
DF	C	12	72	26	40	2	10	875
DF	J	8	11	34	40	2	10	850
DF	K	8	11	34	40	2	10	830
NF	SB	24	72	20	40	2	10	3025
NF	SM	16	72	20	40	2	10	1150
NF	C	12	72	20	40	2	10	655
NF	J	12	11	34	40	2	10	710
NF	K	8	11	34	40	2	10	570
WW	SM	12	72	26	40	2	10	800
WW	C	12	72	20	40	2	10	710
WW	J	8	11	34	40	2	10	660
WW	K	8	11	34	40	2	10	570
Destination VANPORT								
DF	C	12	72	12	40	2	10	800
DF	2SW	8	72	10	40	2	10	650
L	2SW	8	72	12	40	2	10	650
NF	C	12	72	12	40	2	10	750
NF	2SW	8	72	12	40	2	10	600
WP	2SW	8	72	12	40	2	10	650
WW	C	12	72	12	40	2	10	750
WW	2SW	8	72	12	40	2	10	575

[a] Third-quarter 1996 specifications.

[b] DF = Douglas-fir, L = Western larch, NF = Noble fir, WP = white pine, WW = whitewood species.

[c] Grade:
C = Export sort, China
J = Export sort, Japan
K = Export sort, Korea
SB = Peeler quality
SM = Special mill
2SW = No. 2 saw-grade

Overall log grade was high in the unit, resulting in substantial volume being cut into export-quality logs. Most noble fir and Douglas-fir trees in the unit had a 16-inch or greater diameter at breast height (dbh).

Although the timber had already been felled and bucked, the OSU researcher accompanying the log-quality coordinator entered the description of each sample tree as if it had not yet been bucked, including diameters at roughly 30-foot intervals and a description of surface quality (mainly the size and frequency of knots). A description of the length of each of the logs already bucked was then entered, and the values were calculated and stored. The computer then determined the optimal-bucking solution for the tree. The volume and value of the two patterns for each tree were saved by the computer.

Site 2, the Ollalie Butte Timber Sale, also in the northwestern portion of the Warm Springs Reservation, was a mixture of 200-year-old and older whitewood species (hemlock and true firs) with an average 16-inch dbh. The log grade on the site was typical of the export and domestic sawlog quality found on the reservation. The timber on that site had also been felled and bucked, so the same procedure was followed as on Site 1.

On Site 3, the Triple Creek Timber Sale in the southern portion of the Warm Springs Reservation, ponderosa pine was predominant, mixed with lesser volumes of Douglas-fir and whitewood species. Diameters ranged from the minimum merchantable diameter to 40+ inches on the stump. East-side Scribner rules were used for the ponderosa pine, which was sold “camp run” (log grade not considered). For all other species, west-side Scribner rules were used. In general, the fir species were smaller and of lower quality than the fir species on the other two sites.

Sample trees on about one-half of the unit had already been bucked, so on that portion the procedure was the same as on Sites 1 and 2. The optimal bucking solution was used for manufacturing logs from the remaining half of the sample trees. The felling and bucking supervisor did the saw work while the OSU researcher ran the computer.

Findings

Field studies at the three sites on Warm Springs timberlands showed that value increases ranging from 4.5 percent to 8 percent could be obtained by using optimal-bucking technology, yielding revenue increases from \$18 to \$110 per mbf. Increased volume due to west-side Scribner rules accounted for some of this increase, but the major reason was a higher volume of logs in the more valuable sorts, mainly in the export sort. Logs that were specified by the OSU BUCK program had the same average lengths as those bucked without the program.

If optimal-bucking technology had been used, total value for the Site 1 sale would have increased by 7.9 percent, volume by 2.5 percent. A shift in volume into the highest grade at the export destination (see Table 6, page 22, Site 1, Sundial 1) could have been accomplished by cutting logs to combinations of lengths that captured the most high-grade volume. When multiple species are to be shipped to a mill that requires a specific overall average length, OSU BUCK will optimize the volume of the most valuable species and will satisfy the length requirement by cutting the lower valued species to preferred lengths, disregarding value. The total increase of $110.86 per mbf on Site 1 can be attributed to increases of $37.22 per mbf in the scaling volume and $73.64 per mbf in upgrading to sorts of higher value.

Table 6. Volume and value for sites harvested with and without optimal-bucking technology.

Site, destination, and sort	Logs as bucked Volume (board feet)	Logs as bucked Value ($)	OSU-Buck solution Volume (board feet)	OSU-Buck solution Value ($)
Site 1				
Sundial 1	22,490	63,427	25,910	72,288
Sundial 2	25,740	23,370	24,650	21,900
Vanport	14,910	8,012	15,150	8,280
Willamette	3,830	255	3,180	282
Warm Springs	820	320	610	236
Total	67,790	95,468	69,500	102,986
Site 2				
Sundial 2	3,710	2,450	3,730	2,460
Vanport	12,140	6,842	13,160	7,490
Willamette	1,220	108	1,640	146
Warm Springs	1,060	396	950	361
Total	18,130	9,796	19,480	10,457
Site 3				
Sundial 2	9,230	7,558	9,870	8,111
Vanport	5,250	2,678	4,650	2,362
Warm Springs	790	346	790	348
Total	15,270	10,582	15,950	11,163

The dollar-value on the Site-2 sale increased 6.7 percent with optimal bucking, and the total west-side Scribner volume increased 7.4 percent. The destination summary (Table 6) shows the same pattern found in other studies: optimal bucking shifts volumes to sorts of higher value. The total net increase of $36.45 per mbf, derived almost entirely from the increase in scaled volume, was adjusted for logging costs but not for the cost of optimal bucking.

The Site-3 stand was used to investigate the effectiveness of the computer technology in pine stands. The situation differed from that on the other sites in significant ways: 1) The average tree size (1,000 board feet) was smaller than that on other stands. 2) East-side Scribner scale was used, which reduced the possibility of gaining volume by manipulating diameter and length combinations. 3) No destination for a high-value sort such as an export sort was available for the ponderosa pine (average value at the Prineville and Warm Springs destinations was $583/mbf); one mill took almost all volume as a camp run (not graded).

4) There was a restriction on allowable log lengths; the solution forced 70 percent of the logs to be cut in the preferred 32-foot length. Any one of these conditions is a disadvantage in optimal bucking and can make it less effective. The combination resulted in minimal gain in scale and value, and none of the conditions (scaling rules, length requirements, available markets, and tree size) are likely to change in the near future. The sample of 25 ponderosa pine trees gained only 1.3 percent value after optimal bucking, $7.95 per mbf.

Douglas-fir and whitewood evaluated at this site showed modest gains with optimal bucking, increasing 5.5 percent in volume and 4.5 percent in value. The volume going to each mill showed the same pattern found on other sites. Optimal bucking delivered a higher percentage of the total volume to the higher paying export destination (Table 6, Site 3). The total value of Douglas-fir increased $38.16 per mbf—$6.88 per mbf attributable to value and $33.16 per mbf attributable to scaling volume. The total increase for ponderosa pine was $7.95 per mbf.

Minimum Tree Size

Many small trees in this study showed no net value gain. When the cost of optimal bucking was compared with the value gain in order to identify a minimum profitable tree size, a breakeven volume per tree of approximately 200 board feet was found on all sites. The breakeven point is sensitive to available log grades and current mill prices.

Of the large trees, only about half showed significant value gain, and it was not possible to predict which would do so. It appears that optimal bucking must be used on all large trees in order to capture a value increase for some of them.

Comparison of Cutting Patterns

Substantial differences between the log lengths of trees cut hypothetically with the computer solution and the same trees as actually bucked were examined for patterns. No repeatable pattern was detected. There appears to be no rule of thumb for training cutting crews. The OSU researcher, an experienced faller, observed a wide variety of bucking skill on the units sampled: some good decisions were made at the stump; some good opportunities were missed.

The optimal-bucking program has been used by some companies to train a faller/bucker by showing the resulting volume and dollar values of different user solutions. The assumption has been that investigating different cutting alternatives would help the faller/bucker learn how different lengths, diameters, and qualities affect the scaling rules and grade sorts. Another training approach has been to display the optimal bucking patterns for a set of trees on the assumption that the faller/bucker could infer rules-of-thumb for use on other trees. Our research does not support either training approach. The major lesson learned has been that volume in higher grades is maximized by cutting a variety of lengths rather than one preferred length. The only predictable and repeatable selection criteria found in this and other studies is minimum tree size.

Dunn Forest

Optimal-bucking technology was implemented again on a 20-acre clearcut on the northeastern edge of the McDonald-Dunn State Forest in July and August of 1994. The Dunn Forest, located in the Oregon Coast Range a few miles west of Corvallis, Oregon, is a research forest managed by the College of Forestry at Oregon State University. The sale contained approximately 1.3-million board feet of timber. Roughly one-half of the board-foot volume was allocated to the optimal-bucking study, such that 1,064 trees, ranging in diameter from 6 to 46 inches, were bucked into 2,945 logs according to the bucking solutions generated by a handheld computer. The average tree contained 0.564 mbf, gross volume. A total gross volume of 657 mbf was removed from the study unit.

Objectives

Research forest staff worked with contract cutting-crew members in a full commercial implementation with minimal intervention from researchers. For the first time, bar-code numbers were generated for each log by the program, and a corresponding bar-code tag was attached to each log for tracking purposes.

This study also tested the use of a Log Quality Technician (LQT) who worked with each faller. Use of the handheld computer during optimal bucking at the stump adds approximately 5 to 10 minutes per tree for making diameter and length measurements, entering data into the computer, and reading the solution. A potential time-saving solution was to use the technician to make measurements as a tree was being delimbed and to mark the tree with bucker's crayon at the cross-cut locations.

The responsibilities of the LQT were to measure and evaluate each tree, enter data, generate optimal bucking solutions, enter user solutions, process tree-input and log-output files, and operate and maintain the computer in the field.

Two contract fallers, accompanied by the two technicians, used optimal bucking technology for 20 days. The bar-coded tag was attached to logs at the stump. Information recorded by the optimal-bucking program on the grade, diameter, length, and gross scale of each merchantable log was later compared with scaling-station reports on the same logs by sorting files according to bar-code numbers.

The study posed five questions about optimal-bucking technology: Did the bar-code tag and log description provide accurate tracking? Was the use of the LQT effective? Did decisions on bucking grade made at the stump correspond to decisions made at the scaling-station? Were value and volume gains realized? When implementation problems were encountered, were problems resolved?

Procedures

The 20-acre unit contained approximately 33 mbf per acre. The stand was predominantly Douglas-fir, with some grand fir. The No. 2 sawmill-grade logs were purchased by one mill, and the remainder, mostly No. 3 and No. 4 sawmill-grade logs, were purchased by another. Both mills specified that a percentage of logs be in preferred lengths. Both were informed that optimal-bucking technology would be used. Logs were sorted and loaded at the landing. Two experienced contract fallers did the felling and bucking.

Two full-time OSU foresters were chosen as the computer technicians. One LQT had attended the 2-day workshop on OSU-BUCK; the other was trained by the first. Both technicians were familiar with the handheld computer, Husky FS/2, and both worked with local scalers to become proficient in judging the surface quality of logs.

Other than the initial workshop, the only help given the technicians was advice on setting up price-adjustor tables to achieve the desired percentage of preferred-length logs (similar to help that would be given in an industrial implementation). The technicians then prepared the computer tables for log specifications and prices paid by the mills.

Duties of the Log-Quality Technician

The requirements for the LQT are physical stamina to work in the woods with the felling crew; knowledge of safety measures for working around falling trees and bucking operations; and the ability to do the following:

- measure diameters to within 0.1 inch with calipers and lengths to within 0.1 foot with a Spencer tape
- judge the surface quality of a tree with a guide
- type data into a handheld computer
- follow a sequence of computer prompts
- identify defect
- judge sweep or crook in order to eliminate it by means of cut locations

Each LQT worked beside a faller, measuring the tree as the faller delimbed it. After the LQT entered the data, the optimal-bucking solution was shown to the faller, who manufactured the tree into logs. The faller could override the solution after discussion with the LQT. Fallers and technicians practiced for 2 days.

During the third week of the study, the fallers also recorded a user solution for all trees and ran the data as a batch through the optimal-bucking program. In that way, the two sets of log solutions could be compared for volume and value changes achieved through optimal-bucking technology.

Log Tracking

Each bucked log had a sequentially numbered bar-code tag stapled to one end. In this study, the LQT attached tags to the logs in a few seconds as part of the routine. The optimal-bucking program recorded each tag number automatically in a data field that contained a complete description of the log. At the end of each day, a complete inventory of all logs was available, as shown in Table 3, page 11.

A portable scanner was used to read tags at a check station as log trucks left the harvesting unit. The truck drivers used that time to secure the load with binder chains so little time was lost. (This type of monitoring can be done anywhere along the path of the log to the customer: at landing decks, sort-yard decks, mill yards, scaling stations, or, as in this case, during transport.) Almost no tags were lost or destroyed during yarding and hauling.

At both scaling locations that measured logs from the unit, log-tag numbers were entered into computerized scaling files that were later loaded into a spreadsheet for comparison with the files generated by optimal bucking. The two sets were sorted and summarized for comparison of measurements and grades assigned by the computer with those recorded by the scaler.

Preferred-Length Control

The percentage of preferred lengths produced with the computer solution can be manipulated by price-adjustment factors that temporarily inflate the mill price, making preferred lengths more attractive. An adjustment factor of as much as 115 percent is often needed to meet mill specifications. The factors were determined at the beginning of the study by using the batch-processing features of OSU BUCK on a sample of about 50 trees. Trial adjustment factors were entered into the computer, which produced a log listing. The log lengths were then sorted in a spreadsheet and the percentage of preferred-length logs was calculated. If the result was not satisfactory, a new factor was tried, and the batch process was repeated. (When there are several mills with multiple sorts, this procedure may take several days.)

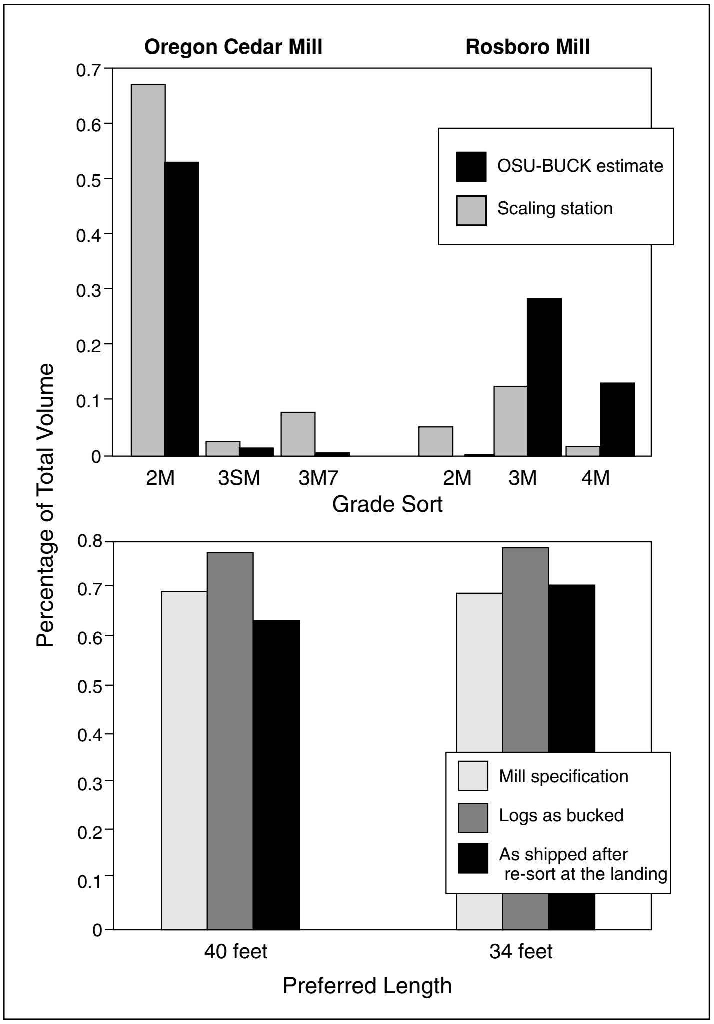


Figure 7. The percentage of total Douglas-fir volume delivered in each grade sort (top) and in preferred mill lengths (bottom), as determined by OSU BUCK and by scalers.

Findings

Reconciliation of Scaling Grades

The grade sorts determined by the optimal-bucking program were from the official rules of the Northwest Log Rules Advisory Group (1982), which applied to the jurisdictions of both the Columbia River Bureau and the Southern Oregon Bureau in which the study mills are located. Figure 7 shows the mismatch between results achieved with the published rules and results achieved with the more lenient scalers. Total stand value was higher than was expected from the computer calculations. This suggests that scaling rules used with the optimal-bucking program should be fine-tuned to the idiosyncrasies of each station by monitoring a sample load of trees or by consulting with specific scalers.

In this study, the logs had been manufactured before the grade discrepancy was discovered, but they had not yet been hauled. A large proportion was therefore upgraded to a higher sort by the LQT during loading at the landing and redirected to the higher paying mill; however, those logs were not in the longer preferred length.

Both mills required 70 percent of volume to be in preferred lengths. To guarantee that percentage, the price adjustors in the program were manipulated according to a sample of trees from the unit. What was actually achieved at the stump was 80 percent because fallers overrode the computer solution on 24 percent of the trees. In most cases, their overrides meant that longer logs were cut.

Volume and Value Gains

Past studies have shown that OSU BUCK increases value in the 8- to 10-percent range. However, the comparison of logs bucked under the optimal-bucking program with those bucked under faller choice showed an increase of only 3.2 percent, largely due to a 4.7 percent increase in gross scale. The result was an increase of about $18 per mbf for the timber harvested. The additional cost of optimal bucking was about $8 per mbf, making the final net gain about $10 per mbf. Although this gain may not be sufficiently attractive alone, log tracking may make optimal bucking worthwhile. The technology provides tracking of information at no additional cost. Log description is automatic, and tagging is part of the routine.

Implementation Problems

The major problems encountered with OSU BUCK were associated with preferred length. First, finding proper price adjustors was difficult with multiple mills and multiple sorts. Second, fallers were reluctant to accept computer solutions that contained more short logs than they were accustomed to bucking. Third, regrading logs during loading disrupted the planned proportion of average log lengths to be sent to each mill.

Mill representatives who visited the site as soon as felling had begun perceived incorrectly that too many short logs were being cut, and they threatened to reject the log loads, which may account for the high percentage of faller overrides of the computer solution. Altering the customary pattern of bucking is evidently difficult. Preferred lengths were 34 to 40 feet for the mill receiving lower grade logs, and 40 to 48 feet for the mill receiving higher grade logs. When the lower grade logs were upgraded, the average length of logs going to the second mill dropped. As a result, although delivery to the first mill was within specifications, only 65 percent of the log volume delivered to the second was in preferred lengths.

The ability to meet preferred-length requirements continues to be a major concern of log buyers. They are apprehensive that too many short logs will be hauled to their mills, which puts pressure on fallers to cut more than the required percentage of volume in preferred lengths. During this study, the fallers overrode the optimal bucking solution on approximately one in five trees, chiefly in order to cut preferred-length logs. The result, as previously stated, was 80 percent in preferred-length logs rather than the required 70 percent. The overrides caused a considerable loss of value that could have been obtained with the optimal bucking solution (Olsen et al. 1990). Past studies have shown that fallers routinely cut 90 percent or more of the volume in preferred lengths, so that when optimal-bucking technology reduces the amount to the required volume (often 70%), both log buyers and fallers become uneasy.

Cost Effectiveness

Previous OSU studies have estimated that optimal bucking slows production about one third when the faller or bucker does the computer work. Although a time study was not conducted in this trial, daily production of both fallers appeared to be about 80 percent of their normal rate when OSU BUCK was used, and there is no indication that that would improve with experience. The statewide average wage for fallers is $24.91 per hour. When other payroll costs are added, that value increases about 50 percent. Using the computer adds from $1 to $4 a log ($8/mbf) in felling cost (Table 7).

Table 7. Daily felling costs with and without OSU BUCK and a Log-Quality Technician (LQT).

Log size	Method	Logs per day	Wages per day	Cost per log	Increase in cost per log	Increase in yield per log
Small (~220 bf)	No computer, faller	100	$192	$1.92		
	Faller, OSU BUCK	67	$192	$2.87	$.95	
	Faller, OSU BUCK, and LQT	80	$288	$3.60	$1.68	$7.20
Large (~600 bf)	No computer, faller/bucker	50	$336	$6.72		
	Faller/bucker, OSU BUCK	37	$336	$9.08	$2.36	
	Faller/bucker, OSU BUCK, and LQT	40	$432	$10.80	$4.08	$21.60

Working conditions for the LQT are the same as for cutting crews in hours and travel time to and from the site. There is currently no such logging job, although the loader operator makes sorting decisions, a judgment skill also needed by the LQT. The wage of the LQT should be negotiated, perhaps being similar to that for a loader operator ($12.92/hr). Using the LQT is more expensive than having the faller use the computer, requiring additional delay and decision-making that slow an operation.

The cost of optimal-bucking technology is approximately 20 percent more in felling costs, plus the additional LQT wages. However, the value increases with optimal-bucking technology can more than cover added labor costs.

The Dunn Forest manager chose not to use the optimal-bucking program for the 1995 harvest because the trained technicians had left the company, and no new ones were trained. Also, the manager believed the increase in log value was insufficient to compensate for the administrative complications of running the system. The number of fallers would have had to be limited to the number of technicians and handheld computers available, which would have caused delay in yarding schedules that could be critical in a short harvesting season.

Conclusions from the Trials

The reluctance of foresters involved in the trials to adopt optimal-bucking technology after the trial studies were completed may have been largely due to a misperception of its potential. Recent successful adoption of similar technology in New Zealand suggests that, as such technology becomes familiar, the North American logging industry may yet find it attractive. Organizational aspects must be addressed more closely. Now that the technical functions have been successfully designed, perhaps the next phase in development should be to focus on the customer and user, acquainting them further with optimal bucking procedures and advantages.

The lessons learned from the trials concern software performance, training of users, the effect on faller production, the effect of preferred-length quotas, reconciliation of scaling grades, and the applicability of OSU BUCK to different species and stand types.

Software Performance

After minor debugging, all new features of OSU BUCK were satisfactory. Calculations were correct, file manipulation worked well, and the computer transitions between species on the sites were made easily and quickly. Bucking-solution calculations were performed approximately 10 times faster with west-side scaling rules than with cubic and east-side scaling rules because of the file structure. Better accuracy of input of diameter and length measurements gave more accurate estimates of the diameters of logs that were subsequently cut. The estimator of inside-bark diameter was not formally evaluated. Automatically generated ASCII files of log descriptions, coupled with the bar-coded tags, made log tracking possible. The equipment performed without malfunction or breakdown, and users were able to operate the program without mistakes after minimal instruction.

Stand Cruises and Appraisals

The optimal-bucking software may be used for estimating volume and value of standing timber because it already contains current mill-price and log-specification files. To conduct a cruise, trees from sample plots should be measured and the measurements run as a batch file through the OSU BUCK program on an office computer. An accurate estimate of the log grades (gross volume and value) is then available.

Adjustment for Inside-Bark Diameter

When regression analysis was performed on all major species to determine equations that would predict inside-bark diameter from an outside-bark measurement, there were in most cases no statistically significant variables; neither distance from the butt nor tree size helped prediction. The ratio of inside-diameter to outside diameter was the best predictor although it varied from species to species and even within species at some sites. If a ratio is to be used, a sample of at least 10 trees at each felling site should be taken in order to establish it.

Bark thickness at the butt is extremely variable and should not be used in the regression analysis. The faller is able to measure inside diameter at the felling cut, so the ratio need not be used until about 8 feet up the bole. From there to the merchantable top the ratio remains fairly constant.

When the inside diameters predicted by the ratio method were compared with those made by an experienced, motivated faller (logs from 20 trees), the accuracy was comparable. However, the ratio method can prevent the conversion error that past studies (Olsen et al. 1989) have shown fallers occasionally make when adjusting for inside diameter. Two factors should determine whether the method is used: the competence (experience, motivation, mathematical ability) of the faller and the expense of sampling trees to find the correct adjustment ratio. Errors in inside-bark diameter can affect the computer solution and can cause substantial loss in log value (Olsen et al. 1989). With large timber, the ratio method should be used because of the wide variation in bark thickness.

Training OSU BUCK Users

It appears that every tree must be individually measured; no short-cut rules were found that consistently applied. The OSU BUCK solutions were complex combinations of diameters, lengths, and grades.

Using a Log Quality Technician rather than a faller to enter data appears promising; however, in the trial with the LQT, faller production dropped (Table 7, page 28). It would be difficult for a timber cutting-contractor to train and supervise the LQT. Usually the LQT would be an employee of the timber owner rather than of the cutting-contractor and would represent the interest of the owner. The LQT can work with either a single faller (on small trees) or with a faller/bucker team (on large trees), with the advantage being that fallers and buckers need not be trained in optimal-bucking skills nor have to carry the computer and calipers in addition to saw equipment and fire-fighting tools. Also, maintenance of the computer is simpler (no oil, sawdust, other contaminants)

Faller Production

No formal statistical comparison was made of faller production with and without optimal bucking, but the logging supervisor estimated that it dropped noticeably with use of the technology. Even with an LQT, the faller needed extra time for making optimal-bucking crosscuts and decisions about data input. However, with a typical mill price of $600 per mbf and a typical value gain of 6 percent, the increase in value more than offsets the added expense.

Steps After Bucking

Once logs have been optimally bucked, other steps are necessary for successful implementation of the program. The loader operator must be trained for sorting to assure that the log arrives at the correct mill, or logs must be marked with destinations with bucker's chalk at the stump. Also, although the average log length will remain the same with optimal bucking, a mixture of log lengths will be produced; thus the customers must be contacted to learn if the delivered logs are satisfactory.

Average Log-Length Requirements

Loosening average-length restrictions could result in substantial value gains. Trucking practices must change to handle the changes in log lengths; however, any increase in hauling costs, if they do occur, should be considerably less than the value gain. It was recommended after the first trial that Warm Springs Forest Industries use OSU BUCK to investigate whether or not the increase in value would justify negotiation with log buyers for fewer length restrictions.

Preferred-Length Quotas

With multiple species and multiple grades, determining price adjustors that would yield the correct percentage of preferred lengths took several days. Because fallers accustomed to cutting greater volume in preferred lengths were allowed to override the optimal solution, they exceeded the target of 70 percent by almost 10 percent. One way to overcome resistance to the computer solution might be to give both log buyers and fallers a weekly report of the percentage of logs cut in the preferred length, which should counter faulty perceptions. The misgrading of logs further altered the percentage of preferred lengths sent to each mill. Because many of the cut logs were directed to a mill other than the one OSU BUCK prescribed, the average length delivered to one of the mills was too low.

Reconciliation of Scaling Grades

The computer-generated log information was easily matched with the scaling-station information through the sequential bar-code numbers. The tags survived handling well, the portable scanner read the tags while logs were on trucks, and the cost of materials and labor for tagging was minimal. But tracking of the logs revealed a major discrepancy between grades assigned by OSU BUCK and grades given by the scalers. OSU BUCK was literal and strict in assigning grades, and the program therefore tended to downgrade logs. More care must be taken to calibrate the algorithm to reflect the scalers’ lenient interpretation of scaling rules.

Applicability to Stand Types

The high value of old-growth fir stands in the study was enhanced by optimal bucking. For several trees, the increase was in the thousand-dollar range. Increases were also made in the ponderosa pine stands. Only on stands of small-diameter classes in which lengths were restricted to 16-foot multiples was significant improvement lacking.

The optimal bucking procedure added approximately $8 per mbf for the ponderosa pine type to a high $110.86 per mbf for the noble fir type. A typical Douglas-fir stand increased in value $38.04 per mbf. Even in the worst case, OSU BUCK yielded a break-even solution; more typically, the value increase was at least four times larger than the added cost.

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Trials to achieve optimal bucking were made with updated OSU-BUCK software in an eastern and a western Oregon location during the summers of 1993 and 1994. The commercial version of the software allows tagging of each log with bar-code identification numbers and therefore provides tracking from stump to customer. Data management is enhanced by automatic creation of input and output files in spreadsheet format. The software allows a choice of scaling rules, and accommodates multiple species while increasing measurement accuracy. The trials showed that, as with previous software, preferred-length requirements are a stumbling block to achieving the most effectiveness. Value and volume increases achieved with OSU-BUCK were moderate. Pairing a Log-Quality Technician with a faller appears to be a promising method for users of optimal-bucking software.

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