Questions About Optimal Bucking

Eldon D. Olsen
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John Sessions
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Optimal Bucking

Introduction

In the last decade the reduced supply of prime old-growth trees, along with lucrative export markets in Pacific Rim countries, has spurred an interest in improving log manufacturing as a way of increasing the value received from timber. In the past the main focus of harvesting economics was cost control, but that has matured into sophisticated marketing considerations. With the aid of a computer, a bucker can now compare the value of a range of combinations of quality, diameter, and length manufactured at the stump or in the sortyard. Using computer technology to investigate possible cross-cutting and sorting decisions is known as optimal bucking. The purpose of optimal bucking is to find the most profitable way to merchandise a tree (Sessions 1988).

This bulletin provides a summary of our work on optimal bucking at Oregon State University (OSU) in the late 1980’s. Major considerations for deciding whether or not to adopt optimal bucking are explained and the steps to implement it are described. We also address arguments against using the new technology. The bulletin expands on a set of published articles, covers unpublished results, and offers practical guidelines. Appendix A provides an annotated bibliography of our articles and reports. Appendix B cites articles on optimal bucking research from around the world. The content of this bulletin is, however, based exclusively on OSU research. The main source of information has been from field studies with private companies participating in evaluating and testing prototype optimal bucking systems. These studies refined procedures to the point where optimal bucking can be adopted by the industry.

BUCK® is the name of a personal-computer (PC) based program developed and tested at OSU (Sessions, Garland, and Olsen 1988, Sessions et al. 1989a). It differs from other optimal bucking programs by being based on a network rather than on a dynamic program (Sessions, Langton, and Li Guangda 1988), but this is of no consequence to the user because the operation of the program does not require knowledge of computer programming.

The increases in value that can be realized by implementing optimal bucking are shown in Table 1, which summarizes the findings of three studies conducted in the Douglas-fir region of Western Oregon and Washington (Sessions et al. 1989a, Olsen et al. 1991). This region has a high potential for increased value because of the size and quality of the timber and diverse market possibilities. The increase in maximum value is the expected limit with perfect information, adjusted for measurement cost (Table 1). The increase in immediate value includes corrections for measurement errors, incorrect quality assignments, and measurement costs.

The immediate increases shown in Table 1 can be achieved with present technology and as optimal-bucking technology continues to develop the maximum value should be approached. Early reports estimated the maximum savings at almost double these levels, but preferred-length restrictions cut the levels in half. When no preferred-length restrictions are imposed the computer solution increases the number of logs cut by 20 to 40 percent, a number unacceptable to mills. When preferred-length restrictions are used the computer solution increases the number of logs

Table 1. Summary of optimal bucking field studies.

<table>
<thead>
<tr>
<th>Study number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Town</td>
<td>Sweet Home</td>
<td>Philomath</td>
<td>Longview</td>
</tr>
<tr>
<td>Operation Location</td>
<td>Stump</td>
<td>Stump</td>
<td>Sortyard</td>
</tr>
<tr>
<td>Equipment</td>
<td>Chainsaw</td>
<td>Chainsaw</td>
<td>Harvester</td>
</tr>
<tr>
<td>Species</td>
<td>Douglas-fir</td>
<td>Douglas-fir</td>
<td>Douglas-fir</td>
</tr>
<tr>
<td>Number of trees</td>
<td>50</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Average logs/tree</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Butt diameter (in.)</td>
<td>47</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Tree length to top cut (ft)</td>
<td>160</td>
<td>103</td>
<td>78</td>
</tr>
<tr>
<td>Top diameter (in.)</td>
<td>18</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>High value use</td>
<td>Peellers</td>
<td>Export</td>
<td>Export</td>
</tr>
<tr>
<td>Low value use</td>
<td>Sawlogs</td>
<td>Sawlogs</td>
<td>Sawlogs</td>
</tr>
<tr>
<td>Preferred length volume (%)</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Maximum value increase (%)</td>
<td>5.9</td>
<td>6.6</td>
<td>19.6</td>
</tr>
<tr>
<td>Immediate value increase (%)</td>
<td>3.6</td>
<td>3.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Immediate $/MBF increase</td>
<td>14</td>
<td>9</td>
<td>17</td>
</tr>
</tbody>
</table>
by 4 to 12 percent compared to conventional bucking.

Some optimal-bucking systems consider only log scale, while others include grade. A number also consider diameter and length premiums. Many of the systems are "post mortems" and check the bucking after it is already done. Dimensions are gathered in the field, analysis is done in the office, and a conclusion is made on whether the trees could have been bucked better. On mechanized equipment the current level of development toward optimal bucking generally considers only scale, although researchers are trying to develop the capability to include grades as well.

Some progressive forestry consultants and company managers have developed procedures to appraise stands by considering optimally bucked representative trees within the stand using detailed knowledge about tree taper and tree quality. This differs from our approach, which always optimizes individual trees based on each tree's specific characteristics.

Can Your Operation Benefit?

One of the best ways to evaluate the feasibility of using optimal bucking in an operation is to use the BUCK© DEMO program written to run on an IBM-compatible PC (Beaulieu 1988, Sessions 1988). This program is available on a 5 1/4" floppy disk along with a 38-page instruction manual and can be ordered from the Forest Engineering Department, Oregon State University, Corvallis, Oregon, 97331. You will also receive all the journal articles published from OSU on optimal bucking.

The BUCK© DEMO program is limited to a 50-in. butt diameter, a 6-in. commercial top diameter, and to two mills with three surface-quality categories. Although this is sufficient for a demonstration, an expanded commercial version is needed for actual implementation. BUCK© DEMO includes graphical output which displays a schematic of the tree and logs. The display is useful for spotting input errors and comprehending the solution while learning to use BUCK©-DEMO, but the graphics are not used in actual production.

In order to run the program you need 640K of memory, a graphics card, MS-DOS, and an IBM-compatible computer. The program is self-loading, has help screens, and includes sample data files of mill log prices, harvesting costs, and tree descriptions. For additional information on using BUCK© DEMO consult Appendix C.

Research at OSU

In addition to the original development of a handheld computer version of BUCK© for determining cuts on individual trees at the stump, a number of exciting office PC applications have been developed. These include timber-sale appraisals, harvest planning, and evaluation of bucking rules. All of these applications involve first measuring a set of sample trees in the field. The shape and surface quality of these trees are assessed either as standing trees or after they are felled. The data can then be analyzed as a batch by BUCK©. The BUCK© program is set up to run a set of price, cost, and bucking patterns. It reports the logs that would be cut under these patterns, allowing various scenarios to be evaluated. Studies demonstrating these applications have been published and are available (Olsen et al. 1990).

To demonstrate BUCK©'s ability as a preharvest appraisal tool, it was used to select the combination of mills that would realize the highest value on a recent 5-MMBF sale (Olsen et al. 1991a). Dimensions on standing trees were obtained with the aid of a relascope. An alternate method using taper equations to obtain the dimensions also proved feasible. Various combinations of mills bidding on the sale were then analyzed by BUCK©. The timber owner picked the set of mills producing the highest value result. The mix of logs forecasted by BUCK© accurately portrayed the actual mix obtained.

A demonstration of BUCK© as a harvest-planning tool showed the change in total value realized if a log-weight limitation was necessary due to harvest design (Olsen et al. 1990). The weight limit did not affect total values until the threshold point was reached and then projected values fell dramatically.

BUCK© was also used to evaluate various slash-burning policies (Olsen et al. 1990). Normally BUCK© assumes that logs with negative values are left in the woods. The program can be altered to see the effect of moving cull sections and small top logs to the landing, and can estimate the cost of removing slash in various ton/acre scenarios. Planners could choose alternatives of yarding unmerchantable material, such as producing firewood at the landing, sending the material to a mill, leaving it to be burned, or leaving it to decay. Costs and benefits can be compared for each scenario. The unique contribution of BUCK© is its ability to report accurately the marginal cost effect of
changes in incremental volumes of slash. A policy can then be implemented that would specify the type and size of slash that can be economically treated under the silvicultural alternatives.

These applications all focus on manipulating the entire stand rather than individual trees. Analysis can be done on the public software BUCK®-DEMO computer program, but this is cumbersome because each tree must be processed individually. Commercial programs are available that can run groups of trees as a batch.

BUCK® is also applicable in a stand with multiple species. The program would require separate mill log-price tables or else different quality codes for each species. When a particular species is encountered, the program would switch to the applicable specifications and prices. The current commercial versions of BUCK® can do this, but BUCK®-DEMO (Appendix C) does not.

Implementing Optimal Bucking

Conditions Favoring Effectiveness

When a handheld computer is used on individual trees, the following general stand and market conditions (in order of importance) increase the effectiveness of optimal bucking:

- If bids include at least one high-value market, such as export or peeler-log for veneer.
- If the value of each log is high (e.g., old growth and large-diameter second growth).
- If log quality varies along the tree stem and mills are included that pay a premium price for quality.
- If several different mills with different specifications are competing for logs.

Several operational conditions also facilitate the use of BUCK®. These include harvesting flexibility, mill cooperation, and management support. Important harvesting conditions are:

- The ability to handle logs of various lengths.
- Enough landing room to sort and store logs.
- Loggers who are willing to adjust to new technology.

Mills receiving logs must be able to:

- Handle logs of various lengths efficiently.
- Take delivery soon after cutting so that log prices used in the computer are still valid.

The following organization support is needed:

- Management expertise in marketing logs.
- Sufficient volume to warrant the extra marketing effort.
- A specific manager or supervisor assigned to oversee the optimal bucking system.

Diameter and Length Measurements

Information on the shape of the tree is required by BUCK® before making decisions on mill size-limits and calculating the log scale. Diameter measurements need to be correct to ± 1 in. or BUCK® gives erroneous solutions and most of the possible dollar value increases are lost (Olsen et al. 1989). Diameters are measured inside bark and are rounded down to the nearest inch. They need to be recorded at each major change in tree taper. After the butt diameter is measured, the next measurement is where the butt swell ends, with measurements at 40-ft intervals thereafter on second-growth Douglas-fir with uniform taper. The final measurement should be close to the estimated merchantable top. Bark thickness must be subtracted from outside-bark measurements before data are entered into the computer. We had the bucker do this correction in his head, but a more sophisticated method should be built into the computer.

For taking measurements, calipers proved more effective than a bucker's tape. Estimating diameters of trees in a uniform size class from taper equations is also promising. Scandinavian companies are currently testing this application on mechanized harvesters. A key to this approach is to monitor accuracy periodically by comparing estimates with actual measurements.

Length measurements are not as critical. To save time, measurements are currently to the nearest foot, but that could be reduced to 3 in. Buckers routinely use a tape to measure within several inches of
accuracy. We have experimented with new sonic measuring instruments that give accurate continuous length measurements and sell for under $100. They are the size of a pocket radio and have the advantage of speed.

Taking extra measurements and inputting data into the computer increases bucking time. Cross-cut locations are sometimes hard to measure when they occur in odd locations and handling calipers and the computer restricts movement. The additional time averages 0.8 minutes for each measurement taken and entered plus an additional 0.9 minutes to measure the specific cross-cut locations. In a second growth stand a tree can be felled and limbed in about 12 minutes. For four measurements the computer would therefore take an additional 4(0.8)+0.9=4.1 minutes. If the number of logs is also increased by optimal bucking, then about 0.5 minutes extra will be required for each additional log. Because the number of logs increases by only a small percentage, this adjustment is not significant.

The additional bucking time translates into additional costs. A good rule of thumb is that the total felling/bucking direct cost is increased by about 1/3 when the computer is used. The additional fixed costs of the computer and engineering (or managerial) assistance would be minor compared to this direct cost.

Cost Data

BUCK® requires input on three types of costs:

- Stumpage,
- Stump-to-truck harvesting, and
- Hauling cost to each mill.

These costs differ for each sale and are required in order to calculate the net value received for logs delivered to a mill. If the combined costs exceed the mill value, then the net value is negative and the computer solution “leaves that log in the woods”. “Left” logs are usually a top-log or a cull section.

The stumpage costs apply if the sale was purchased on net scaled volume. This can be entered either as dollars per MBF or as a percentage of the mill price.

Stump-to-truck costs include felling, bucking, yarding, sorting and loading. For optimal bucking to estimate the cost of harvesting, cost data for various logging conditions, sites, and stands are necessary. The major variations that should be noted, in addition to piece size, are the difference in costs for terrain slope and roughness, yarding distances, volume per acre removed, average turn size, and equipment and labor.

A future extension may include slash treatment as a cost. If the current costing system shows a negative net value for a log, transporting it may still yield a positive return if a credit is given for avoiding penalties or for not having slash treatment costs, such as piling and burning.

In order to accurately reflect effects of bucking decisions, a fixed cost per log, as well as a variable cost per MBF, is needed. Otherwise the optimal bucking program does not control the number of short logs manufactured (Olsen et al. 1990). To obtain proper harvesting costs, records are needed of the dollars per MBF cost for various log sizes. As the log size becomes smaller this dollars per MBF increases. For example, if 100-board-foot logs cost $70/MBF to log while 200-board-foot logs cost $45/MBF to log, the cost per log is obtained by multiplying the cost ($/MBF) by the size (MBF/log). This is $7/log for the smaller logs and $9/log for the larger logs. Plotting this on graph paper shows a fixed cost of $5/log plus a variable cost of $20/MBF. The computer can now calculate the cost of handling each size of log within the range of the data. For instance, a 150-board-foot log would cost 5+20(.150)=8 dollars.

Harvesting costs may also be used to determine the proportion of the total stand that should be cut to certain lengths. The value of the whole stand is optimized within these length restrictions by encouraging specific lengths to be chosen as each tree is optimized.

Hauling costs are calculated on a dollars per MBF basis for the round trip to each mill. If contract hauling is done, the cost is the dollars per MBF payment to the trucker. If company hauling is used, then a calculation is made of the round trip cost divided by the average net load size.

Mill Price Tables

BUCK® requires precise information on log prices for each mill desiring to buy logs. Mills have tables that list the prices paid for various diameters, lengths, and quality of logs (Sessions, Garland, and Olsen 1988). These tables are not in the same format as mill specifications and log price lists received from the mills. In fact, there seems to be no standard format. A standardized mill-price table can be created
from mill specification tables. We based our example on scaling rules for Douglas-fir in western Oregon, but similar approaches can be used elsewhere.

Grading rules for peeler logs and sawmill logs are summarized in Table 2. The grade is arrived at by considering diameter, length, and quality. Quality is determined by surface characteristics (frequency and size of knots), presence of defect, net volume, rings per inch, and slope of grain. A typical mill specification cites log quality within restrictive diameter and length ranges. In addition, a minimum percentage of the log volume must be in that mill's preferred lengths. These preferred lengths are associated with perceived milling efficiencies and overrun capabilities. Table 3 gives examples of lists for two mills. A price per thousand board feet (delivered to the mill) is quoted for each category.

During optimal bucking, trees need not be graded. Buckers are merely asked to judge surface quality so that the computer can estimate the grade of each log being considered. Table 4 shows an example of surface quality classes unique to the optimal-bucking procedure. These classes would be customized for each specific application. In our studies we used up to 12 quality classes for old growth, and as few as three classes for small second growth.

A customized table is created which screens logs into the proper grades. This computer procedure is the key to translating the surface quality (assigned by the bucker) to the log grade (part of the mill's price quotes for logs). For example, if surface is quality 2, diameter 8 in., and length 40 ft the log would be assigned a grade of a No. 3 sawlog.

The logs can now be assigned a value based on the surface quality, diameter and length. Table 5 shows an example for two mills. It is a combination of Table 3 (mill prices for logs) and the computer procedure that translates surface quality, diameter, and length into a log grade. The table can either be set up as mutually exclusive lines (as in Table 5) or with overlapping specifications. In BUCK<sup>®</sup>-DEMO, when an overlap exists, the program gives precedence to the last line listed so that general specifications can be listed first and exceptions listed later. The overlapping of specifications is demonstrated in the BUCK<sup>®</sup>-DEMO user's manual (Beaulieu 1988).

### Table 2. Examples of specifications for grading logs.

<table>
<thead>
<tr>
<th>Gross diam. (in.)</th>
<th>Gross length (ft)</th>
<th>Surface clear %</th>
<th>Ann. Slope of grain #/in. (in./ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 2 Peeler*</td>
<td>30</td>
<td>17</td>
<td>75</td>
</tr>
<tr>
<td>No. 1 Sawmill*</td>
<td>30</td>
<td>16</td>
<td>90</td>
</tr>
</tbody>
</table>

*In addition, ≥35% of NET scale must be suitable for rotary cutting of clear, uniform-colored, face stock veneer.

*In addition, ≥50% of NET scale must yield grade B or better lumber.

### Table 3. Typical mill specifications. Mill z specifies three allowable lengths. Mill w specifies minimum and maximum preferred lengths.

<table>
<thead>
<tr>
<th>Quality specs</th>
<th>Minimum diam (in.)</th>
<th>Maximum diam (in.)</th>
<th>Length (ft)</th>
<th>Price $/MBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill z*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1P</td>
<td>30</td>
<td>none</td>
<td>20, 26, 34</td>
<td>750</td>
</tr>
<tr>
<td>2P</td>
<td>30</td>
<td>none</td>
<td>20, 26, 34</td>
<td>650</td>
</tr>
<tr>
<td>3P</td>
<td>24</td>
<td>none</td>
<td>20, 26, 34</td>
<td>485</td>
</tr>
<tr>
<td>1S</td>
<td>30</td>
<td>none</td>
<td>20, 26, 34</td>
<td>500</td>
</tr>
<tr>
<td>Mill w+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>16</td>
<td>50</td>
<td>17 - 40</td>
<td>275</td>
</tr>
<tr>
<td>2S</td>
<td>12</td>
<td>100</td>
<td>12 - 40</td>
<td>235</td>
</tr>
<tr>
<td>3S</td>
<td>12</td>
<td>50</td>
<td>12 - 40</td>
<td>150</td>
</tr>
<tr>
<td>Utility</td>
<td>12</td>
<td>50</td>
<td>12 - 40</td>
<td>65</td>
</tr>
</tbody>
</table>

*All grades, maximum volume 5750 bd ft, 80% volume in ≥ 26 ft preferred length. P = peeler, S = sawlog.

*75% volume ≥ 26 ft. SM = special mill.

### Table 4. Examples of surface-quality class descriptions.

Quality 1: 90% clear of knot indicators, min of 8 rings/in. 1/6 outer diameter without stain

Quality 2: 75% clear of knot indicators, min of 8 rings/in. 1/10 outer diameter without stain

Table 3 (mill prices for logs) and the computer procedure that translates surface quality, diameter, and length into a log grade. The table can either be set up as mutually exclusive lines (as in Table 5) or with overlapping specifications. In BUCK<sup>®</sup>-DEMO, when an overlap exists, the program gives precedence to the last line listed so that general specifications can be listed first and exceptions listed later. The overlapping of specifications is demonstrated in the BUCK<sup>®</sup>-DEMO user's manual (Beaulieu 1988).
Table 5. BUCK® log price list.

<table>
<thead>
<tr>
<th>Surface quality</th>
<th>Small end diam. (in.)</th>
<th>Log length (ft)</th>
<th>Price ($/MBF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Mill y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>30</td>
<td>8</td>
</tr>
</tbody>
</table>

Checklist of Prerequisites

In order to implement optimal bucking successfully, a company manager or a consultant must accomplish the following tasks:

- Develop hauling costs to various mills.
- Develop harvesting costs for different piece sizes.
- Determine acceptable log lengths for hauling.
- Negotiate acceptable log lengths for mills.
- Set up surface-quality categories and train buckers to recognize them.
- Translate mill specifications into specific price ranges for the computer.
- Choose the optimal bucking software program and hardware.
- Find the adjustment factors to force BUCK® to give the desired percentage of preferred-length logs.
- Train buckers in diameter measurement and computer data entry.

Some of these factors may require an investment of time and money to develop.

After the system is operational a manager would need the following part-time responsibilities:

- Repeat the above nine steps as major changes occur. The first six will probably change with each new sale.
- Monitor scaling tickets against BUCK®'s estimates.
- Monitor bucking and sorting.
- Adjust to feedback from mills, truckers, logging crew, and the feller/bucker.
- Update mill log price changes as they occur.
- Maintain computer equipment.

Since BUCK® will automatically give a detailed inventory of all the logs cut, the same manager may be responsible for developing a record keeping system which takes advantage of the information. This manager could do periodic batch analyses on the office PC to establish slash policy, evaluate harvest-planning options, and make stand appraisals.

Optimal Bucking Tailored to Your Needs

Preferred-Length Quotas

Many mill managers believe that certain specified log lengths result in more efficient processing. If most logs conform to those lengths, the mill’s performance is improved by increased through-put volume or by increased value, yet this preference is not always reflected in the pricing structure of the logs. Instead a qualitative statement is made that certain lengths are “preferred”. We found that this message is taken seriously by the buckers. In several of our studies, >90 percent of the volume was bucked into preferred lengths, even though this rarely optimized the value of the log from the timber owner’s viewpoint.

To impose a minimum percentage limit of volume in the preferred lengths, mill specification may include a clause such as “at least 80 percent of the...
volume must be in lengths of 36 to 40 ft”. BUCK© is able to manipulate the volume cut into preferred lengths. However, since this is an added restriction it does decrease the “theoretical” total value of the stand (Garland et al. 1989).

There are three ways to achieve preferred-length goals.

- The most restrictive is to specify the preferred lengths as the only allowable lengths in portions of the mill’s log-price list. This results in 100% compliance for specific line items in the log list. When this is averaged with the other logs, a trial-and-error approach can be used to achieve the 80 percent desired for the stand.

- A second approach is to artificially inflate prices in the log price lists for preferred log lengths (Sessions et al. 1989b). Trial and error is again used to find how much the price should be increased to reach the percentage goal exactly. After the optimal bucking achieves the desired volume, then the true value is calculated for these lengths before the value of the tree is assessed.

- The third and least restrictive method of getting preferred lengths is to use the mill prices that included price premiums for preferred lengths and harvesting cost functions that contain both a fixed and a variable cost (Olsen et al. 1990). As was mentioned, this correctly reflects true harvesting costs. As a spin-off benefit it encourages the bucking of longer (preferred-length) logs.

Trial-and-error methods in the first two procedures are done as batch runs on a sample of trees. Once the adjusting values have been determined, the remainder of the trees are processed using those numbers. New adjusting values must be found for each new stand or for new mill prices.

We recommend that mills use the third alternative described above. Bucking only to preferred lengths should be avoided because this loses up to 5 percent of the total value of the stand (Garland et al. 1989).

Log Grading

BUCK© assigns a value to each log based on estimated diameters and log grade. At any point along the tree the diameter estimate is a computer interpolation between the closest two measured diameters. Log grade is based on observed surface quality. There are several sources of possible error in this procedure.

- If the taper is non-uniform interpolated diameter may be inaccurate. The bark-thickness estimate used to get an inside bark diameter may be wrong since the faller will use a correction that results in a whole number. These interpolated values could result in incorrect scaled volume estimates.

- The computer is providing a partially “blind” estimate in contrast to the scaler, who has a completely different view of the log. He is able to see the face cuts which reveal defect, rings per inch, and grain slope. He also can measure the diameters directly. It is expected that he will down grade a significant proportion of the logs compared to the somewhat “blind” estimate made by the computer before the tree was bucked.

To assess the accuracy of grading, OSU researchers entered surface qualities and diameters for 150 trees into the computer (Olsen et al. 1991a). The computer designated about 450 logs, which were cut by the contract bucker. The logs were then tagged and followed through the scaling station. The actual value received as a result of the scaling station assessment of each log was compared to the value assigned by the BUCK© program. A marked difference was found between the two researchers. The first had grade differences with the scaler on 34 percent of the logs, half of which were due to grading the log too high. This occurred on the more valuable logs. A quarter received length or diameter reductions for defects, and the remaining quarter were assigned a higher grade by the scaler than by the researchers (which may in some cases be a scaler’s error). These generally happened on the lower quality logs. The last category probably occurred on logs that were borderline and reflected the overly optimistic nature of the researcher’s grades assignments. Overall these discrepancies resulted in BUCK©’s value estimates being 3.3 percent too optimistic. This adjustment could be made to the BUCK© estimate to obtain a more realistic expectation of mill receipts.

The second researcher also had around 33 percent of the logs wrongly graded by the computer, but undergraded about two-thirds of these logs. The other errors were about evenly distributed between overgrading, defect deductions, and missing the minimum volume requirements on a grade. Overall this researcher’s total BUCK© value estimate was 8
percent too low. This researcher therefore appears to be overly conservative. With some feedback both of the researchers could, over time, get closer to the scalers results.

Diameter differences between the scaler and BUCK© occurred in slightly <50 percent of the logs. The overall result was that BUCK© value estimates were 2 to 3 percent too low. The error was most common in longer logs and larger diameters.

Sorting errors also occurred. The loader at the landing sorted the logs without knowing the destination recommended by BUCK©. A surprising 37 percent of the logs were sent to a different mill (there were eight mills) than the one recommended by BUCK©. About one third of the logs were sent to and accepted by mills that paid a higher price than the specifications in BUCK© allowed.

The reduction in the total gross volume reported by BUCK© was 10 percent. This was due mainly to defect deductions made by the scaler that were not visible to the faller when data was entered into the BUCK© program.

### Additional Considerations

#### Tracking Inventory

An advantage of using BUCK© is that it provides a felled-log inventory. The data can be sorted and rearranged in any manner desired. Summaries can combine categories, for example, by mill and length. The data are an automatic output from the field computer and can be analyzed on an office PC using a spreadsheet, a data base, or a custom written program. This information can be converted to give:

- Log grades from the surface-code quality along with length and diameter measurements.
- Cubic-foot volume from diameters of both ends and length.
- Log weights from weight per cubic foot.

Some of the uses of this information could be:

- Payment method for fallers/buckers based on volume and value.
- Matching against scaling tickets after yarding and hauling by verifying how much volume is left in the woods; checking scale on the scaling agency; controlling of log theft; and calculating the cost of carrying inventory.
- Keeping records of production rates by estimating weekly production rates for yarding and calculating the cost/MBF of each logging function.
- Tracking the payment due from the mills for delivered logs.
- Matching against mill needs, e.g., changing bucking instructions to match mill requirements if the records indicate too much current inventory volume in certain lengths or grades.

However, unless each log is labeled with a unique identification, such as a numbered tag, the full benefit of the information cannot be realized. The most sophisticated labeling method would be a bar code system that could be read with a scanner. A specific log could then be tracked all the way through the system. A less sophisticated method would be to paint the ends with a color code, then at least total volumes could be tracked in various sorts. Even if no tagging is done, some benefits can be realized by reconciling the total volumes handled.

#### Changes in Office-Staff Duties

Log inventory stored in the handheld computer can be transferred to the office computer on a daily basis. The office then uses a spreadsheet-type program to summarize the data. Table 6 shows the form of the log data as it is stored. Each company can customize how this log inventory is set up.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Example</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log identification</td>
<td>100 1</td>
<td>tree 100 first log</td>
</tr>
<tr>
<td>Length</td>
<td>41</td>
<td>40 ft with 1 ft trim</td>
</tr>
<tr>
<td>Diameter</td>
<td>13</td>
<td>13 small end, inside bark</td>
</tr>
<tr>
<td>Quality</td>
<td>2</td>
<td>surface code</td>
</tr>
<tr>
<td>Mill</td>
<td>3</td>
<td>for mill number three</td>
</tr>
<tr>
<td>Volume</td>
<td>240</td>
<td>gross board feet (Scribner)</td>
</tr>
<tr>
<td>Value</td>
<td>71</td>
<td>dollars after costs</td>
</tr>
</tbody>
</table>
Office staff can update prices paid by mills for logs when prices change, or on a monthly basis. This information can then be "downloaded" into the handheld computers by telephone modem if the area is remote. Office staff may also run batch optimization runs. Data from sample trees would be typed into a computer file and the staff would then follow a simple set of instructions to batch-run BUCK®. Output would be transferred into a spreadsheet format for analysis.

BUCK® has to be set up for each company. A company supervisor, engineer, or accountant needs to be trained to do the setup. An alternate approach would be to have a consultant perform this setup installation.

Changes in the Falling and Bucking

A member of the logging crew needs a handheld computer in the field to apply optimal bucking to individual trees. Bucking may take place at the stump or at a processing area, such as the landing, concentration yard, or sortyard. The crew member will likely be the traditional faller/bucker, but it could be someone who does only bucking or even just marks the trees for bucking.

Adding the handheld computer to the job requires additional duties and skills that can be mastered in a week of on-the-job training. The new duties are to:

- Estimate the inside bark diameter at several locations on the tree before it is bucked. The crew member would probably use calipers to make this measurement.
- Judge the surface quality changes along the tree's length. The crew member would recognize defect, knot size, and knot frequency. The surface would then be assigned a numerical category from a list.
- Designate "must buck" and "can't buck" zones on trees with special configurations.
- Enter data into the keyboard using prompts from the computer screen and typing in the numbers and/or letters. The operator needs to remember the sequence of key strokes to be used and adjust to measurement changes at a tape break, such as starting over with a new length each 50 to 75 feet.
- Coordinate measurement, data entry, and delimbing. These activities must be performed in an efficient sequence. The operator should remember measurements until they are entered.
- Interpret and execute the computer output instructions. A series of crosscut locations must be remembered. The computer solution should be overridden by experience or commonsense.
- Judge which trees to buck without the computer by identifying low value trees, based on diameter or defect.
- Transfer data between the handheld computer and the office computer using a telephone modem. Proper sequence of key strokes must be used to transfer log inventory information (i.e., dump the day's memory to the office). The handheld computer must be updated with new mill prices in a similar manner.
- Keep the computer in good working order. Handle the computer with reasonable care. Charge the batteries daily.

The production rate of each faller/bucker could decrease by about 30 percent. This is due to the additional time involved in taking measurements and entering the information into the computer. The system will probably cost about $10,000 per company to install. Hardware and software would cost an additional $5000 per faller/bucker.

Available Options

Learning Optimal Patterns

One hundred second-growth trees were bucked by two experienced contract fallers (Sessions et al. 1989a). Their bucking-pattern lengths are compared with those suggested by the optimal bucking program in Table 7. For each tree, logs were sorted into a high- or low-quality sort. Preferred lengths in the high quality grade were 36, 38, and 40 ft, with at least 80 percent of the volume in these lengths. One
foot of trim was added to all logs. There was no preferred-length requirement on the lower quality logs.

On 53 trees the optimal bucking solution gave a significant increase in value by increasing the volume of high quality logs. On the remaining 47 trees the actual bucking pattern and optimal bucking solution were the same. Increase in the value could be attributed to one of the following reasons. The percentage occurrence for each category is given in brackets.

A. The first log was bucked shorter so that a second high quality log was possible (8%).

B. A short high quality second log was bucked (10%).

C. The second log was bucked shorter so that a third high quality log was possible (4%).

D. A combination of lengths was used (4%).

E. Longer high quality logs were bucked (8%).

F. A short high quality first log was bucked (7%).

G. Large diameter logs were cut shorter to increase the volume (12%).

This brings up the question: Could buckers be taught the optimal patterns so that the same increase in value could be realized without using a computer in the field? Improvements in categories other than D (combinations) and G (scaling rules) are based on two simple operational rules:

- Buck as close to quality breaks as possible in order to maximize the volume in the higher qualities.
- Use a variety of log lengths instead of only the maximum preferred length.

By adhering to these rules, buckers should approach the optimal bucking solution. However, our example illustrates one of the least complicated situations that buckers face. Just two sorts were required, only high quality logs had preferred lengths, and a complicated price structure was not in place for different length logs. Where log markets are complex, buckers cannot evaluate alternative patterns without computers. An example of the complex interactions of length, diameter, grade, and price is illustrated in a recent article by Olsen et al. (1991b).

In an old-growth study (Sessions et al. 1989a), the same types of improvement patterns were noted. The optimal solution cut a nonpreferred-length, high-quality (peeler) log on 52 percent of the trees. The experienced crew cut non-preferred length peeler logs on only 14 percent of the trees. The optimal solution also cut at least one more nonpreferred-length, high-quality sawlog on an additional 16 percent of the trees, allowing more high quality volume to be realized.

Buckers could learn optimal patterns in one of two ways:

- Buckers could use BUCK© DEMO to see a comparison between their solutions and the optimal-bucking solution. From observation they would see how value could be increased. This should be followed by a trainer working alongside buckers in the field for a few hours.

<table>
<thead>
<tr>
<th>Table 7. Volume by grade as designated by actual bucker and BUCK©.</th>
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<tbody>
<tr>
<td><strong>Category</strong></td>
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</tbody>
</table>

*Categories explained in text.*
The felling/bucker supervisor could go over results of a batch of solutions with a bucker, as was done in this paper and devise a set of simple rules that could then be practiced in the field.

**Tree Selection**

During our optimal bucking field studies, we found significant increases in value on only about half of the second growth trees that were analyzed. Optimal bucking procedures increase the felling cost by about one third, so the increase in value of a tree must exceed that amount for optimal bucking to be economic.

Sessions et al. (1989a) created a spreadsheet that displayed the increase in value for a sample of 100 second growth trees from a stand. When value increase of each tree was plotted against its volume, with a logarithmic scale on the vertical axis so that the smaller values could be seen more clearly, it was apparent that smaller volume trees do not realize enough value increase to cover the cost of optimally bucking (Figure 1). For a minimum value increase of $5 per tree for this stand, the economic breakeven point for tree volume is 0.55 MBF. Thus 52 percent of the trees benefit from optimal bucking, contributing 90 percent of the value increase possible if all the trees are subjected to optimal bucking (Figure 2).

Two unpublished studies show how optimal bucking affects a single mill. Because they were done as a batch on the office computer, their validity was never field-tested. In both studies, cubic-feet measures were used to calculate volume to avoid bias introduced by Scribner board foot measures.

The first study was for a ponderosa pine mill (Pilkerton 1989), using log prices for January 1989. The usual policy was to cut the tree into only 16- or 32-ft logs. One hundred hypothetical second growth trees were batch-processed through BUCK® to find if a value increase was possible. Two surface quality classes and Eastside scaling rules were used. The solutions found by BUCK® had 80 percent of the logs in the preferred lengths of 16 and 32 ft, with an increase of 6 percent in volume and
7.1 percent in value. However, the optimal bucking solution cut 22 percent more logs.

The second study (Acker 1990) was for a Douglas-fir mill complex that manufactured fir veneer as well as dimensional lumber. Twenty-four trees were measured and analyzed. The average butt diameter was 15.5 in., average height to merchantable top was 96 ft. BUCK® produced approximately 4 percent more logs and increased value by 9 percent. No quality sorts were made and log prices were based on the value of the veneer and lumber. A sensitivity analysis case showed that when prices changed before the cut logs were processed through the mills, then the value increased by only 5 percent. These values represent this one special case, but show that the technique loses much of its advantage if time is lost between analysis, bucking, and log delivery.

These studies show that optimal bucking increases the value even when cubic-foot volumes are used. Value increased although no export markets were involved and surface quality played a minor role. Optimal bucking can be used on species other than Douglas-fir and can be effective even when the allowable lengths are severely limited.

Case Study of Complete Implementation

We investigated the full implementation of optimal bucking at the stump on a commercial thinning of a 70-acre unit in McDonald State Forest. The trees were mostly Douglas-fir, 35 to 90 years old. The thinning regime was based on crown spacing with a co-dominant/dominant residual. There were two fellers, one trained to use BUCK®, while the other used traditional methods. The BUCK®-trained feller made measurements and operated the handheld computer without assistance. An OSU researcher set up the cost data and mill prices in the computer, making sure that the program was cutting the right percentage of preferred lengths. Getting the correct information ready for the optimal bucking program took 10 manhours. The time could vary greatly depending on the data base available from the company and would probably be longer for first time users. However, on subsequent sales within the same company, BUCK® setup preparation time should be less.

The feller, who was already experienced in log grades and on desktop personal computers, was given a user’s guide and a card summarizing the computer commands. He had on-the-job-training for one day while he was felling. The researchers were present for two more days, but little additional instruction was necessary. The feller worked out his own sequence of measurement, data entry, deliming, and bucking, using his memory more than we had anticipated. For instance, when he measured the butt diameter he did not enter it until he had made the next measurement. He devised a clever way to use his measuring tape so that he did not have to reset it to cut the first log. He soon felt comfortable with the computer and reached his maximum efficiency after about one week.

The computer was used only on trees ≥15 in. diameter because earlier studies suggested that it is not economical to use the computer on small or low grade trees.

The study lasted 16 days with 2959 logs cut. Daily activities were:

<table>
<thead>
<tr>
<th>Days 1-2</th>
<th>Day 3</th>
<th>Days 4-9</th>
<th>Day 10</th>
<th>Days 11-13</th>
<th>Days 14-16</th>
<th>On Day 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>bucking without the computer</td>
<td>training on using the handheld computer</td>
<td>bucking about 60 percent of the logs with the computer</td>
<td>bucking without the computer</td>
<td>bucking about 23 percent of the logs with the computer</td>
<td>bucking without the computer</td>
<td>bucking was video taped and the feller was interviewed</td>
</tr>
</tbody>
</table>

The feller using the computer averaged about 70 percent of the daily production accomplished by the other feller for days 4 through 9. During days 11-13 the comparative production rose to 95 percent. This was in a poorer section of the stand with few large trees. On days when neither feller used the computer the comparative rate was 112 percent.

The difference in production rate between the first day and the sixth was small.

Based on this comparison, production appears to drop by about 25 to 35 percent when using the computer in the better part of the stand. The feller not using the computer averaged 19 logs per productive work hour.

To supplement the production data, the feller was interviewed on video tape. His attitude to the handheld computer was generally positive. The forest manager was also interviewed to include the perspective of the person marketing the logs.
Some Common Questions

Common arguments against using BUCK® are listed below along with a response.

• Most of the value increase comes from “playing games” with the Scribner scaling rules.

In every study we have done, the BUCK® solution increased the total scaled volume reported. In three studies where Scribner was used the increase averaged 2.6 percent, (0.1, 1.5, and 6.1 percent). In two studies where volume was measured in cubic feet increase averaged 4.5 percent (3 and 6 percent). In the Scribner-based studies, some of the value increase (probably less than half) comes from volume increases. But as the cubic foot studies show, BUCK® can find ways to get maximum value even without Scribner rules.

• BUCK® produces small logs to maximize scale.

This can happen if an incorrect cost function and/or no price adjustors are used. We are now, however, able to produce any desired percentage of logs in preferred lengths. Current bucking practices over-emphasize long logs to the detriment of total dollar value. When properly used, BUCK® increases the number of logs by about 10 percent, but the additional handling costs have been factored into the computer solution. BUCK® is less likely to “manufacture” volume by cutting short logs for cubic-volume systems than for Scribner-volume systems.

• The system only works on old growth stands.

Although BUCK® produces large dollar per day increases in old growth stands we found the largest percentage increase in value in the mechanized-harvester study which had small, low quality trees (see Table 1).

• Loading and hauling short logs is difficult and dangerous.

Some adjustment is necessary to handle any short logs. An option would be to mark short logs going to the same destination, but not buck them until they reach the mill.

• Sorting and decking all the log grades takes too much room.

Although there may be resistance to changing to more elaborate sorts, crews were able to handle this on the three field studies we observed.

• Buckers may object to carrying more pieces of equipment, such as calipers and a computer.

This complaint is legitimate for the computer in our field studies. It weighed 4 lb and was awkward to handle, but compact handheld computers have been developed, such as an industrial computer weighing 1.6 lb. The need for calipers could be eliminated if diameter-measuring devices were built into the computer. These are already used in pipe inspections.

• Buckers cannot delimb, measure, use BUCK®, and buck all at the same time.

Where measuring and using BUCK® is an extra step in the operation a sequence needs to be developed. More buckers may be needed in the workforce, which could add about 30 percent to the felling-bucking cost/MBF. Improved methods of measuring should reduce this considerably.

• Buckers would have to learn log grades.

Amazing as it may seem, buckers do not grade the logs; they only assign surface-quality categories. Anywhere from 3 to 12 categories are used depending on the stand and only 2 days are needed to learn this new skill.

• Buckers need to become computer “experts”.

Buckers do need to enter numbers on a keypad and learn a sequence of key strokes that operate the program, but the screen provides prompts for each input required.

• Sufficient vendor support and operational “hardening” of the system is lacking.

This is a value judgement that may be valid for smaller contractors. Considerable technological support is required to install, debug, and operate an optimal bucking system. However, potential gains should be sufficient to induce some of the industry leaders to implement the technology and thus create a demand for better support.
APPENDIX A: OSU Research

Literature Cited and Annotated Bibliography


The dominant challenge for west coast mills in the 1990's will be procuring stumpage. Integrated log manufacturing links the competitive advantages of the firm with customer orders, which are then translated by handheld industrial computers as bucking instructions to cutters. The cut logs are immediately delivered to the mill for true cut-to-order processing. Test runs on second-growth westside Douglas-fir show that the operational efficiencies gained through integrated log manufacturing would support net stumpage bid price increases of 1-6 percent for pay-as-scaled sales in the $300-500/MBF price range, and 9-16 percent net bid price increases for lump-sum sales in the same price range. Additional savings would include reduced log trim, log scale-back, and low log inventories.

Beaulieu, J. 1988. BUCK®-DEMO. Forest Engineering Department, Oregon State University, Corvallis. 38 p.

This is a users' manual. The software developed by John Sessions, Professor of Forest Engineering, and programmed by J.B. Sessions, an engineering student at OSU, introduces to the forest industry, students, and others the potential of computer-aided bucking. User support is available through the Department of Forest Engineering and questions of general interest are welcome. For information on sources of commercial optimal bucking software for handheld computers or publications on optimal bucking, call (503) 737-4952 or write to the Forest Engineering Department, Oregon State University, Corvallis, Oregon 97331.


The value of computer-aided bucking in determining various log mixes of western Oregon old-growth and second-growth Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) was tested. Techniques were developed to predict log grades from observed surface characteristics. The increase in log volume was negligible, but the computer solution shifted a large percentage of volume from low-value to high-value logs. Value for 50 old-growth trees increased by 14.2 percent and for 100 second-growth trees by 11.9 percent. Preferred-length restrictions decreased these values.


The accuracy of length and diameter measurements, and the effect on log value of three methods of measuring diameter (bucker's tape, angle-gauge and calipers) were evaluated. Data entry added 33 percent to the total time needed to fell and buck a tree. When the potential gain in log value was considered, the additional cost represented 0.4 percent of old-growth value and 2.0 percent of second-growth value. Errors in length measurement were not significant. Angle-gauge and tape measurements varied more than did caliper measurements. Errors in diameter measurement resulted in a substantial loss in potential value: 2.7 to 5.2 percent when a bucker's tape was used, 2.0 percent with the angle gauge, and 1.2 to 1.4 percent with calipers.


Optimal-bucking strategies can be implemented in the field with powerful handheld computers. They not only match market needs with logs cut, but address other management decisions within the bucking context. Weight limits for various harvesting systems and conditions can be included to assure feasible log sizes. The optimal-bucking program can incorporate various cost functions to determine the best equipment selection for various logging systems. Decisions on how much of a tree to leave or remove at harvest can also be made with the optimal-bucking algorithms. Knowledge of the harvesting cost for various levels of slash removal aids in planning slash decisions.


This study documented and field tested a method of using optimal bucking procedures to aid in cruising and stand value appraisals, and compared alternative methods of collecting diameter measurements. The CRUISE/BUCK© method can estimate the potential revenue for different sets of mills as the pur-
chasers. This type of preharvest analysis can aid managers in how to "merchandize" trees.


The feasibility of using the computer program BUCK® to aid the Hahn Harvester operator in determining the best bucking cuts was evaluated. The computer increased the net value by an average of 7.5 percent per tree. This is about $6.40 per tree for the size being processed during the study. A major portion of this increase was from increased scaling volume when Scribner rules were used. The computer solution cuts roughly 16 percent more logs and increased the volume in the best export sort by 8 percent. It could increase the net value by 19.6 percent if more accurate tree quality information were sent to the computer before the bucking cuts were made.


Bucking of 100 second-growth Douglas-fir trees was simulated under cost and price conditions provided by mill personnel. These trees had two distinct surface-quality classes. Log-price differentials were based on wood quality descriptors and small end diameters. Currently BUCK®-DEMO does not use actual taper to determine scale volume according to eastside practices. However, eastside scaling rules (20 ft scaling) were approximated, with butt logs and logs < 20 ft being exact, long log butt segments scaled based on a 1 in. in 8-ft taper of the top segment. The strategy of cutting only 16 and 32 ft lengths generated 7.1 percent less value than did the computer optimal solution.


This introduction to optimal bucking explains the concept of maximizing value from the viewpoint of the logger, a mill, and a timber owner. The network approach to solving the problem is introduced and how information on costs, log prices, and tree dimensions are used is outlined.


Two field tests of a handheld computer using the BUCK® program demonstrated gross value increases of 14 percent for old-growth and 12 percent for second-growth logs. These percentages were reduced to net value increase of about 3.5 percent after all corrections were made for errors and costs.


Many log sellers in the western United States face price schedules that require a given percentage of the volume to be in logs of a specified length. A simple heuristic procedure for deriving a set of log prices, based on bucking decisions for individual trees, provides nearly optimal stand value while meeting volume-length restrictions.
Appendix B: Other Research


Appendix C: Using BUCK©-DEMO

Figure 3 illustrates the optimal bucking procedure. Block 1 allows any length to be designated as an allowable length in 2 ft intervals from 8 to 40 ft. One foot of trim is automatically added to each log. Length measurements are to the nearest foot and diameter measurements to the nearest inch, with all measurements rounded down. In BUCK©-DEMO the scaling rules are Scribner board foot as shown in block 2, but the commercial versions can use any scaling scheme. An upper limit on the weight of an individual log can be specified in block 3. This can be used if the harvesting system is being used in old growth or if one of the pieces of equipment has a weight restriction. The block 7 surface qualities are limited to three categories.

Starting at the butt, an inside bark diameter is entered. Other mid-tree diameters are estimated every 40 ft up the stem or at points with significant taper change by subtracting an assumed bark thickness from the measured outside diameter.

The BUCK©-DEMO program also allows the user to specify zones along the stem where bucking cuts must be made (block 6). These might be where the tree is broken, has rot, or has another defect. It also can be used to reduce the amount of sweep or to cut out severe butt swell. This is the “must buck” option. Another less-used option is the “can’t buck” zone, which notifies the computer that a bucking cut cannot be made within the designated zone and is used to specify inaccessible spots on the stem, zones of the stem that would be unsafe for bucking, or zones that might damage the saw chain.

A surface quality description is entered for length zones of the stem (block 7). For instance the first 30 feet might be relatively knot free and thus given a code of 1. The remainder of the tree might be very knotty and be given a code of 3.

The mill prices and harvesting costs are represented in block 10. Each log category has a delivered price. The category has a diameter range, a length range, and a surface quality. The stump-to-truck harvesting costs are needed. The haul cost to each mill is also needed. A stumpage cost to be paid to the tim-
ber owner can also be listed. This completes the specifications for the operation.

At this point either the “user defined” solution or the optimal bucking solution is calculated. In the “user defined” case, the volume and value of each log is displayed. In the optimal bucking case a search is made to find the best combination of logs to cut from the tree. The volume and grade of every conceivable combination of logs that could be manufactured from the tree is calculated (blocks 8 and 9). The value of each of these log combinations is summed and the combination with the highest total value is identified and reported (blocks 11 and 12).

The optimal solution will not violate any of the allowable length, weight restrictions, “must or can’t buck” zones. The “user defined” solution can violate these limitations, but the computer will report that the user is “not playing by the rules for ..(whatever) reason”.

Based on this initial evaluation timber owners, logging contractors, or mill managers can determine if optimal bucking procedures would give significant increases in log values. If optimal bucking looks promising then the next step is to consider implementation. Using optimal bucking will have a major impact on felling/bucking and a lesser impact on yarding/hauling. Some significant changes to office procedures will be needed.

Another major implementation step is to pick the program to be used (software) and which equipment to use (hardware). Assignment of a manager to be responsible for implementation is vital.

Figure 3. Optimal bucking procedure.
Appendix D: Checklist for Using Optimal Bucking

Can your operation benefit?

- Are you a timber owner who has the opportunity to sell to several different mills that have a variety of specifications?
- Is there a short lead time between felling and milling (30 days or less) so that prices do not change during that period?
- Is it an allowable practice to cut logs into several different lengths?
- Is log quality (knot size and frequency, defects) a major consideration in what you are paid for logs?

Does your harvesting operation have the flexibility to change the volume of wood going into each sort?

- Is the volume going to each mill the most important consideration in log procurement? Does the mill management feel that a constant supply of nearly uniform lengths is more important to overall operations than to “high grade” logs?
- Are your harvesting conditions adequate to handle numerous sorts? (Landing size? Trained personnel? Trucks dispatched to different mills?)
- Does your hauling allow for a variety of log lengths?

Do you have a manager, supervisor, or engineer who can be assigned part time to this responsibility or is the company willing to pay a consultant to implement the system?

A compilation of Oregon State University research work on computer-aided crosscutting (bucking) of trees into logs. Major considerations for deciding whether to adopt optimal bucking and steps to implement it are described. The bulletin references field studies which evaluated and tested prototype optimal bucking systems.