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PP PRUNE Users Guide

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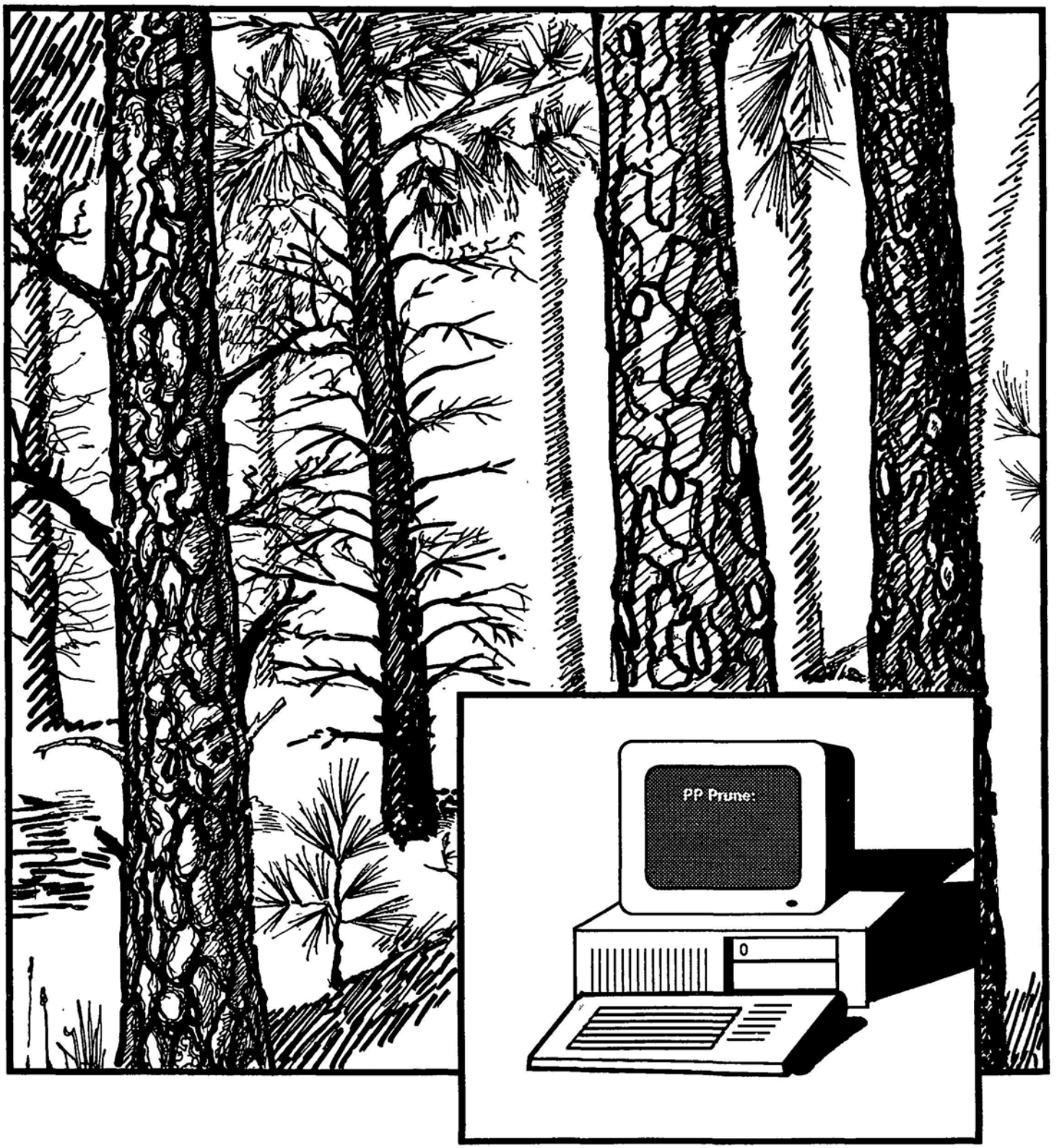

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Abstract

Bolon, Natalie A.; Fight, Roger D.; Cahill, James M. 1992. PP PRUNE users guide. Gen. Tech. Rep. PNW-GTR-289. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

The PP PRUNE program allows users to conduct a financial analysis of pruning ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.). The increase in product value and rate of return from pruning the butt 16.5-foot log can be estimated. Lumber recovery information is based on actual mill experience with pruned and unpruned logs. Users supply lumber prices by grade, the cast of pruning, and tree descriptions from growth and yield information. The program estimates the difference in value for trees and stands with and without pruning and the difference in present net worth from adding pruning to a given regime. The Lotus 1-2-3 spreadsheet program was used to develop PP PRUNE. Users need a basic knowledge of spreadsheets to use this program.

Keywords: Ponderosa pine, pruning, forest product value, product recovery, simulation.

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Introduction

As the harvest of ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) resources shifts from old-growth to second-growth forests, lumber recovery will decrease in the traditional and high-valued lumber products of the Select and Shop grades (Cahill, 1991). Anticipated harvest cycles do not allow enough growth of clear wood after natural branch death and dislodgement to yield significant amounts of clear wood products. Product recovery from young-growth pine will consist mainly of the lower valued Common and Dimension lumber grades. Pruning often is mentioned as a forest-management tool to achieve recovery in traditional types of clear wood products from young-growth stands, yet it has not been seriously implemented in the Pacific Northwest.

The effects on tree growth from pruning young-growth stands of ponderosa pine have been documented by Barrett (1968) and (1959). Lumber grade recovery studies (Bowman 1983; Cahill, 1991) and evaluations of the financial return to pruning ponderosa pine (Davis 1958, Shaw and Staebler 1950) also have been conducted. These studies commonly show increases in the higher valued lumber grades for the pruned trees. Pruning recovery studies and financial evduations for other tree species, particularly Douglas-fir *(Pseudotsuga rnenziesii* (Mirb.) Franco var. *rnenziesii)* are numerous (Anderson 1951, Brown 1962, Cahill and others 1988, Childs and Wright 1956, Dimock and Haskell 1962, Dobie and Wright 1978, Helmers 1946, Sutton 1984). Fight and others (1987) evaluated the financial return from pruning young-growth Douglas-fir through the use of a pruning spreadsheet and found many situations where pruning would be feasible.

The literature clearly shows that pruning is the only way to ensure the growth of significant volumes of clear wood in intensively managed stands. What silviculturists and forest managers need to know is whether the increase in value from pruned logs is sufficient to justify investments in pruning.

The objective of the PP PRUNE program and this users guide is to provide and document a tool to aid forest managers in their decisionmaking process. The PP PRUNE spreadsheet is a program that can be used to do a financial analysis for pruning ponderosa pine. It should be widely applicable to interior Northwest ponderosa pine regions. The program is based on only one study, however, and further documentation of lumber recovery studies from pruned pine logs is needed. The PP PRUNE program estimates the increase in product value from pruning 16.5-foot butt logs. It is based on lumber volume and grade recovery information reported by Cahill (l991) and from a young-growth pine recovery study by Willits.[1] The analysis requires pine lumber prices by grade, the cost of pruning per log, and tree descriptions. The tree descriptions are supplied by the user from sources of growth and yield information, such as Prognosis (Wykoff and others 1982). The Lotus 1-2-3 spreadsheet program was used to develop PP PRUNE. We suggest that the user follow along with the program on the computer screen while reading this manual.

Use of PP PRUNE

The PP PRUNE program projects the difference in value for trees and stands with and without pruning. The present net worth of this difference takes into account the cost of pruning and the mortality of pruned trees (success rate) and represents the financial return of adding pruning to a given regime. The rate of return to pruning can also be

[1] Unpublished data. On file with: S. Willits, research forest products technologist, USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland, OR 97208.

estimated for each regime. Setting the cost equal to zero gives the maximum amount that can be spent on pruning without reducing the rate of return on the investment below the specified rate.

Users will find this guide and program more useful than any specific analysis we might publish, because the program allows users to analyze the regimes most relevant to their situation. The combinations of prices, regimes, and other assumptions in an analysis will differ for each user.

Appendix A specifies the steps for operating PP PRUNE. Once users input current and future price assumptions and generate new equations, specific regimes or tree descriptions can be analyzed. The PP PRUNE program predicts average log values and is designed to analyze one regime (tree description) at a time. The data are entered and the spreadsheet is then calculated. Detailed results for each regime can be seen on the same screen as where the regime data were input. The whole screen, with both input and output, is identified with a range name and can easily be printed (see appendix A, part 1). Comparisons for regimes can then be made, but for several analyses this might be cumbersome.

Analyzing a set of regimes under fixed prices will probably be the most common evaluation done, so PP PRUNE has a macro feature that allows the results for each regime run to be saved (see appendix D). After the results for each regime are calculated, the user can copy them into a summary table with the macro. Graphs then can be used to compare several regime runs. An example of analyzing several runs includes a regime with four different rotation ages. Four separate analyses with the same tree description at time of pruning but different descriptions at time of harvest (age, diameter, and height) are run and stored in the summary table. Graphs for the regime include the results for specific variables under all four harvest ages (see 'Interpretation," below). An example of a generic pruning analysis with results is included (column I in the program). By using the same regimes and price assumptions as those shown in the program, the user can duplicate these regime runs and compare results.

An explanation of how the spreadsheet is laid out and a description of the various sections follows. After reading this guide and the appendices, the user will understand the input needed and the results generated, and be able to run the program. The spreadsheet has been "protected" so that only the entries needed for the program to execute are allowed. It is also set for manual recalculation; that is, the spreadsheet will not automatically update after each entry is made. The program instructions tell the user how and when to calculate the spreadsheet (see appendix A). This method saves computer operating time and allows the program to run faster.

Spreadsheet Layout

Figure 1 shows the general layout of the PP PRUNE spreadsheet program. In Lotus 1-2-3, the entire PP PRUNE worksheet covers columns A to BT and rows 1 to 240. It consists of 10 blocks that make up six main areas; the areas and a brief description of each block follow:

1. Regime data input and output: three blocks. Block 1a is regime input. Block 1b is individual regime output. Block 1c is a summary results table for various regime runs.

2. Price input and output: two blocks. Block 2a is lumber grade and residue price input. Block 2b contains tables of product values ($/CCF) from equations for a range of diameters and clear wood percentages that are derived from the user's price input.

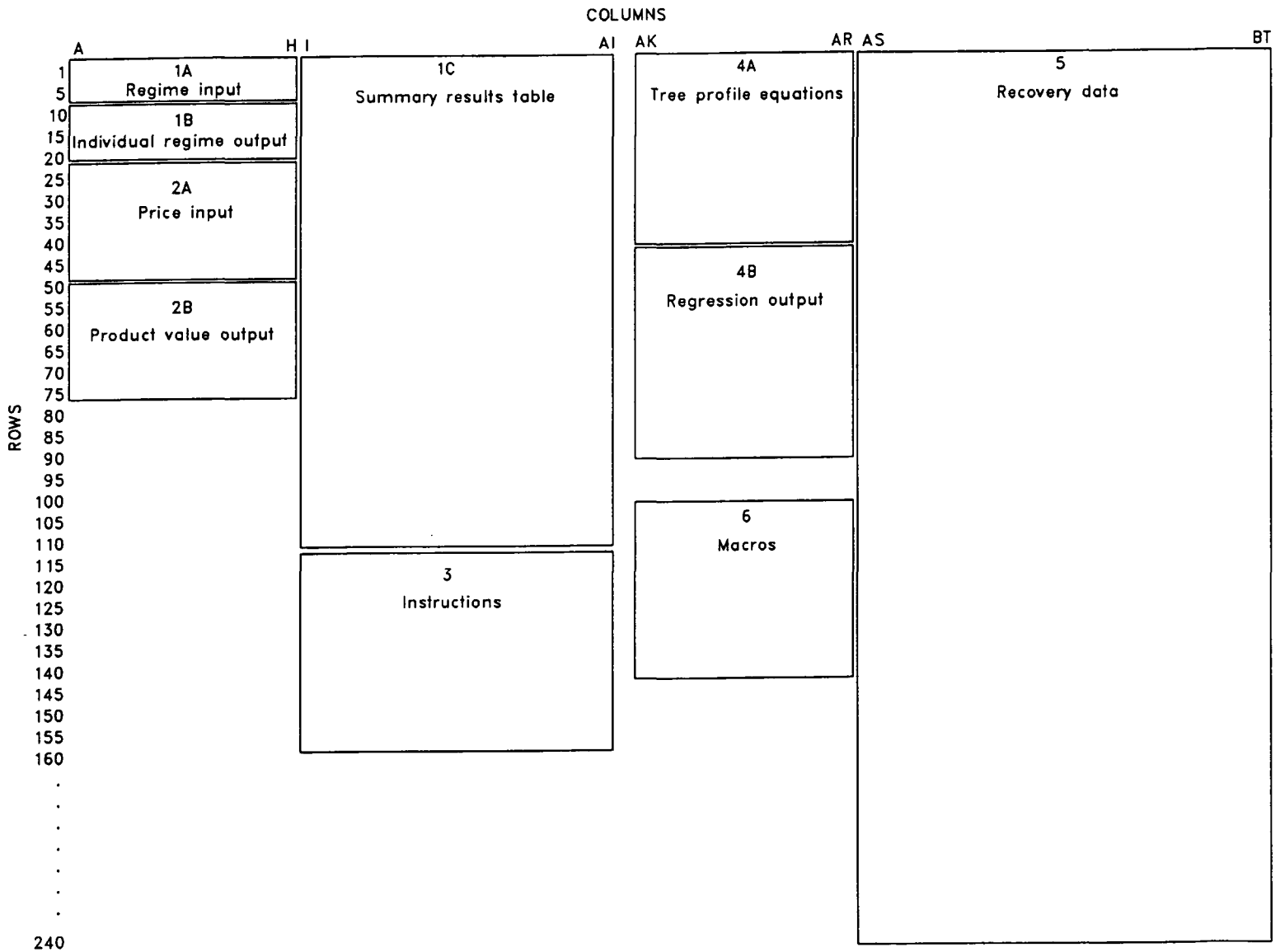

Figure 1—General layout of the PP PRUNE spreadsheet. Letters and numbers refer to columns and rows in the spreadsheet.

3. Instructions: one block. This block holds instructions for running the program (see appendix A).

4. Computations: two blocks. Block 4a has tree profile equations used to calculate the diameter inside bark (d.i.b.) and percentage of clear wood. Block 4b stores the regression output for the product value equations that use the calculated d.i.b. and the percentage of clear wood.

5. Recovery data: one block. Block 5 stores the ponderosa pine recovery data. These data are used to determine the value of each log given the input prices for lumber, chips, and sawdust. Regression analysis is used to predict average log values for the pruned and unpruned logs.

6. Macro features: one block. Block 6 contains the series of commands that allow the user to use two sets of prices and store the results.

Further details of PP PRUNE are illustrated in three sections. Brief narratives of these sections follow with full descriptions in the appendix noted:

1. Regime and price input and output. The general information needed to run the program and the output generated are illustrated in appendix B.

2. Computations. This section of the program provides users with a detailed description of the necessary computations made in the PP PRUNE spreadsheet to produce the results. See appendix C.

   a. Log diameters. The tree profile equations used to estimate log diameters at the time of pruning and at the time of harvest are discussed.

   b. Product value calculations. Use of the recovery data and the product value calculations made by the program are reviewed (also see appendix E).

3. Macro features. The macro features allow the user to analyze pruning under both current and future price assumptions. Several PP PRUNE regime results also can be stored for further analysis. See appendix D.

Discussion

The operational costs of pruning can differ depending on the methods and equipment used, number of trees pruned, wage rate, height the trees are pruned to, the terrain, proportion of live to dead branches and so forth. The cost of pruning to a height of 18 feet is likely to be in the range of $2 to $5 per tree. This cost can be specified in the spreadsheet, but additional costs, such as recordkeeping, are not included in the calculations. By setting the cost to zero, the user can look at the break-even cost (PNW1 or PNW2 variables), or what one could afford to pay for pruning and just break even (doing this type of analysis causes the IRR variable to display ERR because the internal rate of return is meaningless when the cost is zero). In a reasonably competitive stumpage market, buyers can be expected to pay a premium for pruned logs that reflects the increase in value resulting from recovery of clear wood products. Convincing future buyers of the quality of pruned logs may require records showing tree or stand descriptions, as well as proof of the size of trees at time of pruning, so that the amount of clear wood can be estimated.

In determining the growth and yield of a regime, it is helpful to track the pruned trees in the stand; that way the average diameters and other regime input are limited to those trees. Whole stand averages would cause any thinning effects to be apparent in the inches per decade of growth and in the return to pruning as well (because this depends on the volume of the log). When pruning, it is important to pick those trees that will become crop trees; therefore, at the time of pruning not every tree will be pruned. Prognosis (Wykoff and others 1982) is able to generate tree lists from which the tallest trees, assumed to become crop trees, can be chosen for pruning.

To determine the age when a stand might be pruned, users can establish a rule of thumb, such as removing one-third of the live crown, or refer to Barrett's (1968) study on the effects of pruning ponderosa pine. Barrelt determined that various levels of crown removal can result in certain percentages of diameter-growth loss. Users must decide what level of diameter-growth loss is acceptable to them given various stand crown ratios. If 5 percent or less diameter loss is chosen, then only specific levels of live crown can be removed from trees of a certain crown ratio. A tree with 80 percent live crown, for example, can endure 40 percent live crown removal with only a 5-percent loss in diameter growth. If 5 percent is the maximum growth loss permitted, the earliest the tree can be pruned up to 18 feet is when it reaches a total height of 35 feet. This information can be used in conjunction with stand growth and yield data to determine the age and diameter that this height occurs.

The PP PRUNE program also can be used to conduct a sensitivity analysis on lumber prices. Haynes and Fight (in press) give projections of lumber prices to 2040. Users may have their own insight as to what future prices will be, but caution must be exercised in making price assumptions. Clear wood products from pruned young-growth logs may have a different appearance than clear wood products from old growth. The pruned young-growth clear wood products should be a close substitute for clear wood products from old growth; however, there could be market resistance to clear wood products from pruned young growth. But historical evidence indicates that as any high-quality resource becomes scarcer and more expensive, people become more creative in using substitutes. As old-growth clear wood becomes more expensive, the market resistance to young-growth clear wood likely will diminish.

One final note of caution: The predicted lumber grade recovery for pruned logs outside the range of diameters at time of pruning and time of harvest sampled in the product recovery study should be examined carefully (see appendix E).

Interpretation

It is assumed that the reader has referred to and read the appendices while following along in the spreadsheet. Once specific regime results have been produced, ideas for what to do with them may be useful. As the proportion of clear wood on a log is an important determinant of the value of a pruned log (appendix E), users might like to know what kind of growth a particular regime is producing on the logs Over time. Graphing the inches per decade (output variable in column AG in the program) Over several rotation or harvest ages (column J) shows this. To find out how this translates to the percentage of clear wood on a log, graph the percentage of clear wood (column R) over the years since pruning in column AI. This and other graphs can be seen in the spreadsheet by using the graph macro provided (see appendix D). If the user is interested in the undiscounted future value of the logs, graphs using the future value of the unpruned log and the pruned log (columns Z and AA) Over the years since pruning can be created to see the difference in value between the two. Present net worth, the break-even cost

pruning, the internal rate of return, current or future returns per acre, and so forth are other variables that can be used to create graphs to understand the regimes and results of the user's financial analysis. Refer to appendix D for the available graphs provided from the program example regimes. Results graphed in this way make it easier to answer such questions as ,"Is it financially worthwhile to prune, and if so, what age is optimum and when is the best time to harvest?"

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.305 meter
1 cubic foot = 0.028 cubic meter
1 acre = 0.4047 hectare

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Appendix A: Instructions

Part 1: Instructions Found in Program

The following is a copy of the instructions found in the PP PRUNE program starting at cell I118.

INSTRUCTIONS

See USER'S GUIDE for details. Use the 'HOME" key to return to cell A1.

STEP 1— Starting at cell E27 enter prices beside each of the grades (columns E and F, rows 27-48).

STEP 2— Once prices have been entered, press 'Alt" and "C", for current price results AND/OR "Alt F" for future prices. The $/CCF regression equations will use your prices to generate results. Tables using the new equations for each set of prices are found directly below where the prices are input (cells A53 and A66).

EACH time you re-enter current or future prices, you must rerun either "Alt C" or "Alt F". This is not necessary if you are running sensitivity analyses on regime data with fixed prices.

STEP 3— Enter a summary table analysis heading one screen to the right of HOME, at cell M2 (an example has been provided that can be erased, if you like).

STEP 4— In the HOME screen (A5), fill in the regime data. Calculate the spreadsheet now by pressing "F9". Results are shown at A8. To store your input and results in the summary results table (starting in column I, directly above these instructions), press 'Alt A". Up to 100 results can be stored.

The Lotus Worksheet Titles or Window options can be used to scroll through the table. It is highly recommended that you add labels to the summary table as you go. This keeps the data separated for easier viewing. Headings or labels must be entered only in column I.

Note: ****PLEASE DO NOT INSERT ROWS ANYWHERE IN THIS SPREADSHEET!****

The following options also are available:

"Alt G" presents example graphs, including the Current & Future $/CCF and four example regimes graphs. Press "enter" after each graph is shown to choose again from the graph menu (see appendix D of the user's guide). Erasing the example regime results from the summary table will invalidate these graphs.

Named Print Ranges for the "PRICES", "CCFTABLE", & "RESULTS@A8" exist. To use these, press "/" select "PRINT", "PRINTER", "CLEAR", and "RANGE". Now choose "RANGE" and type in the name of the range you wish to print. Select "GO".

Part 2: Steps

The following is a list of PP PRUNE operating steps:

1. Input current and future prices (columns E and F, rows 27 through 48).
2. Press "Alt C" and/or "Alt F" to update the product value equations with the user's prices.
3. Input cost and interest rates (columns A, B, and C; row 5).
4. Input regime data; that is, age, diameter and height at time of pruning and at harvest (columns A through F, row 7).
5. Input number of trees to be pruned (cell G7) and the success rate (proportion of pruned trees surviving to harvest, cell H7).
6. Calculate spreadsheet by pressing "F9".
7. Press "Alt A" to store
8. Look at individual regime results in cells A8 to H20. Look at stored results of several regime analyses in column I.
9. Graph results by using Lotus graphing procedures and the output variables of interest (see 'Interpretation," in text).

Appendix B: Regime and Price Input and Output

Figure 2 shows the regime input needed and the section for individual regime results. Regime input is in rows 4 through 7. Individual regime results are in rows 8 through 20. Figure 3 shows the price input and resultant product value output when using a range of diameters and clear wood percentages. The lumber grade price input is in rows 21 through 49. The tables using these prices follow this section in rows 50 through 77. Figure 4 shows a summary table of several regimes that can later be used for further analysis.

Variable Definitions

All variables in the spreadsheet have hidden definitions that appear when the cursor is on the cell. If, for example, the cursor is moved to column C and row 7 (cell C7), the variable name HT1 is highlighted and the hidden definition, "HT1-Total height at time of pruning," will show above the spreadsheet on the command line. Most input and output variables from the list described below also can be found in the summary results table. To compact the output into a summary results table, several of the variable labels had to be compressed. If a shorter abbreviation is used in the summary results table, it will be shown in parentheses after the term used in the input or individual output section in the following definitions.

Input variables—Four types of input are needed in the program.

Cost and interest rates—The estimated cost and interest rates to be used in the analysis must be entered by the user. The specific information in the cells is:

A5 = COST, the cost of pruning per log;
B5 = RATE 1, the interest rate used in the analysis; and
C5 = RATE 2, the second interest rate used in the analysis.

Tree descriptions—The tree descriptions are contained in cells A7 through F7. Users must get this information from yield tables such as Prognosis(Wkyoff and others 1982). The specific information in each cell is:

A7 = AGE1 (AI), age at time of pruning;
87 = DBH1 (DI), diameter at breast height at time of pruning;
C7 = HT1 (HI), total height at time of pruning;
D7 = AGE2 (A2) , age at time of harvest;
E7 = DBH2 (D2) diameter at breast height at time of harvest; and
F7 = HT2 (H2), height at time of harvest.

Number of trees and success—An estimate of the number of trees to be pruned and the proportion surviving to age of harvest must be made by the user. The specific information in the cells is:

G7 = TREES (TRES) the number of pruned trees per acre; and
H7 = SUCCESS (SUCC), the proportion of pruned trees assumed to be present at the time of harvest (in decimal form).

Lumber prices—Users must supply lumber and residue prices (columns E and F, rows 27 through 48). Lumber prices are entered in dollars per thousand board feet ($/MBF)

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[1] Prioes used in the program differ slightly because they were based on a preliminery producer price index for 1989.

```
      A         B         C         D         E         F         G         H
1   PONDEROSA PINE PRUNING SIMULATOR - For help press F5 and type "I112".
2   Enter Cost, Interest rates & Regime data here. Calculate worksheet (F9).
3   Hold "ALT" and press "A" to store results & regime input at cell I5.
4       COST     RATE 1    RATE 2
5      $2.00       4.0%      6.0%
6       AGE1      DBH1       HT1      AGE2      DBH2       HT2     TREES   SUCCESS
7         45      11.6        40       115      22.0        80        37      0.90
8   **********************RESULTS FOR EACH REGIME RUN**********************
9   Log Length (ft)     dib (in)              CfVol              % Clear        *
10      16.5                17.6                32.0                79.2         *
11                          CURRENT PRICES     FUTURE PRICES                    *
12                         $/ccf    $/log     $/ccf    $/log                    *
13  Value unpruned log      $288      $92      $390     $125                    *
14  Value pruned log        $457     $146      $600     $192                    *
15  Increase in Value       $168      $54      $210      $67                    *
16  IRR                                4.7%                5.0%                  *
17                         Rate 1   Rate 2    Rate 1   Rate 2                   *
18  PNW of butt log        $1.11   ($1.18)    $1.88   ($0.98)                   *
19  PNW per acre             $41     ($44)      $70     ($36)                   *
20  ***********************************************************************
```

REGIME INPUT

INDIVIDUAL REGIME OUTPUT

Figure 2– An example trom the spreadsheet of the individual regime input and output sections. Letters and numbers refer to columns and rows in the spreadsheet.

by lumber grade (fig. 3) . Haynes and Fight[1] (in press) give detailed descriptions of the ponderosa pine lumber grades as well as future price projections out to 2040. Price information also is available in Warren (1990-91). The residue prices can be entered in dollars per cubic foot ($/CF) of solid wood equivalent or be determined from the conversion table provided (cell G36) . Conversions to $/CF are supplied for the following prices: dollars per bone dry unit ($/BDU), dollars per metric ton ($/MT), and dollars per short ton ($/Short ton). These residue prices, regardless of how initially entered, must come from the user's professional judgment as they differ widely with location and are not readily available.

Future prices of pine lumber will be important in determining the financial returns from pruning young pine stands, because the return from pruning will not be captured until the stand is harvested. This return will depend on the difference in price between clear grades and lower grade products. Various studies of supply and demand for timber and historical trends can help project prices, but the future is really unknown. Because we do not know what future prices will be, we suggest looking at the financial return from pruning for a range of future prices.

Output variables—Locations and descriptions for the individual regime output variables follow (see fig. 2):

A10 = Log length, length of butt log with trim.

C10 = dib, calculated small-end diameter inside bark in inches for the butt log.

E10 = CfVol, the predicted cubic-foot volume for the average butt log in the regime.

G10 = % Clear (%C), the calculated percentage of clear wood in the pruned butt log.

C13,E13 = Value unpruned log, undiscounted value in $/CCF for the average unpruned butt log at harvest, under current and future prices, respectively.

D13,F13 = Value unpruned log (VUL), undiscounted value in $/log for the average unpruned butt log at harvest, under current and future prices, respectively.

```
      A         B         C         D         E         F         G         H
21  ENTER PRICES HERE. Press"ALT C" or "ALT F" for Current or Future price
22  results.  Tables from equations that use your prices follow (A50).
23  GRADE                                PRICES $/MBF
24  GROUP    GRADE                      CURRENT   FUTURE
25  ******************************************************
26  *4/4 SELECT & 1 SHOP                -------  ------- *
27  1     -  C Select & Btr, 6-12"      1805.00  2206.00 *
28  2     -  D Select, 12"              1523.00  2130.00 *
29  3     -  C & Btr, 4" AND D, 6-10"   1016.00  1408.00 *
30  4     -  D Select, 4"                740.00   935.00 *
31  5     -  1 Shop                      438.00   583.00 *
32  *5/4 & THICKER MOLDING & SHOPS      -------  ------- *
33  6     -  Mldg & Btr                 1265.00  1649.00 *
34  7     -  1 Shop                      730.00   893.00 *
35  8     -  2 Shop                      589.00   780.00 ******************
36  9     -  3 Shop                      434.00   586.00 * Residue Price  *
37  10    -  Shopout                     258.00   326.00 *  Conversions   *
38  *4/4 COMMONS & 8/4 STANDARD & BTR   -------  ------- * $/BDU =   52.00
39  11    -  2 Common, 12"               532.00   705.00 * $/MT  =   48.00
40  12    -  2 Common, 4-10"             331.00   506.00 * $/Short        *
41  13    -  3 Common, 6-12", 8/4 dim    261.00   367.00 *   Ton =   43.50
42  14    -  3 Com, 4" AND 4 Com, 4-12"  189.00   297.00 *                *
43  *LOW VALUE                          -------  ------- * Results in order
44  15    -  No. 3 & Utility             155.00   262.00 * of above entry *
45  16    -  5 Common & Economy          105.00   153.00 * $/CF =     0.50
46  *RESIDUES                           ------$/CF------ * $/CF =     0.50
47  17    -  Chips                         0.50     0.50 * $/CF =     0.50
48  18    -  Sawdust                       0.00     0.00 ******************
49  ******************************************************
50  BUTT LOG PRODUCT VALUE TABLES
51  EQUATIONS USED -  PRUNED  -->  $/CCF = b0 + b1(%C) + b2(%C/dib)
52                    UNPRUNED ->  $/CCF = b0 + b1(1/dib)
53  Value per CCF for pruned butt logs using CURRENT Prices
54  dib / %C       50       60       70       80       90 Unpruned
55        10      210      244      278      313      347      226
56        12      246      287      329      370      411      250
57        14      271      318      364      411      457      267
58        16      290      341      391      442      492      280
59        18      305      359      412      465      519      290
60        20      317      373      429      485      540      298
61        22      327      385      443      500      558      305
62        24      335      395      454      513      573      310
63        26      342      403      464      524      585      315
64        28      348      410      472      534      596      319
65
66  Value per CCF for pruned butt logs using FUTURE Prices
67  dib / %C       50       60       70       80       90 Unpruned
68        10      289      331      374      417      459      313
69        12      334      386      438      490      541      342
70        14      367      425      483      542      600      364
71        16      391      454      518      581      644      380
72        18      410      477      544      611      678      392
73        20      425      495      565      635      705      402
74        22      438      510      583      655      728      410
75        24      448      523      597      672      746      417
76        26      457      533      609      686      762      422
77        28      464      542      620      698      776      427
78
79
80
```

PRICE INPUT

PRODUCT VALUE OUTPUT

Figure 3—An example from the spreadsheet of the lumber grade input and output sections. Letters and numbers refer to columns and rows in the spreadsheet.

```
   I    J    K    L    M    N    O    P    Q    R    S    T    U    V    W    X    Y    Z   AA   AB   AC   AD   AE  AF   AG   AH   AI   AJ
1  THIS SUMMARY RESULTS TABLE STACKS THE RESULTS OF SEVERAL REGIME RUNS.
2  ANALYSIS HEADING - - Ponderosa Pine N.F. Example Pruning Regimes
3                                                  |--------Current Prices--------| |--------Future Prices--------|                YRS SINCE
4   A1   A2   D1   D2   H1   H2 TRES SUCC COST  %C VUL VPL PNW1  PNW2  PA1  PA2 IRR VUL VPL PNW1 PNW2  PA1  PA2 IRR IN/DEC CFVOL PRUNING
5  This analysis assumes only crop trees at harvest are pruned (@ $2/tree).
6  EXAMPLE REGIME LABEL->PP Meyer's SI75, No TRT
7   45   75 10.1 14.4   39   60  115 0.90 2.00  60  30  34 -1.0  -1.4 -115 -165   2% 41  46 -0.9 -1.4  -98 -155   2%  1.4  12.6    30
8   45   85 10.1 15.7   39   65  115 0.90 2.00  67  39  49 -0.0  -1.1   -0 -123   4% 53  66  0.4 -0.9   50 -100   5%  1.4  15.4    40
9   45   95 10.1 17.0   39   68   92 0.90 2.00  73  48  67  0.4  -1.1   34 -100   4% 65  88  0.9 -0.9   85  -80   5%  1.4  18.3    50
10  45  105 10.1 18.1   39   72   92 0.90 2.00  76  57  84  0.3  -1.3   29 -116   4% 77 111  0.9 -1.1   80 -100   5%  1.3  21.1    60
11  45  115 10.1 19.3   39   74   73 0.90 2.00  79  67 103  0.1  -1.4    8 -105   4% 90 136  0.6 -1.3   46  -95   4%  1.3  24.2    70
12 PCT & 3 CT's
13  45   75 11.6 16.6   40   62   54 0.90 2.00  60  43  51  0.0  -0.8    3  -46   4% 59  68  0.5 -0.6   25  -33   5%  1.7  16.9    30
14  45   85 11.6 18.0   40   68   54 0.90 2.00  67  55  72  1.3  -0.5   68  -26   5% 74  96  2.0 -0.1  109   -7   6%  1.6  20.5    40
15  45   95 11.6 19.6   40   73   37 0.90 2.00  73  69  99  1.8  -0.5   68  -19   5% 93 131  2.8 -0.2  103   -6   6%  1.6  24.8    50
16  45  105 11.6 20.9   40   76   37 0.90 2.00  77  81 123  1.6  -0.9   59  -31   5%109 162  2.5 -0.6   92  -21   5%  1.5  28.4    60
17  45  115 11.6 22.0   40   80   37 0.90 2.00  79  92 146  1.1  -1.2   41  -44   5%125 192  1.9 -1.0   70  -36   5%  1.5  32.0    70
18 ------------------------------------------------------------------------------------------------------------------------------------
19
20
```

Figure 4—An example from the spreadsheet of the summary results table. User's regime results are stored here. Letters and numbers refer to columns and rows in the spreadsheet.

C14,E14 = Value pruned log, undiscounted value in $/CCF for the average pruned butt log at harvest, under current and future prices, respectively.

D14,F14 = Value pruned log (VPL), undiscounted value in $/log for the average pruned butt log at harvest, under current and future prices, respectively.

C15,E15 = Increase in Value, the undiscounted difference in value ($/CCF) between unpruned and pruned logs, under current and future prices, respectively.

D15,F15 = Increase in Value, the undiscounted difference in value ($/log) between unpruned and pruned logs, under current and future prices, respectively.

D16,F16 = IRR, the internal rate of return for pruning the butt log, using $/log under current and future prices, respectively. This will be computed only if a cost of pruning is entered.

C18,E18 = PNW of butt log (PNW1), discounted difference in value between unpruned and pruned logs ($/log), using interest rate 1 under current and future prices, respectively.

D18,F18 = PNW of butt log (PNW2), discounted difference in value between unpruned and pruned logs ($/log), using interest rate 2 under current and future prices, respectively.

C19,E19 = PNW per acre (PA1), PNW for the butt log on a per acre basis, using interest rate 1 under current and future prices, respectively.

D19,F19 = PNW per acre (PA2), PNW for the butt log on a per acre basis, using interest rate 2 under current and future prices, respectively.

The summary results table (fig. 4) also includes a variable for user convenience in describing the regime:

AG4 = IN/DEC, average inches of growth per decade.

AI4 = YRS SINCE PRUNING, difference in years between the age at the time of pruning and at harvest.

Appendix C: Calculations

Log Diameters

Figure 1 (block 4a) shows the section of the spreadsheet containing the equations needed to compute the inside bark diameters of the 16.5-foot butt log. These values are used in equations predicting volume for the log, both at the time of pruning and at harvest. The percentage of clear volume (% Clear or % C) is calculated as the difference between the volume of the log at harvest and the volume of the log at the time of pruning.

A tree profile equation was used to predict d.i.b. at any point on the stem. A correction factor for initial overestimations of the inside bark diameters was then applied as in Czaplewski and others (1989). The independent variables needed to make diameter predictions are diameter at breast height (d.b.h.) and total height, both at the time of pruning (cells B7 and C7) and at the time of harvest (cells E7 and F7). Stump height is set at 1 foot with a log length of 16.5 feet. To meet user specifications, these variables can be changed manually in cells AK8 through AL8 and AM8 through AN8 for the pruned butt log at time of harvest and the knotty core at time of pruning, respectively. We recommend, however, that these variables not be changed, because the recovery data are based on trees pruned to 17.5 feet, which allows for a 1-foot stump and a 16-foot log plus one-half foot for trim.

Product Value Calculations

The recovery data are used along with lumber prices and log descriptions to determine the regression coefficients needed for predicting the value of butt logs in a regime (see appendix E). Product value per hundred cubic feet ($/CCF) of log volume is calculated by computing the total value of products (lumber, chips, and sawdust) manufactured from each log in the data set. The $/CCF value, under both current and future price input, is then used as the dependent variable in regression procedures. Independent variables are log diameter and percentage of clear wood. The stored regression output is shown in block 4b of figure 1, The model forms for the value of unpruned and pruned logs are in appendix E. The equations also are shown with the product value output tables in the spreadsheet (cell A50).

The resultant equation coefficients are used with the small end d.i.b., as calculated from the user's input tree description, to determine the value for unpruned butt logs. The value for pruned butt logs, given the user's tree description, uses the calculated percentage of clear wood (%C), as well as the interaction between %C and the calculated d.i.b. These equations allow the product value tables (cell A50) and individual regime results (cell A8) to be calculated. The generic product value tables use a range of diameters and clear wood percentages and give users a feel for the range of data the pruning model is based on, as well as a tool to gauge the range of returns their own regimes may produce.

Appendix D: Macro Features

For ease in use, the spreadsheet contains four macros that execute the calculations and give results as found in figures 2, 3, and 4. These macros can be run from anywhere in the spreadsheet and will return the user to the same screen from which the macro was evoked. For ease in running the program, brief instructions for operating the program have been included in the spreadsheet (cell I112), and a copy also can be found in appendix A, part 1.

Lumber prices are entered in cell locations E27 through E48 for current prices and F27 through F48 for future prices. Once entered, the macros can be executed to calculate new product value equations based on these prices. For equations using current prices, hold down the "Alt" key and press "c", and for those using future prices, hold "Alt" while pressing "f". The new regression coefficients are calculated and reported in block 4b as shown in figure 1. These coefficients are used to generate estimates for the product value ($/CCF) tables starting at cell A50 and for the $/CCF values found in the individual regime results section (cells A8 through H20).

Once the product value ($/CCF) information has been generated, the tree descriptions (regimes) can be entered (cells A4 through H7). After this is completed, the spreadsheet is calculated. Lotus 1-2-3 does this for the user through the F9 function key. The individual results section has now been updated. To store these results into the summary results table so that more runs can be made, hold down the "Alt" key and press "a". Once this is completed, the user will find an abbreviated version of the individual results, as well as the user's input, copied under the last line found in the summary results table (located in cells I5 through AH105). This is a convenient way to summarize and store results from a series of analyses. To break up the results, users may want to include data headings in the summary results section before each run or set of runs is entered and copied over. The heading must be entered in column I to avoid being overwritten when the "Alt A" macro is executed.

These results can be graphed to facilitate comparison of alternative regimes or assumptions. A macro showing examples of possible graphs can be evoked by holding "Alt" and pressing "g". The graphs available through this macro include the product value tables for current and future prices (cell A50) as well as four graphs from the example regime analyses provided with the program (located in the summary results table at cell I5). After selecting a graph to view, press "enter" to make another choice. To exit this macro, choose the quit option, and the screen will return to where the user was when the macro was first executed.

The user can make graphs similar to those shown (see "Interpretation" in text) by following the Lotus 1-2-3 manual procedures for graphing. An example of creating a new graph would be to first clear old settings by pressing "/", "GRAPH", "RESET", then "GRAPH". Now use "X" to specrfy a range for the X-axis, and "A" through "F" for the Y-axis ranges (up to six lines of data can be shown on the graph). Use the "." (period) to anchor the cursor and set the range. The "OPTIONS" command lets the user add titles and other labels to the graph and specify formats. Use "Alt G" to see graphing examples.

The product value graphs will be updated each time new prices are input and value equations generated; the regime example graphs are fixed, however. If the regime examples provided with the program are erased, the graphs may no longer be that is, if users erase the examples from the summary results table and then fill that space with their own analyses, graph variable ranges will need to be updated if users wish to make similar graphs with their own results.

Appendix E: Recovery Data

Lumber recovery data from a recent study form the basis for estimating log values for pruned and unpruned young-growth ponderosa pine in the PP PRUNE spreadsheet. A brief description of the study, including basic stand information, range of data, types of products produced, and analyses conducted, are presented below. A complete description of the study is available (Cahill 1991).

Pruned Sample

Pruned trees were selected from the Pringle Falls Experimental Forest in central Oregon. Stand age at the time of pruning (1941) was 55 years; Meyer site index was 78 at 100 years. Trees included in the study were harvested in 1988; thus 47 years of growth had occurred since pruning. Pruned trees were selected by the amount of growth that occurred since pruning, and to represent the range of sizes pruned in 1941. Tree d.b.h. at the time of pruning ranged from 6 to 18 inches; d.b.h. at the time of harvest ranged from 13 to 25 inches. A total of 98 pruned 16.5-foot logs were selected.

Log diameters and the diameter of the knotty core were measured to the nearest one-tenth of an inch. The core of knotty, unpruned wood was identified by counting annual rings back to the year of pruning. The proportion of clear wood (% Clear) formed after pruning was estimated as the ratio of clear wood to total log volume:

$$\% \text{ Clear} = \frac{\text{total cubic log volume} - \text{volume of knotty core}}{\text{total cubic log volume}} \times 100$$

This estimate of clear shell includes an unknown amount of massed pitch, occluded bark, and distorted grain developed during the healing of branch stubs.

Unpruned Control Sample

Sixty unpruned logs, also 16.5 feet long, were selected from the Pringle Falls Experimental Forest. These were from the same stand as the pruned trees. The sample of unpruned logs was broadened to include an additional 78 young-growth butt logs. These logs were sampled from several young stands in the Cascade Range of central and southern Oregon; they were processed in the same mill and at the same time as the logs from Pringle Falls. We decided to combine the two sources of unpruned logs after statistical analyses indicated no significant differences in lumber volume or lumber grade recovery.

Table 1 shows the range in % Clear, range in radial growth, and the number of pruned and unpruned logs by log diameter for the logs included in this study. Users of the PP PRUNE spreadsheet program should take careful note of this table and determine if regimes under evaluation fall in the category of prediction or extrapolation.

Processing

The logs were processed in a mill equipped with a double-cut band saw, twin-band resaw, edger, and trimsaws. Each piece of lumber was identified with the log it originated from. The mill produced 4/4 and 5/4 lumber in the Select, Moulding, Shop, and Common grades. All lumber, except the Shop, was kiln-dried, surfaced, and graded; Shop lumber was dried but was graded in the rough-dry condition. Grading was supervised by inspectors from the Western Wood Products Association (WWPA) according to WWPA grading rules (WWPA 1981).

Analysis

Regression analysis was used to determine appropriate model forms for the pruned and unpruned logs in the data set. Average log value per hundred cubic feet of log volume (QCCF) was used as the dependent variable. Log value is defined as the value of lumber, chips, and sawdust produced from the individual logs in the sample. Log diameter was used as the independent variable for the unpruned logs; log diameter, % Clear, and

Table 1—Range in % Clear, range in radial growth, and the number of pruned and unpruned logs by log diameter

Log diameter at harvest	Pruned logs: Range in % Clear	Pruned logs: Range in radial growth since pruning	Number of logs: Pruned	Number of logs: Unpruned
Inches	*Percent*	*Inches*		
≤ 10	65-91	2.0-4.0	8	45
11-12	58-88	2.5-5.0	18	32
13-14	60-91	2.5-5.5	31	25
15-16	56-91	2.5-6.0	29	19
17-18	57-86	3.0-6.0	9	12
19-20	57-67	3.5-4.5	3	5
Total			98	138

the interaction belween diameter and % Clear were used as independent variables for the pruned logs. The analysis indicated the following models consistently "best" at representing the data:

Unpruned: $\$/CCF = B_0 + B_1(1/dib)$
Pruned: $\$/CCF = B_0 + B_1(\%\ Clear) + B_2\ (\%\ Clear/dib)$

where:
dib is small-end diameter of the log;
$/CCF is product value per hundred cubic feet of log volume;
% Clear is the proportion that is clear wood; and
B_0, B_1, B_2, are regression coefficients.

The general trends were consistent with other recovery studies on pruned and unpruned logs. In the unpruned data, average log value increased as diameter increased because more lumber per unit of log volume is recovered in large logs versus small logs, and the opportunity to recover more valuable items (wide Commons, Clears, and Shops) increases with log size. Trends for the pruned logs showed similar trends with diameter but also indicated that log value increased as the proportion of clear wood increased.

The recovery information for each log in this study (lumber volumes by lumber grade and chip and sawdust volume) is included in the spreadsheet program. After users input lumber, chip, and sawdust prices relevant to them, new coefficients are estimated with the model forms shown above. These coefficients are used to estimate average log values in the economic analyses of pruning. It should be noted that the recovery information from this study is somewhat biased against pruning for two reasons: First, the pruning conducted at Pringle Falls was done at age 55; in general it is perceived that pruning would be carried out earlier in stand growth. Second, the sawmill was oriented towards production rather than recovery of the maximum amount of clear wood. Mills handling large numbers of pruned logs in the future would likely try to maximize the recovery from the clear shell portion of the log.

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Bolon, Natalie A.;Flght, Roger D.;Cahlll, James M.1992. PP PRUNE users guide. Gen. Tech. Rep. PNW-GTR-289. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

The PP PRUNE program allows users to conduct a financial analysis of pruning ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.). The increase in product value and rate of return from pruning the butt 16.5-foot log can be estimated. Lumber recovery information is based on actual mill experience with pruned and unpruned logs. Users supply lumber prices by grade, the cost of pruning, and tree descriptions from growth and yield information. The program estimates the difference in value for trees and stands with and without pruning and the difference in present net worth from adding pruning to a given regime. The Lotus 1-2-3 spreadsheet program was used to develop PP PRUNE. Users need a basic knowledge of spreadsheets to use this program.

Keywords: Ponderosa pine, pruning, forest product value, product recovery, simulation.

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