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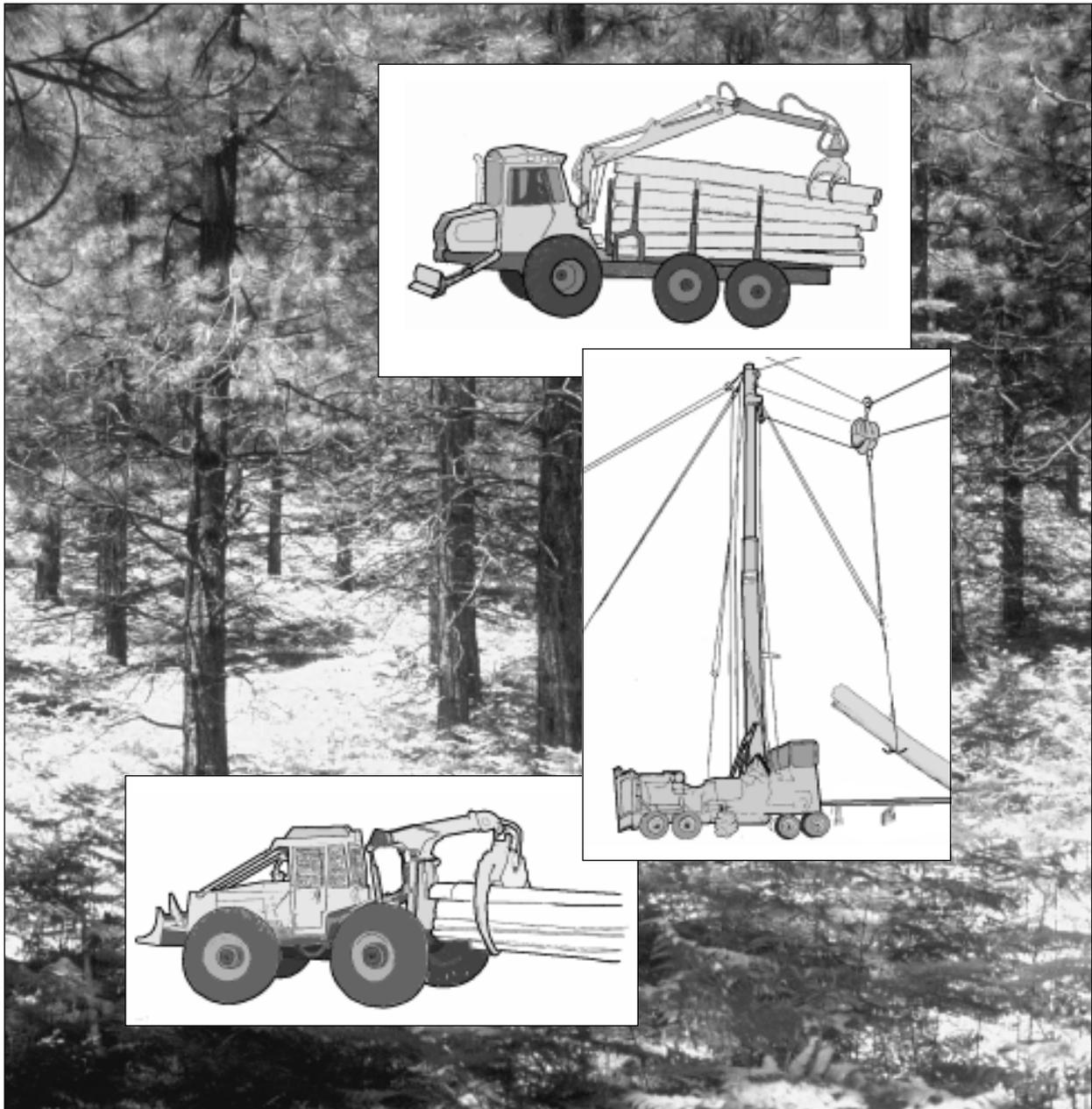
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Harvesting Costs for Management Planning for Ponderosa Pine Plantations

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Abstract

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The PPHARVST computer application is Windows-based, public-domain software used to estimate harvesting costs for management planning for ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) plantations. The equipment production rates were developed from existing studies. Equipment cost rates were based on 1996 prices for new equipment. Harvesting systems include a cut-to-length harvester-forwarder system, a whole-tree/log-length skidder system, and a skyline cable system. Harvesting costs can be estimated for both clearcutting and partial cutting for trees ranging from 3 cubic feet to 250 cubic feet. Cost estimates are in U.S. dollars per 100 cubic feet.

Keywords: Costs (logging), logging economics, timber management planning, young-growth stands, ponderosa pine.

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Introduction

An important factor in plantation management planning is the effect of silvicultural decisions on the cost of harvesting. It is generally more costly to harvest smaller diameter trees than larger diameter trees and more costly to harvest lower volumes per acre than higher volumes per acre. The cost penalties for low volumes per acre and small trees differ among types of logging systems; for example, harvesting with a cable system is typically more expensive than with a mechanized system, and the incremental penalties of increasing costs also are greater when lower volumes per acre or smaller trees are harvested. It is therefore appropriate to consider, at the time the silvicultural prescription is developed, the type of harvesting system likely to be used in a stand. With that system in mind, harvest costs can be estimated that will indicate the effect of different management strategies on harvesting costs and total financial return. If logging cost relations are ignored, prescriptions may be developed that call for early thinning or frequent light thinning, which will reduce the overall value of the regime, or cause the cost of the harvest to be more than the timber is worth. Even on those lands where financial return from timber may not be the primary goal, it is important to know that the costs of the anticipated regime are such that it is feasible to implement the prescription.

The PPHARVST application was specifically developed for use in exploring optimal silvicultural regimes for ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) plantations. Realistic harvesting costs over a wide range of stand conditions are essential for such an application because optimizing algorithms search more-or-less all possible combinations of treatments. Some combination that ordinarily would not even be considered practical might be judged optimal if inappropriate costs are used. We have taken care to develop cost relations that are sensitive to the stand variables that are directly affected by silvicultural decisions and have a significant impact on harvesting costs. The two most important variables determined by manipulation of stocking and harvest age are the number of trees per acre harvested and the average volume per tree for each harvest entry.

The purpose of this paper is to describe PPHARVST and how it can be used to estimate the cost of harvesting ponderosa pine plantations over a wide range of tree sizes and volumes removed by three types of harvesting systems: a cable yarding system, a ground-based cut-to-length harvesting system, and a ground-based whole-tree/log-length harvesting system (hereafter referred to as a "whole-tree system"). Enough information is included to provide a clear understanding of the system configuration and situation being simulated. It was not our intent to provide the information needed to determine whether a particular system is appropriate for a particular situation. It is presumed that the user will get the technical and policy information needed to make that decision. The PPHARVST software, this document, and related documents can be accessed from the Internet at <http://www.fs.fed.us/pnw>.

The production rates on which the model is based are drawn from the existing literature. These sources, resulting equations, and costing approach are described in detail in Hartsough and others (1998). The capital and operating costs on which the model is based were developed by use of a standard machine cost approach with replacement purchase prices for new equivalent equipment. Equipment prices were for January 1996. Those interested in the detailed assumptions have access to them through the software and can change them if they wish.



Figure 1—Screen showing PPHARVST input values and results.

Description of PPHARVST and Requirements

The PPHARVST application was developed for a Windows 95 operating system.¹ A PPHARVST exercise typically involves specifying a logging system, whether it is a partial cut or clearcut, the average slope yarding distance, slope, move-in distance, and the number of acres being harvested at that location. Results are shown for a user-specified range of tree sizes in cubic feet and range of numbers of harvested trees per acre. The resulting table of costs would then be an appropriate estimate of cost for a single harvest, a series of harvests that might occur in a stand, or the cost for alternative harvests or stands. Figure 1 is an abbreviated example of such a table and the key assumptions on which the table is based.

Harvesting Systems and Conditions

The model provides cost estimates for two systems on gentle terrain and one system on steep terrain for both partial cutting and clearcutting. The following tabulation summarizes the circumstances covered:

Item	Harvest parameters			
Terrain	Gentle		Steep	
System	Whole-tree		Cable	
Tree size (cubic feet)	3-250		3-150	
Harvest type	Partial cut	Clearcut	Partial cut	Clearcut

¹ The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

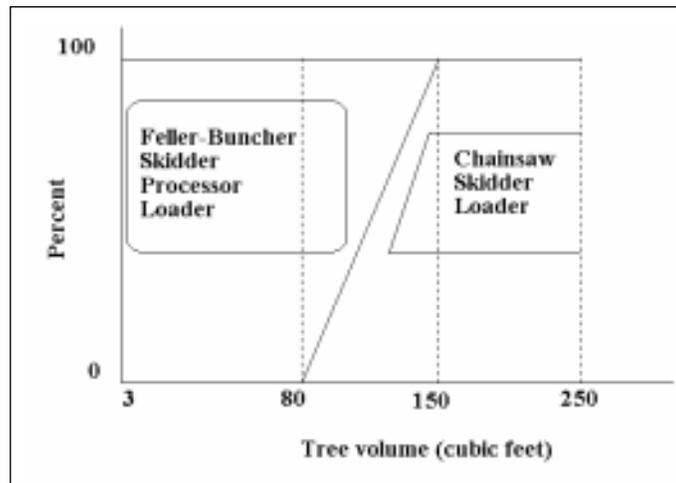


Figure 2—Harvesting cost is a weighted average based on proportion of volume harvested by two configurations going from 0 percent chainsaw felling for trees under 80 cubic feet to 100 percent chainsaw felling for trees over 150 cubic feet.

For the whole-tree and the cut-to-length systems, the equipment components are the same for partial cutting and clearcutting but differ with tree size. For the yarding system, a smaller yarder is used for partial cutting than for clearcutting. With the exception of the yarding system for partial cutting, each system has one configuration for small trees and one for large trees. The resulting production relations and costs were developed by blending the proportions of the two configurations. The blending process is explained below.

Gentle Terrain Systems

The whole-tree system for smaller trees consists of a feller-buncher, a skidder, a stroke processor, and a loader; for larger trees, it consists of chainsaw felling and processing, a skidder, and a loader. For harvests with average tree size of less than 80 cubic feet, the cost is based 100 percent on the feller-buncher system. For harvests with average tree size of greater than 150 cubic feet, the cost is based 100 percent on the chainsaw felling system. If average tree size is between 80 and 150 cubic feet, the cost is a weighted average of the two systems; i.e., if average tree size is halfway between 80 and 150 cubic feet the cost is a 50:50 weighting of the two systems. Figure 2 shows how the proportions of the two systems differ with tree size. (We are not suggesting that these systems be used in combination in any given harvesting operation.) The logic of this approach is that the two configurations represent but two choices from a continuum of configurations actually used, and this blending of costs approximates the gradual shift to heavier equipment that tends to occur as tree size increases. The other systems are blended similarly. Details on the blending for all systems are found in Hartsough and others (1998).

The cut-to-length system for smaller trees consists of a small harvester, a forwarder, and a loader; for larger trees, it consists of a feller-buncher, a stroke processor, a forwarder, and a loader.

Steep Terrain System

The steep terrain system is a cable yarding system. For partial cutting, it consists of chainsaw felling, a small mobile yarder, and a loader. The yarding system for clearcutting of smaller trees consists of chainsaw felling, an intermediate-sized mobile yarder, and a loader; for larger trees, it consists of a combination of the same system as for smaller trees and a system consisting of chainsaw felling, a large tower yarder, and a loader.

How To Get Started With PPHARVST

PPHARVST runs under Windows 95/NT/98. It produces a table of harvesting costs in dollars per 100 cubic feet (US\$/cunit) for ponderosa pine plantations, over a range of tree sizes (cubic feet per tree) and number of trees cut (trees per acre). The harvesting conditions are chosen by the user by selecting options on the program results screen. The screen resembles a spreadsheet.

The application was first created as an Excel spreadsheet. It was then converted to a stand-alone program by use of Visual Basic and Formula One. All the calculation routines are available to the user through the Formula One Workbook Designer (double right-click within the spreadsheet portion of the program window) or as an Excel spreadsheet (open any saved spreadsheet in Excel). No software beyond PPHARVST itself is necessary to use the program.

Installing PPHARVST on a Hard Drive

Although PPHARVST does not require a spreadsheet program, it requires some dynamic link library files and other files that may not be available on all personal computer systems. Some of these are supplied with Visual Basic or Formula One; however, they may be distributed without charge. To install PPHARVST and the required files, execute the *setupex.exe* file that you downloaded from the PPHARVST web page and follow the instructions in the setup program. The files will be transferred to the appropriate sub-directories on the hard disk, and a PPHARVST program icon will be created.

Entering Data Into PPHARVST

Double-click on the PPHARVST icon that shows up in Program Manager. The program results screen will appear (fig. 3). The following four steps are required.

1. Click on the top left combo box to select the type of harvesting system: whole tree, cut-to-length, or yarding.
2. In the next box below, select the type of harvest: clearcut or partial cut.
3. In the fifth row in the spreadsheet area, enter an array of tree sizes, each in cubic feet, beginning in cell C5. Any number of tree sizes may be entered, but no cell within the range should be left blank because results for entries beyond a blank cell will not be calculated. Tree sizes must be within the range of 3 to 250 cubic feet (3 to 150 for the cut-to-length system). The tree sizes can be of any value within the valid range; they do not have to be evenly spaced.
4. In the second column, enter an array of removals, in number of trees per acre, beginning with cell B6. Removals must be 400 trees per acre or less.



Figure 3—Window that appears when PPHARVST is opened.

These are the minimum data entry requirements for the program to run. The data can be modified if desired. Clicking the *Calculate* button will run the program and display the cost results in the body of the spreadsheet table. You can save the results, modify the input data and resubmit to generate new results, or you can start over again with a clear spreadsheet by clicking on the *Clear* button.

Changing Other Input Data

Slope, one-way slope skidding/forwarding/yarding distance, and the hourly costs per productive machine hour (US\$/PMH) for each of the different machines can be easily changed by making entries in the appropriate boxes in the results screen. The number that appears when a change is needed in the hourly costs of one of the machines is the default value. Once it is changed, the new value becomes the default value for that session. If the session is saved, the changed value will remain the default value if that session is reopened.

The average one-way distance is interpreted as either a skidding distance, forwarding distance, or yarding distance, depending on the harvesting system selected. It is limited to 1,200 feet for cable systems, which corresponds to an external slope distance of 2,400 feet for rectangular units with parallel corridors. All yarders have physical upper bounds on yarding distance, based on the line capacities of their drums.

Move-in costs can be a significant portion of the total cost where total removal volume is low. Move-in costs will be included in the results unless the “include” box, under move-in costs, is unchecked. Values for the area harvested and the one-way move-in travel distance for the equipment can be modified as needed. If the results have been previously calculated, be sure to click *Calculate* again so that the results will include the modified move-in costs.

Saving and Printing

Use the Formula One Workbook Designer to save or print. Double-click on the right button of the mouse while in the spreadsheet portion of the PPHARVST results screen to activate the Formula One Workbook Designer. This spreadsheet program offers great flexibility; it is compatible with Excel, and its use is similar to Excel.

To save the results and all the assumptions entered, select *Write* under the file menu. Then choose the preferred format for your new file. Type the file name and extension in the file name box. Choose from the following:

- Formula One format (vts) if it will be used later in the Formula One Workbook Designer
- Excel spreadsheet (xls) if it will be used with Excel
- Tabbed text (txt) for use with another notepad or another word processor. In this case, only the spreadsheet from which the command is executed is saved.

The results table can be saved for importation into another program by selecting that table with the mouse, copying it, then pasting it into a file created by any appropriate Windows application, such as Notepad, another word processor, or a spreadsheet.

The table can be printed from within the Formula One Workbook Designer by choosing that option under the file menu.

Exit either application by clicking the X in the upper right corner of the screen. PPHARVST cannot be closed while the Formula One Workbook Designer is active.

Changing the Spreadsheet Calculations (for Advanced Users)

If values of internal variables need to be modified, certain harvesting conditions changed, or calculations of cost or productivity verified, these can be done with PPHARVST by working in the Excel workbook through Formula One. Double-click on the right mouse button. Then browse or make changes. Save changes by specifying a vts format and typing in the file name and the vts extension.

The changed workbook also can be saved as an Excel file. In this format, the data entry and tabular calculation features developed with visual basic and Formula One are not available.

Description of Calculation Spreadsheets

The PPHARVST workbook includes five spreadsheets. Four are calculation routines; the fifth is used only to display tabular results.

Flat—Flat contains all data and formulas for the whole-tree and cut-to-length systems. The three most important variables—volume per tree, removals, and yarding distance—are situated in the following cells: C2, C3, and C4, respectively. The values found in these cells are the values left from the last calculation performed. Any changes to the values of these cells will be reflected throughout the spreadsheet. Therefore, if there is need to change the value of any of those variables, do it only from those cells, and the productivities of all the machines will correspond to the data entered. The body of the spreadsheet includes the productivity relations for each piece of equipment

included in any of the whole-tree or cut-to-length systems. Beginning on line 48, the results for the whole-tree systems are summarized, with the productivity of each machine in 100 cubic feet per hour (ccf/h), its cost per PMH, and finally the cost per ccf. The summary of the results for the cut-to-length systems begins on line 61.

Steep—Steep contains all data and formulas for the yarding systems, in similar order to that in “flat.” Beginning on line 60 is the summary of the partial cut yarding system with the productivity of each machine in ccf/h, the corridor change costs, the cost per PMH, and finally the cost per ccf. A similar summary for the clearcut yarding system begins on line 68; one difference is that line and landing shift costs are included instead of corridor change costs. From line 34 to 55, the corridor change, line, and landing shift costs are explained.

Machine cost—PPHARVST allows the user to change the cost per PMH directly (and shows the default value), but through Formula One, any of the assumptions for parameters such as machine life, salvage value, and fuel cost per gallon also can be changed. The parameters are named in the first column of the spreadsheet, and data for any one machine are listed in the column under the name of that machine.

Move-in cost—The calculations for each component of move-in cost are displayed in this spreadsheet.

Running a Modified Version of PPHARVST

To reload a modified version of PPHARVST, open PPHARVST and Formula One. Then read in the vts file with the version of PPHARVST you want with the Eile, Read command.

Conclusions

The PPHARVST application was developed with machine productivities found in the literature. Machine costs were based on 1996 equipment prices. Selection of studies and adjustment of productivities were done to make PPHARVST as applicable as possible to ponderosa pine plantations. The PPHARVST model is a general model intended to be used for broad planning applications. It develops estimates for a limited number of machines across the range of tree sizes; it estimates for intermediate sizes through an interpolation process. This results in a smooth transition of cost over the range of tree sizes and volumes per acre for a particular type of machine configuration. It may be necessary to adjust productivity equations or equipment costs to make a reasonable cost estimate for a particular setting with a particular machine. The model was not designed for that purpose. The PPHARVST application does not allow estimating of costs beyond those considered reasonable extrapolations of the data and beyond reasonable limits imposed by machine performance characteristics. The ranges allowed, however, should accommodate most any regime that might be contemplated for management of ponderosa pine plantations with a timber production objective. Because the variability in natural stands of mixed species is much greater than in ponderosa pine plantations, these cost estimates should not be used for those types of stands without some corroborating data.

Literature Cited

Hartsough, Bruce R.; Gicqueau, Alex; Fight, Roger D. 1998. Productivity and cost relationships for harvesting ponderosa pine plantations. Forest Products Journal. 48(9): 87-93.

Glossary

Area harvested—The total area in acres to be harvested by one harvesting system during one entry.

Ccf—100 cubic feet.

One-way move-in distance—Distance in miles that equipment is transported to reach the harvest unit.

Operator wage and benefit rate—Total cost per scheduled hour for the operator or crew.

Skidding/forwarding/yarding distance—This is the skidding distance for the whole-tree system or the forwarding distance for the cut-to-length system or the yarding distance for the cable yarding system. In all cases, it refers to the average (not external) one-way distance measured along the slope.

Slope—The average fall-line slope for the harvest unit, measured as a percentage.

Trees/acre—Number of trees per acre being harvested.

Tree volume—Average volume in cubic feet to the merchantable top diameter of trees being harvested.

Utilization rate—Productive hours divided by scheduled hours.

Vts—Extension applied to Formula One output files.

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