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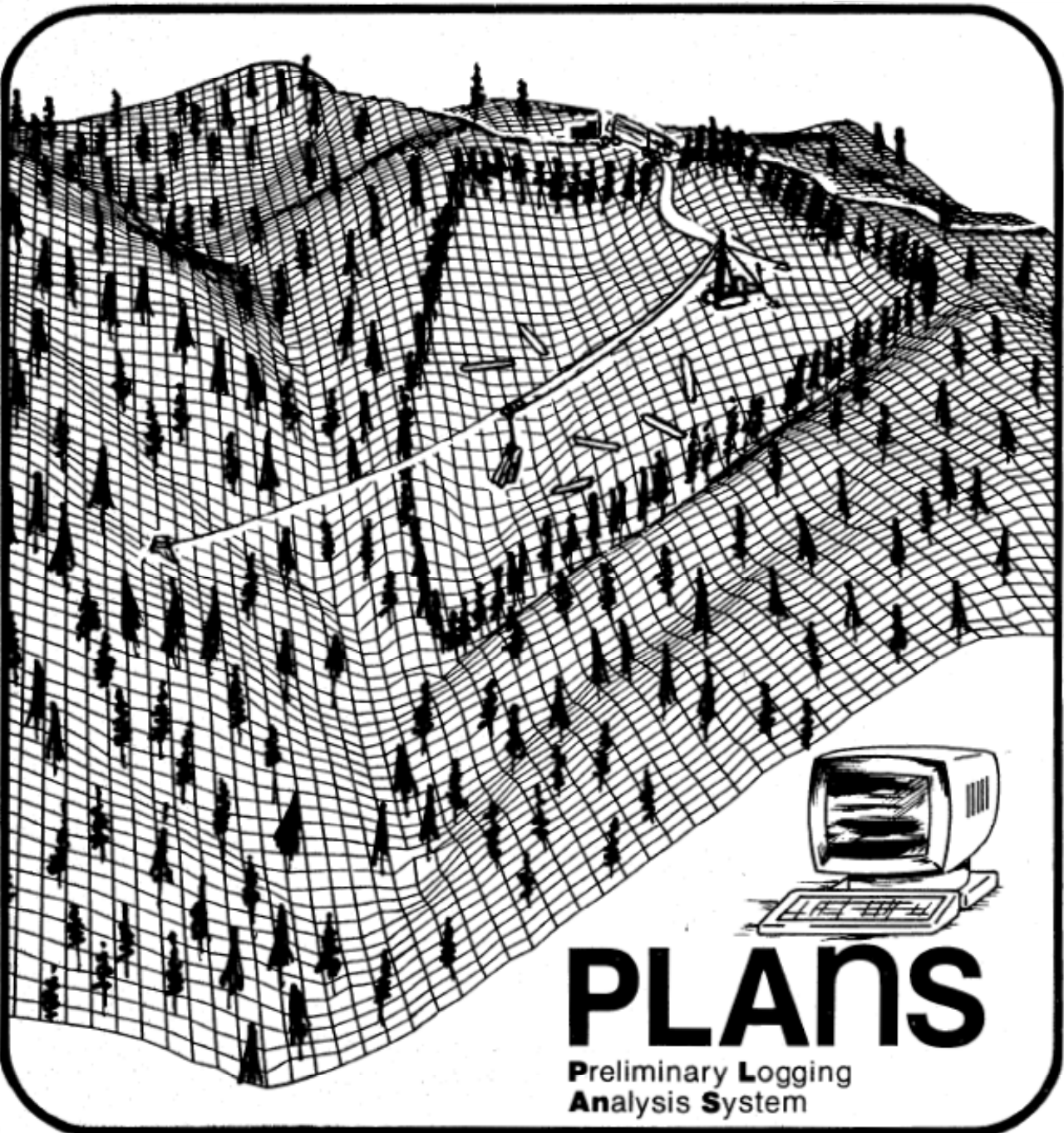
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SIMYAR: A Cable-Yarding Simulation Model

Robert J. McGaughey and Roger H. Twito



Authors

ROBERT J. McGAUGHEY and ROGER H. TWITO are research forester and research civil engineer, Forestry Sciences Laboratory, 4043 Roosevelt Way NE, Seattle, Washington 98105.

Abstract

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A skyline-logging simulation model designed to help planners evaluate potential yarding options and alternative harvest plans is presented. The model, called SIMYAR, uses information about the timber stand, yarding equipment, and unit geometry to estimate yarding co stand productivity for a particular operation. The costs of felling, bucking, loading, and hauling are not considered. Included are a description of the input requirements for SIMYAR, descriptions of the major algorithms, suggested applications, and a discussion of limitations. A users guide is available as an appendix to this publication.

Keywords: Simulation, cable logging, yarding operations,-timber harvesting, costs (logging).

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Introduction

The direct result of decisions made during timber-harvest planning is the allocation of equipment, personnel, and other resources to harvesting operations; consequently, such decisions are critical to the success or failure of a timber harvest. To help planners make better decisions, a system of computer programs called PLANS (preliminary logging analysis system) was developed. PLANS uses data from topographic maps, expressed as a digital terrain model (DTM), to show planners the projected outcomes of planning alternatives. PLANS rapidly displays the degree of success for various alternatives and, by minimizing the effort needed to redesign a landing or road, eases the fitting together of a system of harvest units and roads into a complete timber-harvest plan (Twito and others 1987). The interactive nature of PLANS supports a trial-and-error process during design of a harvest plan. Planners can quickly make modifications until the precise harvest plan meeting their objectives is created. The trial-and-error strategy for a single plan can be used to design several alternative plans for an area. Alternative plans emphasizing different harvesting objectives or logging equipment are important and give flexibility to the planning process. The best plan can be selected through a comparison.

The best alternative harvest plan is sometimes difficult to determine, but a critical factor is the cost of yarding logs from the woods to the landings. SIMYAR, the subject of this report, is a cable-yarding simulation model in PLANS that predicts yarding cost and production for cable-yarding systems. SIMYAR provides information useful for increasing the efficiency of a specific yarding operation and for comparing the yarding costs for alternative timber-harvest plans.

Simulation of Cable-Logging Systems

"A simulation model is a mathematical-logical representation of a system which can be exercised in an experimental fashion on a digital computer" (Pritsker and Pegden 1979). It is generally used when the system in question is so complex that describing it with a strict mathematical model is beyond the capabilities of the analyst. Biller and Johnson (1973) characterize timber harvesting and its relation to the environment as one such complex system.

With few exceptions, simulation analyses of timber-harvest systems have required large mainframe computers. Progress in simulation for planning purposes has been slowed by timber-harvest planning being given low priority on many central computing systems. In addition, the lack of individuals trained in both computer sciences and timber-harvest planning has led to limited interest in using mainframe simulation methods to compare harvesting alternatives.

In a study of simulation models applicable to the southeastern United States, Goulet and others (1979) found a wide range of modeling techniques used to portray logging operations. They reported no models dealing specifically with cable-logging systems. Some of the logging-system models included cable yarding as an option, but treatment of the cable-yarding process was too generalized to allow comparison of specific yarding systems and configurations. Models specifically designed to portray cable logging have been developed (LeDoux and Butler 1981, Pexton 1978), but their use has been limited to research and education.

SIMYAR uses digital terrain data describing specific harvest-unit and stand conditions to estimate the cost and productivity of yarding activities. The model, developed for a desktop computer system, uses data readily available to timber-harvest planners to provide an economic ruler for measuring the effectiveness of various timber-harvest alternatives developed with PLANS.

SIMYAR Overview

The primary objective of SIMYAR is to provide reasonable estimates of:

1. Volume per turn (turn refers to a single yarding cycle).
2. Number of logs per turn.
3. Yarding time per turn (that is, cycle time).
4. Total number of turns.
5. Total yarding cost.

Estimates of yarding-system performance can be used to compare alternative yarding systems and system configurations. Another objective for the model is to use detail commensurate with area-planning activities. The model requires input data that is both pertinent and reasonably available to logging planners. Finally, the model uses a simple question-and-answer session to obtain the data needed for each run.

SIMYAR is written for an interactive graphics work station designed around a Hewlett-Packard 9020 microcomputer.⁷ The system, programmable in HP EXTENDED BASIC, also incorporates an HP 7580B drum plotter, HP 2932A printer, HP 7908 16.5 Mbyte disc drive, and a Calcomp 36- by 48-inch digitizer.

SIMYAR presents three major routines (fig. 1) designed to:

1. Accept time-study information.
2. Accept stand descriptions.
3. Simulate yarding activities.

Time-study information consists of descriptive information and regression equations derived from specific time studies. The regression equations are used during simulation activities to predict the time to complete each yarding cycle. Descriptive information provides users with details needed to judge how applicable the time study is to their conditions. Time-study data are entered interactively and stored for later retrieval, editing, and use.

Stand descriptors include location of the stand, species present, distribution of d.b.h. (diameter at breast height) classes, and the total tree height for each diameter class. The model uses stand data to generate a stand of trees for simulated felling, bucking, and yarding. Like the time-study information, stand descriptions are entered interactively and are accessed during simulations.

When using SIMYAR, users follow the process outlined in figure 2.

⁷ The use of trade names, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

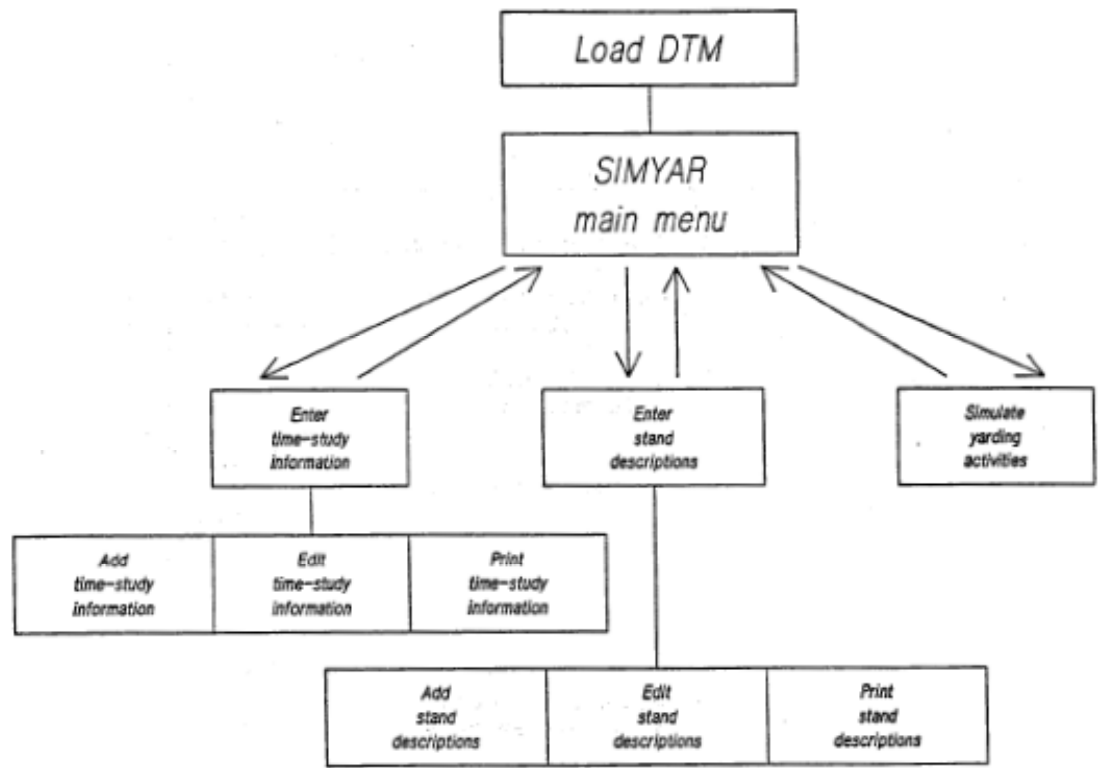


Figure 1—Options available on the main menu of SIMYAR.

Suggested Applications of SIMYAR

Cost and productivity output from SIMYAR is an estimate of actual behavior based on a mathematical-statistical model that has rational characteristics. Decisions based on results from SIMYAR simulation studies should be carefully examined. SIMYAR is designed to compare harvest-planning alternatives on economic and operational bases. Yet planners are advised to review skeptically any SIMYAR results before incorporating them into decision-making strategies.

SIMYAR has several applications for timber-harvest planning. Using its simulation techniques, planners can analyze proposed harvest plans and ask "what-if" questions to investigate specific alternatives. The applications include:

1. Matching equipment size and capability to stand characteristics.
2. Estimating yarding cost.
3. Investigating operational characteristics.

Matching Equipment to Stand Characteristics

The selection of yarding equipment and subsequent layout of that equipment are influenced by the design payload perceived as needed for the planning area. Although the actual payload depends on tree size and spacing, log bucking required, number of chokers, choker lengths, and the choker setters, the design payload is generally selected by using various rules of thumb or simply past experience with similar conditions. Because timber-harvest plans permitting excessive payloads (that is, physically unattainable payloads) can result in severe increases in cost, predicting the actual payload for the area and selecting a design payload accordingly may be advantageous.

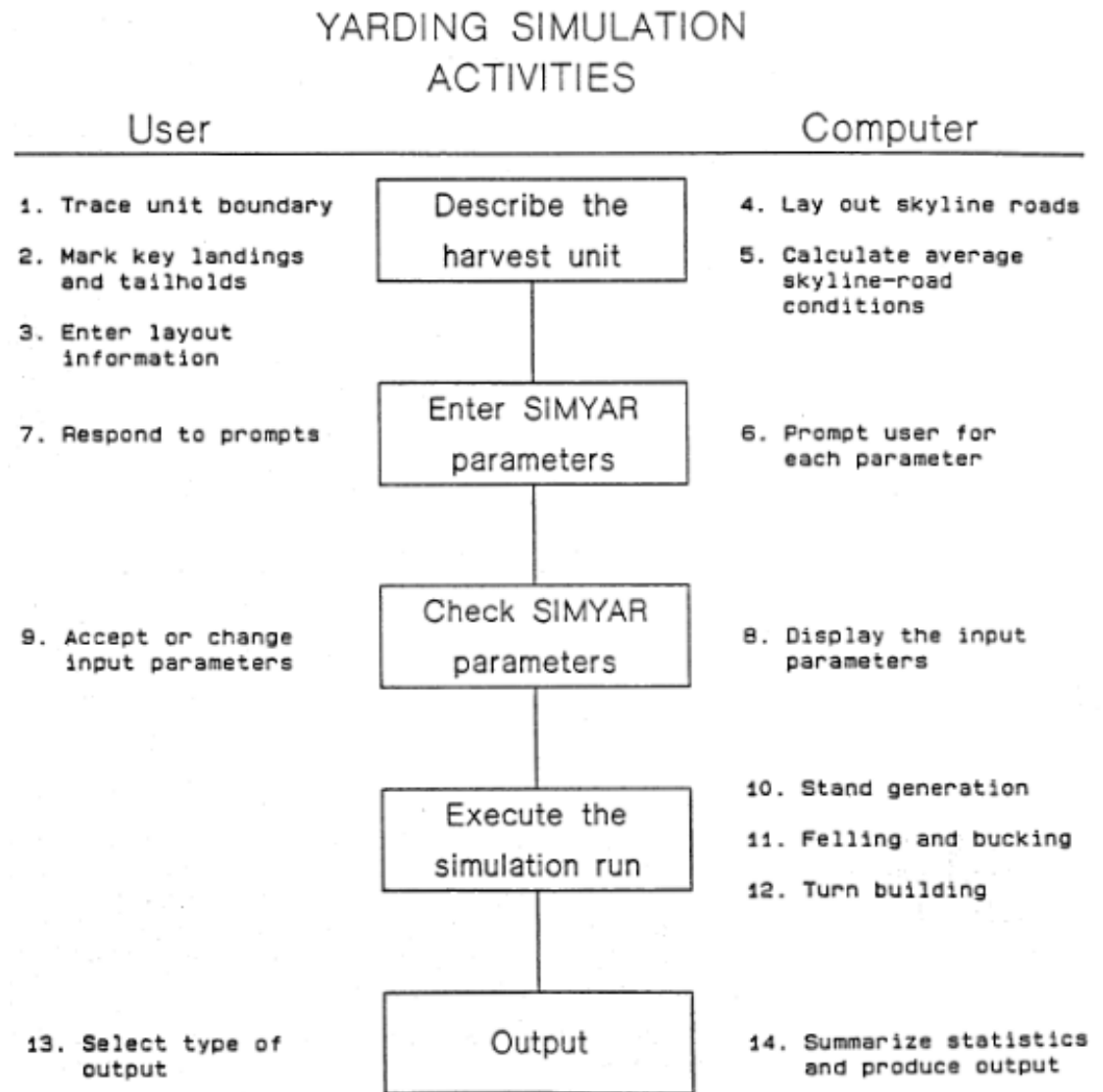


Figure 2—Activities in a run of SIMYAR.

Examining the relations between operating conditions and design payload is easy with SIMYAR. By varying the payload and number of chokers for representative timber stands in the planning area, users can estimate maximum and average turn weights. Then, payloads in a realistic range for the stand conditions can be used as bases for planning activities.

Estimating Yarding Cost

Valid yarding-cost estimates can be made with SIMYAR if a suitable regression equation for yarding-cycle time is used. Because cost is directly related to time, a regression equation must be used that accurately represents a yarding system operating on terrain similar to the planning area.

Yarding-cost estimates serve many useful purposes. They provide, first and foremost, an economic ruler for comparing alternative harvesting systems or harvest strategies. If the planner wishes to compare yarding patterns using the same yarding equipment, the criteria used to select a regression equation can be relaxed. Although such compromise is not desirable, it may be justified by the logic that both yarding patterns are being measured by the same economic ruler. The relative error may be tolerable, even though the absolute error is not.

A second application of yarding-cost estimates is to determine the relative value of a given timber stand. A comparison of the end-product net worth of a particular unit and the harvesting cost for that unit allows an assessment of the economic feasibility of harvesting individual units.

Investigating Operational Characteristics

The complexity and degree of interaction found in timber-harvesting systems make studying the effect of individual variables on system performance by direct observation difficult; with simulation, individual variables can be isolated and quantified. SIMYAR allows planners to experiment and see the effect a particular variable will have on performance; for example, the effect of piece size on yarding cost can be analyzed by varying the preferred and minimum log lengths and observing the resulting changes in yarding cost.

This type of "what-if" experimentation is useful as an educational tool. Planners can assess the effect of such things as skyline payload capacity and lateral yarding distance on performance. In some low-density stands, a large allowable skyline payload (15,000 pounds or greater) is not important because full payload turns are physically impossible or economically infeasible. Planners may discover that a smaller, less costly yarding system could easily perform the yarding operation at substantial cost savings. By asking these questions, planners can verify what is and is not important in skyline-system design and layout.

Input Requirements

Because SIMYAR is designed for large-area planning applications, modeling detail has been held commensurate with readily available parameters. Three major categories of data are required by SIMYAR:

1. Harvest-equipment specifications—parameters describing the yarding equipment.
2. Harvest-unit geometry—parameters describing the yarding area and the number of skyline-road changes in the harvest unit.
3. Timber-stand characteristics—parameters describing the distribution of tree diameters and heights for the stand being harvested.

Harvest-Equipment Specifications

Type of system—The type of yarding equipment being evaluated for the harvest determines the regression equation used for the yarding-cycle time. Several regression equations and their associated time-study descriptions can be entered by the user and stored for later use.

Average payload—The area-weighted average of the allowable payloads for each yarder and tailhold combination on a harvest unit can be calculated within SIMYAR when yarding to several landings with parallel skyline roads, or it can be entered directly. If the harvest unit is yarded to a single landing, the average payload (calculated by other PLANS design programs) must be entered directly. When payloads are calculated within SIMYAR, the percentage of deflection for the skyline is calculated at the

limiting point on a profile. This deflection is applied at midspan to determine the payload capacity for the profile by using a rigid-link approach as described by Carson (1976). An average payload for the unit is obtained by calculating an area-weighted average of all profiles for the unit.

Number of chokers—The number of chokers used with the selected yarding system is a constraint on the maximum number of logs yarded in a single turn. The model does not hook more than one log to a choker.

Choker length—The choker length, or total length in feet of the chokers being used for the yarding operation, is another possible constraint on the maximum number of logs yarded in a single turn. Logs too widely scattered cannot be hooked simultaneously. The model uses only 80 percent of the choker length (horizontal distance) when building turns to allow for the impossibility of stretching chokers tautly from a log to the actual hook point. An additional reduction in choker length corresponding to the diameter of each log is made as the log is hooked.

Machine rate—Machine rate is defined as the hourly cost of owning and operating the yarding system. Machine rate includes both fixed and variable costs and can be calculated using a cost guide (for example, Mifflin and Lysons 1978). This parameter directly affects the validity of yarding-cost estimates, so care should be taken to ensure its accuracy.

Skyline-road change time—Depending on the regression equations used for cycle-time estimates, the skyline-road change time—the time required to move the yarding system between skyline roads—may or may not be needed. If the regression analysis for the yarding system being evaluated considers skyline-road changes as a separate yarding activity (that is, not included in the regression equation), the change time should be entered. If the regression equation includes skyline-road changes, enter 0.0 for the skyline-road change time.

Moving cost—The cost of transporting equipment to and from the sale area and the initial placement of the yarder are the moving costs. A reasonable assumption is that the moving costs will be about the same for several systems on the same unit, so the cost can be set at a constant value with little effect on the results.

Preferred log length—The preferred log length is the length in feet of the longest log to be cut during bucking. Load-size restrictions determine the longest log that can be hauled and thus the longest log that should be cut. Industrial requirements may also dictate a maximum desirable log length. The bucking algorithm increases or decreases log lengths by 2-foot intervals. The model adds a trim allowance of 6 inches per 16 feet of log length.

Minimum log length—The minimum log length is the length in feet of the shortest log to be cut during bucking. Minimum log length will usually be dictated by industrial requirements. The model adds a trim allowance of 6 inches per 16 feet of log length.

Harvest-Unit Geometry

With the exception of the number of choker setters, parameters describing the harvest-unit geometry are calculated from the digitized unit boundary and digital terrain information. These parameters cannot be changed without digitizing a new unit boundary.

Skyline-road shape—The skyline-road shape is the shape of the area to be yarded from one yarder and tailhold placement. More information about the skyline-road shape is in the description of the average skyline-road algorithm.

External yarding distance—The external yarding distance is the horizontal distance, in feet, measured along the skyline from the yarding spar to the most distant logs to be yarded over the cableway.

Maximum lateral yarding distance—The maximum lateral yarding distance is the distance, in feet, measured perpendicular to the mainline that logs can be yarded across.

Average chordslope—The SIMYAR program uses a value for the average chordslope that meets the needs of the simulation but is theoretically incorrect. The program uses chordslope as the slope, in percent, from the base of the tower to the base of the tail hold. This approximation disregards the possible difference in height between the tower and tail hold.

Average groundslope—Average groundslope is the average slope, in percent, of the harvest unit and is derived from the average chordslope according to the following assumptions:

<u>External yarding distance</u>	<u>Groundslope</u>
(Feet)	
< 600	Chordslope
600-1000	Chordslope * 1.25
> 1000	Chordslope * 1.6

Groundslope is approximated because actual calculation of average groundslope for a large area can be misleading. Positive and negative slopes tend to cancel one another to yield an underestimate of the average groundslope. The assumed relations between chordslope and groundslope are based on the logic that as the span increases, deflection must also increase and thereby increase the difference between chordslope and groundslope.

Number of skyline-road changes on the harvest unit—The number of skyline-road changes is the number of different yarder or tailhold placements, or both, needed for the harvest.

Number of choker setters—The machine rate should reflect the number of choker setters used for a yarding operation in a particular run of SIMYAR. This parameter is used only if required by a particular regression equation.

Timber-Stand Characteristics

Wood density—Wood density is the density in pounds per cubic foot of the tree species being harvested. If several species are being harvested, calculate an average density.

Upper diameter limit—The upper diameter limit is the minimum top diameter in inches (outside bark) that stems should be bucked to. This merchantability limit is often dictated by industrial requirements.

Average felling angle—The average felling angle is the average angle, clockwise from the skyline around the tower with the tail hold at 0°, that trees will be felled at. Felling angles are determined by sampling from a uniform distribution about the average felling angle. Deviations from the average felling angle of up to 20° can occur. Herringbone felling patterns can be modeled by setting the average felling angle to 0°. The 20° variation in felling angles will result in at least 50 percent of the trees being felled in lead with the skyline. A default value of 90° is used in the model, and experimentation has shown that the felling angle has little effect on yarding cost and productivity estimates produced by SIMYAR.

Randomness factor—The value of the randomness factor for tree distribution, which ranges between zero and one, controls the spatial arrangement of trees on the harvest unit. Zero results in trees arranged in perfect rows and columns. As the randomness factor is increased to one, the orderly arrangement of trees degenerates to trees randomly placed on the harvest unit.

Stand name—The stand name is the name of the stand-data file containing tree d.b.h. classes, number of trees per acre, and total tree heights to be used for the simulation.

Run name—The run name is used to label output from the simulation. A name should be chosen that identifies the individual run.

Model Outputs

Three output summaries are available from SIMYAR: yarding summary, echo check, and stand summary. The yarding summary gives statistics on the yarding operation and a unit summary detailing yarding cost and production (fig. 3). Specifically reported are the minimum, maximum, mean, and standard deviation for turn weight, turn volume in cubic feet and board feet (Scribner), number of logs per turn, and cycle time along with frequency distributions for turn weights, number of logs per turn, and cycle times. The unit summary is the total yarded volume, number of pieces yarded, number of turns, total yarding time, total yarding cost, and cost per volume unit yarded. Additional information is provided on the yarding system and harvest area.

The echo check reports all the input parameters used for the simulation run (fig. 4). This includes parameters input by the user and parameters calculated from the DTM and the user-traced boundary.

The stand summary reports the number of trees per acre in each diameter class for the generated stand and the standing and yarded volumes on the average skyline road (fig. 5). Both standing volume and yarded volume are reported to show the effect of trees falling into or out of the average skyline road. The stand summary also includes a table of log lengths cut from each diameter class.

SPEARFISH SALE: UNIT 3

1 May 1986

Type of system: SKAGIT BU-90; LIVE SKYLINE
 Operating cost per hour: \$ 203.86.
 Set up cost for the logging system: \$ 1000.00.
 Maximum slope yarding distance: 787.53 feet.
 Maximum lateral yarding distance: 42.39 feet.
 Average system payload: 15000.00 pounds.
 Preferred log length: 40.00 feet.
 Minimum log length: 12 feet.
 Small end merchantable diameter limit: 6.00 inches.
 19.00 skyline-road changes are required on the harvest unit.
 The average skyline road services 0.73 acres.
 Skyline-road change time: 1.15 hours.
 The stand contains 34230 board feet per acre (Scribner).

TURN STATISTICS

	Mean	Std dev	Minimum	Maximum
Weight (pounds)	6909.41	3232.55	727.01	14377.02
Volume (cu ft)	138.19	64.65	14.54	287.54
Volume (bd ft)	701.10	403.27	31.00	1745.00
Number of logs	3.39	.92	1.00	4.00
Cycle time (min)	6.45	.39	5.67	7.41

Cycle times determined using user selected regression equations.

DISTRIBUTION OF TURN WEIGHTS

Weight per turn (pounds)	Relative frequency
1 - 1500 ***	.0526
1501 - 3000	.0000
3001 - 4500 *****	.1579
4501 - 6000 *****	.2105
6001 - 7500 *****	.1579
7501 - 9000 *****	.1842
9001 - 10500 *****	.1053
10501 - 12000 *	.0263
12001 - 13500 ***	.0526
13501 - 15000 ***	.0526

Figure 3—Yarding summary from SIMYAR.

SPEARFISH SALE: UNIT 3

1 May 1986

DISTRIBUTION OF LOGS PER TURN

Number of logs per turn		Relative frequency
1	*	.0263
2	*****	.2105
3	*****	.1053
4	*****	.6579

DISTRIBUTION OF CYCLE TIMES

Time per turn (min)		Relative frequency
0.00 - 0.74		.0000
0.75 - 1.48		.0000
1.49 - 2.22		.0000
2.23 - 2.96		.0000
2.97 - 3.70		.0000
3.71 - 4.44		.0000
4.45 - 5.18		.0000
5.19 - 5.93	*****	.1316
5.94 - 6.67	*****	.5526
6.68 - 7.41	*****	.3158

UNIT SUMMARY

Unit area:	13.80 acres
Number of pieces yarded:	2451.00
Number of turns:	722.00
Total yarding time:	77 hours 38 minutes
Total yarded volume:	997.72 cunits
	506.20 M board feet

YARDING COST

Total yarding cost:	\$ 21044.66
Yarding cost:	\$ 21.09 /cunit
	\$ 41.57 /MBF

Figure 3 (continued)—Yarding summary from SIMYAR.

SPEARFISH SALE: UNIT 3 1 May 1986

HARVEST-EQUIPMENT SPECIFICATIONS

11--Type of system: SKAGIT BU-90: LIVE SKYLINE
12--Average payload: 15000.00 pounds
13--Number of chokers: 4.00
14--Choker length: 30.0 feet
15--Machine rate: \$ 203.86
16--Skyline-road change time: 1.15 hours
17--Moving cost: \$ 1000.00
18--Preferred log length: 40.00 feet
19--Minimum log length: 12.00 feet

HARVEST-UNIT GEOMETRY

21--Skyline-road geometry: TRAPEZOID WITH YARDER OUTSIDE THE UNIT
22--External yarding distance: 787.53 feet
23--Maximum lateral yarding distance: 42.39 feet
24--Average chordslope: 28.00 percent
25--Number of skyline roads on the setting: 19.00
26--Average groundslope: 35.00 percent
27--Number of choker setters: 2.00

TIMBER-STAND CHARACTERISTICS

31--Wood density: 50.00 lb/cu ft
32--Upper diameter limit: 6.00 inches
33--Felling angle: 90.00 degrees
34--Randomness factor: 1.00
35--Stand name: CARBON RIVER: MT. BAKER-SNOQ. NF

GENERAL INFORMATION

41--Run name: SPEARFISH SALE: UNIT 3

Figure 4—Echo check from SIMYAR.

SPEARFISH SALE: UNIT 3 1 May 1986

STAND SUMMARY

Diameter- class midpoint	Number of trees per acre	Volume per acre on average setting: Per diameter class		Volume per acre on average setting: Cumulative volume	
		Standing volume	Yarded volume	Standing volume	Yarded volume
inches		bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)
12.00	4.08	564 (172.78)	547 (153.13)	564 (172.78)	547 (153.13)
14.00	4.85	2815 (759.43)	1209 (309.84)	3379 (932.20)	1756 (462.98)
16.00	14.15	0 (0.00)	2711 (631.75)	3379 (932.10)	4467 (1094.73)
18.00	7.40	1920 (435.16)	1866 (390.21)	5299 (1367.36)	6333 (1484.94)
20.00	3.44	5835 (1246.82)	2299 (487.90)	11134 (2614.18)	8633 (1972.84)
22.00	9.56	3537 (719.78)	5503 (1120.60)	14671 (3333.96)	14136 (3093.44)
24.00	10.84	0 (0.00)	4877 (945.94)	14671 (3333.96)	19013 (4039.39)
26.00	7.14	5724 (1079.72)	4731 (866.73)	20395 (4413.68)	23744 (4906.11)
28.00	3.19	0 (0.00)	2149 (426.96)	20395 (4413.68)	25892 (5333.07)
30.00	1.91	3382 (604.12)	3957 (719.13)	23777 (5017.80)	29850 (6052.20)
32.00	.89	2014 (351.77)	2082 (355.77)	25791 (5369.57)	31932 (6407.97)
34.00	0	0 (0.00)	0 (0.00)	25791 (5369.57)	31932 (6407.97)
36.00	.51	5436 (917.86)	4737 (741.36)	31227 (6287.43)	36668 (7149.33)
Total	67.96			31227 (6287.43)	36668 (7149.33)

Figure 5—Stand summary from SIMYAR.

SPEARFISH SALE: UNIT 3 1 May 1986										
LOG LENGTHS										
Diameter-class midpoint	Log no. 1									
	1	2	3	4	5	6	7	8	9	10
<u>Inches</u>										
12.0	30.9	12.8								
14.0	41.3	13.0								
16.0	41.3	22.2								
18.0	41.3	30.3								
20.0	41.3	37.2								
22.0	41.3	30.9	12.9							
24.0	41.3	35.1	14.3							
26.0	41.3	41.3	13.5							
28.0	41.3	41.3	17.8							
30.0	41.3	41.3	22.0							
32.0	41.3	41.3	26.0							
34.0	41.3	41.3	29.1							
36.0	41.3	41.3	32.1							

Figure 5 (continued) —Stand summary from SIMYAR.

Program Algorithms

The following descriptions of the key algorithms in SIMYAR provide users With details about the general structure and operation of the program so they can make better use of the model as a planning tool. These descriptions do not provide detailed information about the internal structure and coding of the model. See McGaughey (1983) for a detailed description of the model. SIMYAR has undergone several revisions since its original version; however, the basic structure has remained the same.

Average Skyline Road

To simulate yarding activities, SIMYAR creates an average skyline road from a user-traced harvest-unit boundary and the DTM. The average provides a representative sample of the timber-harvest unit and frees the planner from a total analysis of each yarder and tailhold placement. When using SIMYAR, users trace the unit boundary and mark critical landing and tailhold locations. After the desired skyline-road spacing and average payload are entered, skyline roads are automatically placed on the unit.

Regardless of the configuration of the yarding system, a skyline road is calculated whose average yarding distance, average lateral yarding distance, and area match averages for the entire unit. Three average skyline-road shapes are possible (fig. 6):

1. A trapezoid with the yarder outside the skyline-road boundary: this shape occurs when a unit is yarded to a single landing outside the unit.
2. A trapezoid with the yarder on the skyline-road boundary: this shape occurs when a harvest unit is yarded to multiple landings; for example, parallel skyline roads.
3. A triangle with the yarder on the skyline-road boundary: this shape occurs when a harvest unit is yarded to a single landing inside the unit.

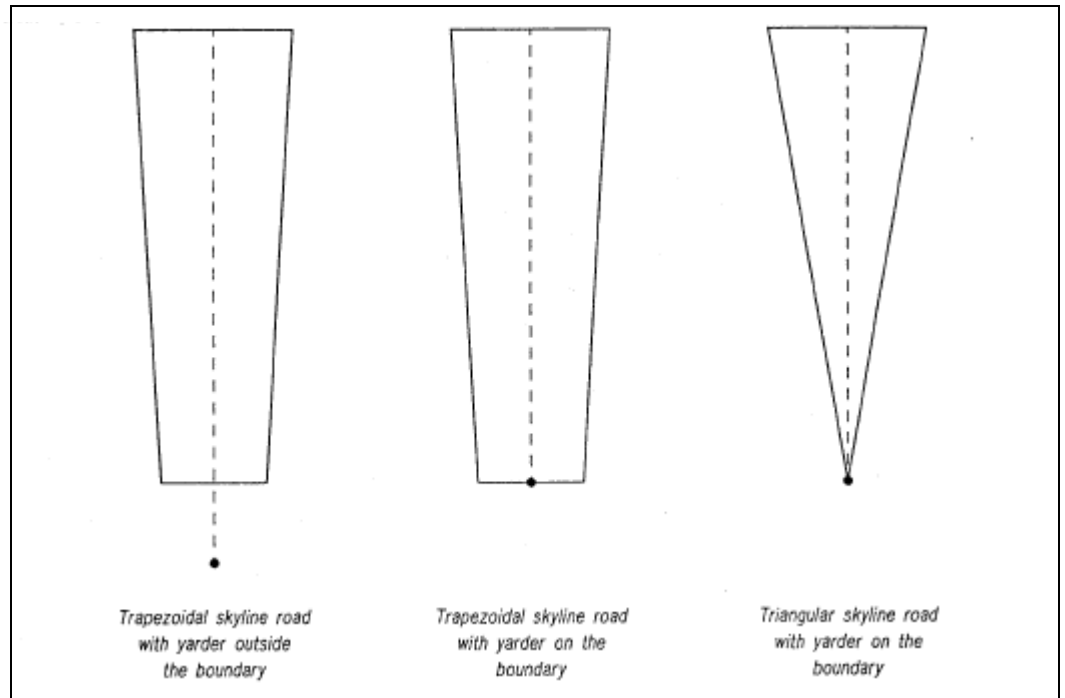


Figure 6—Average skyline-road shapes possible in SIMYAR.

Stand Generation

The stand-generation process begins by calculating the average tree spacing, in feet, from the number of trees per acre:

$$\text{Average tree spacing} = \sqrt{\frac{43,560 \text{ ft}^2 / \text{acre}}{\text{number of trees per acre}}}$$

Next, the average skyline road is overlaid by a stand grid of individual tree blocks (fig. 7). The stand grid is larger than the area delineated by the yarding boundary for the average skyline road. This allows trees outside the boundary to be felled such that some logs fall within the boundary.

To determine the actual coordinate location of each tree, one tree block is isolated within the grid. An initial coordinate corresponding to the center of the tree block is temporarily assigned to the tree. The initial coordinate will shift by a random amount within the tree block. The magnitude of the shift (that is, offset from the center of the tree block) is controlled by a variable called the randomness factor for tree distribution.

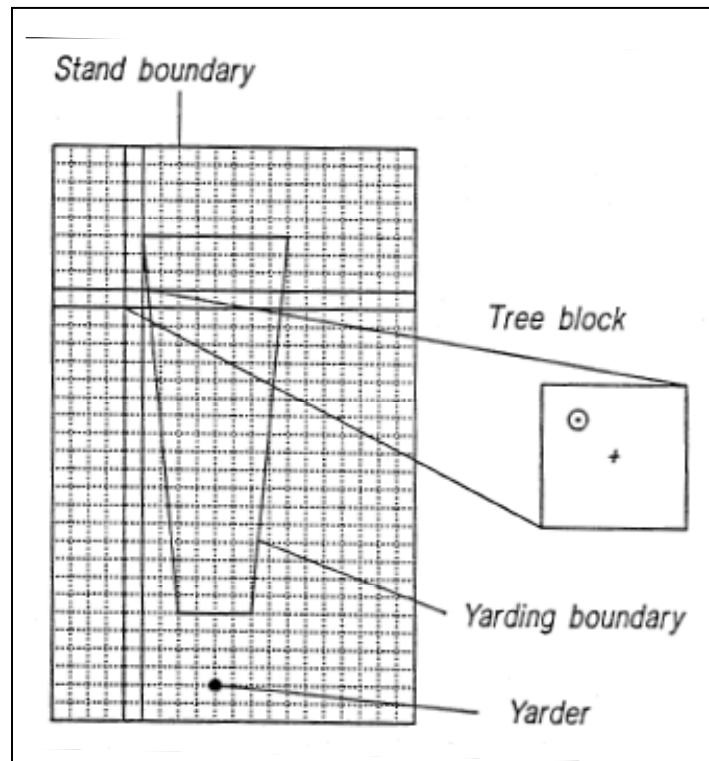


Figure 7—A rectangular grid is overlaid on the yarding area to isolate individual tree blocks.

By varying the randomness factor from zero to one, the user can influence the spatial arrangement of trees on the area. Various patterns of tree placement ranging from plantation conditions (randomness factor=0.0) to natural stands with stem clumping (randomness factor=1.0) can be modeled. Figure 8 shows three patterns possible with values for the randomness factor of 0.00, 0.50, and 1.00. Further investigation of the effect of the randomness factor on spatial distributions reveals that the row-and-column structure apparent with values of 0.00 and 0.50 disappears at values greater than 0.70. This method of tree location, similar in concept to a log-location algorithm used by Le Doux and Butler (1981), results in a stand with the desired density and provides a framework for generating tree coordinates.

The final step in stand generation is to assign a diameter and felling angle to each tree. Diameters are assigned by sampling from actual stand inventory data (tree d.b.h., number of trees per acre, and total tree height for each diameter class) input by the user. Felling angles are determined by sampling from a uniform distribution about the average felling angle. Deviations from the average felling angle of up to 20° can occur.

As trees are felled, the location of the large end of each log in the tree is checked to see if it is within the average skyline-road boundary. Logs outside the boundary will not be considered for yarding. The large end of the log is used throughout the model to identify the log's location making it possible to track the number of logs falling into and out of the average skyline road. If locations of both the large and small ends of the log were stored and used while turns were built, the model would produce an average skyline road with too many logs. More logs would fall into the average skyline road than fall out, which would result in a distorted statistical sampling of the stand volume.

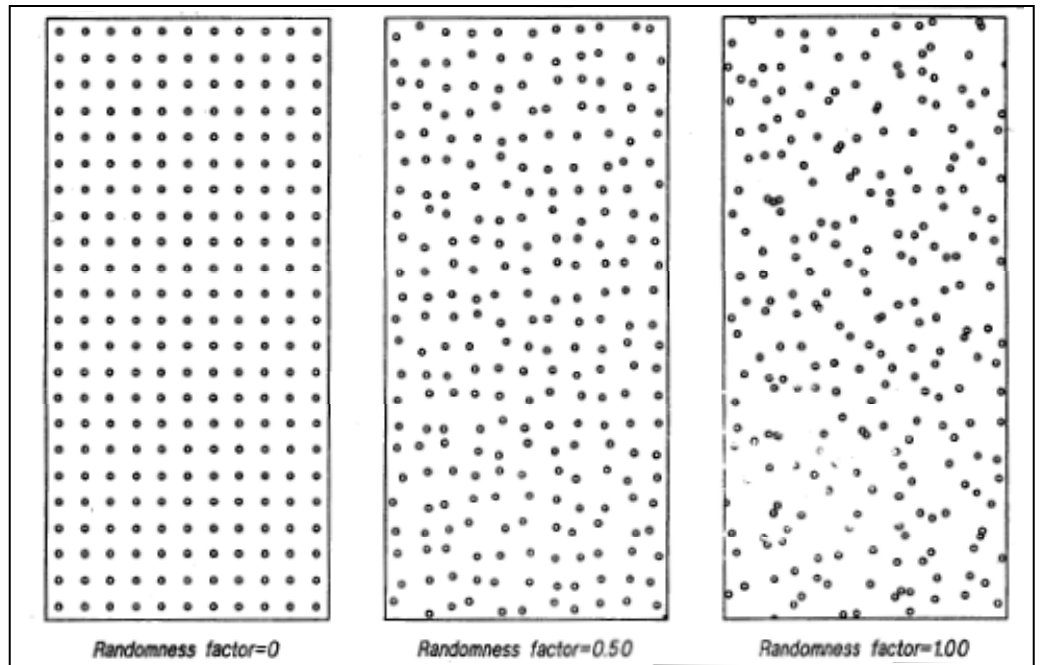


Figure 8—Spatial tree distributions on a 4.1-acre stand with 62 trees per acre.

Bucking

The bucking algorithm is designed to approximate actual bucking practices. An attempt is made to get the maximum volume from large-diameter logs, and emphasis is placed on fully using all merchantable material. One log is cut from the merchantable stem, thereby reducing its length, each time the stem passes through the algorithm. Three bucking rules are used to determine the length of each log cut from the merchantable stem:

1. Log lengths must be within a range defined by the minimum and preferred log lengths.
2. Log weights must not exceed the payload for the yarding system.
3. The length of any remaining merchantable stem after cutting a log must, whenever possible, be greater than or equal to the minimum log length. When this is impossible, a log is cut to the maximum length possible without violating the second rule.

Initial-decision rules for the algorithm are established by comparing the length of the merchantable stem with various combinations of the minimum and preferred log lengths. The bucking algorithm uses five mutually exclusive decision strategies:

1. If the remaining length of merchantable stem is greater than twice the preferred log length, then one log is cut from the stem subject to bucking rules 1 and 2.

2. If the remaining length of merchantable stem is greater than the preferred log length and also is greater than twice the minimum log length, then one log is cut from the stem subject to bucking rules 1, 2, and 3.
3. If the remaining length of merchantable stem is greater than the preferred log length but less than twice the minimum log length, then a log is cut subject to bucking rules 1, 2, and 3. In this case, some portion of the top material may be left in the field.
4. If the remaining length of merchantable stem is greater than twice the minimum log length and also less than the preferred log length, then the entire stem is checked to see if further bucking is required. If bucking is required, the log is halved and the length of the half with the largest diameter is adjusted for maximum volume subject to bucking rules 1 and 2. In this case, material might be left in the field; however, material will be left only if the payload capacity for the yarding system is low.
5. If the remaining length of merchantable stem is greater than the minimum log length, then one log is cut from the stem subject to bucking rules 1 and 2. Material might be left in the field but only if the average payload for the yarding system is low.

Where large trees are being yarded by a system with a low payload, the bucking algorithm can manufacture logs that are unyardable; that is, their length is equal to the minimum log length and their weight exceeds the payload for the yarding system. When this happens, the user is alerted and can correct the situation by changing either the payload or the minimum log length. In actual practice, these logs would usually be ripped and yarded as two or more pieces. If the user does not correct this, the resulting volume of unyarded logs will be reported on the simulation output.

Calculation of Log Volumes

The bucking algorithm characterizes the stem profile as a cone and its logs as frustums of a cone. Characterization of the tree form by any other method requires measuring tree height and diameter at many points along the stem. Such data are generally not available to timber-harvest planners. The assumption that a tree is a conoid solid allows reasonable estimates of the stem taper and volume given only d.b.h. and total tree height. Additional assumptions affecting the calculation of log volumes are that (1) bark thickness averages one-half of an inch along the entire stem, (2) logs are free of defects, and (3) board-foot volumes are calculated for 16-foot logs.

Board-foot volumes are calculated using Knouf's rule of thumb to approximate the Scribner board-foot rule (Dilworth 1971):

$$V_{bf} = \frac{D^2 - 3D}{10} \cdot \frac{L}{2};$$

where: V_{bf} = volume in board feet,

D = small-end diameter of the log in inches, and

L = log length in feet.

Logs cut by the bucking algorithm are sectioned into 16-foot lengths to calculate board-foot volume.

Cubic-foot volumes are calculated using a standard formula for volume of frustums of a right circular cone:

$$V_{cf} = 1/4 \cdot \pi \cdot L \left((R + R')^2 + 1/3 \cdot (R - R')^2 \right);$$

where V_{cf} = volume in cubic feet,

L = log length in feet,

R = radius of the large end of the log in feet,

R' = radius of the small end of the log in feet, and

π = 3.14159.

Assembling Log Loads

The turn-building algorithm assembles potential turns (the logs brought to the landing during one yarding cycle) from all logs on the average skyline road and checks each turn to see that its weight does not exceed the payload for the system. An attempt is made to carry the greatest number of logs in the turn without exceeding the payload. The algorithm uses the stand log list, a record of the location and size of each log within the average skyline road, to produce a turn file with statistics for each turn.

The turn-building algorithm begins by selecting the log closest to the yarder as the first log in a turn log list. This list will eventually contain the first log and all logs that could be combined with the first log as if forming a two-log turn. A check is made before logs are added to the turn log list to see if the difference between the weight of the first log and the maximum allowable payload is less than the weight of the lightest log in the stand log list. If this condition is true, then the turn should include only the first log because no other log could be added to the turn without the weight exceeding the maximum allowable for the yarding system.

If the initial weight check of the first log indicates that more logs can be added to the turn, the algorithm attempts to build multilog turns. An effective choker length is calculated for the first log. The effective choker length is the amount of choker needed to encircle the log and secure it for yarding. This length is equal to 80 percent of the input choker length minus the large-end circumference of the log. Next, the stand log list is scanned for logs that can be combined with the first log to form a two-log turn. Two rules are used to determine if the log being checked should be added to the turn log list:

1. The straight-line distance between the large ends of the two logs must be sufficiently small so that these logs can be hooked at a common point to create a two-log turn; that is, the straight-line distance must not exceed the sum of the effective choker lengths for the two logs.
2. The sum of the log weights must be less than the maximum allowable payload for the yarding system.

When the turn log list has been completed, it is sorted by distance from the first log. The algorithm then forms and checks various combinations of logs in the turn log list until an acceptable turn is found. If needed, the logic will check all combinations of N logs (N equals the number of chokers) in the turn log list. If no satisfactory turn is found, all

combinations of N-1 logs will be checked. This process will continue until a satisfactory turn is found or until N=1. When N=1, the turn will be yarded containing only the first log in the turn log list (that is, the log closest to the yarder that has not been yarded).

When a possible turn combination is checked, the algorithm determines if the logs can be hooked together by their chokers and if the combined weight of the logs exceeds the allowable payload. To check whether or not all logs can be hooked together, an average coordinate based on the location of each log in the turn is calculated, and the distance from each log to this average coordinate is compared to the effective choker length for the log. If a log that cannot be hooked is found in the combination, the combination is rejected and the next possible turn is generated and checked.

When a satisfactory turn is found, statistics describing the turn are computed and stored in the turn file. Turn statistics include total turn weight, turn volume, longitudinal yarding distance to the turn, lateral yarding distance to the turn, sum of log diameters in the turn, and the cycle time of the turn. As a turn is yarded, each of its logs is flagged in the stand log list to indicate that it has been yarded. The turn-building process continues in this fashion until all yardable logs in the stand log list have been yarded.

Regression Equations for Estimates of Cycle Time

Regression equations obtained from statistical analysis of time-study data are used to determine cycle times for yarding activities. Regression equations are of the form:

$$\text{Cycle time} = \text{constant} + ax^i + by^j + cz^k + \dots$$

Any or all parameters shown below can be included in a regression equation:

Slope yarding distance in feet

Lateral yarding distance in feet

Turn volume in cubic feet

Turn volume in board feet

Number of logs in the turn

Percentage of groundslope

Percentage of chordslope

Turn weight in pounds

Number of choker setters

Cubic-foot volume per log

Board-foot volume per log

LN (slope yarding distance)

(Lateral yarding distance) * (percentage of groundslope)

Number of chokers

Slope yarding distance squared

Estimates of cycle time obtained from the equation are adjusted according to the percentage of delay time per yarding cycle observed in the time study. The following relationship is used:

$$\text{Cycle time with delay} = \text{cycle time} * \frac{100}{100 - \text{delay (\%)}}$$

Using regression equations to predict cycle time requires few inputs about the operation of the yarding system, but some disadvantages are present:

1. Regression equations are valid only for systems operating under conditions similar to those observed in the time study.
2. The sensitivity of a regression equation to various conditions not represented by the equation is difficult to determine.
3. A regression equation based on a specific yarding system and operation may be influenced by specific operating conditions rather than by the yarding system; applying the equation's projections to the yarding system may be an error.
4. Time-study procedures are not standardized, so regression equations differ widely in form and in the variables used to predict cycle times.

In SIMYAR, the equation and the operation being examined must match as closely as possible. Published information or personal communication on a particular time study should be used to verify the applicability of the regression equation. Aubuchon (1982) reviews several time studies and provides a bibliography of time-study literature. His publication is a good starting point, but planners should study the actual time-study reference if possible. Using regression equations can result in reasonable estimates of yarding cost and production despite inherent problems with the equations.

Calculating Yarding Costs

Yarding cost is based on the total time required to yard the harvest unit. As each turn on the average skyline road is yarded, its cycle time is estimated with a user-selected regression equation. Cycle times for all turns are summed to obtain an estimate of the total yarding time for the average skyline road. The total yarding cost (Tot_cost) is calculated using the following formula:

$$\text{Tot_cost} = \text{Mach_rate} * \frac{((\text{Cycle_sum} * \text{N_skyr}) + \text{Chng_time} * (\text{N_skyr} - 1))}{60} + \text{Set_up};$$

where: Mach_rate = the hourly cost of owning and operating the yarding system;

Cycle_sum = the sum of the individual cycle times in minutes for each turn on the average skyline road, including normal operating delays;

N_skyr = the number of skyline roads on the harvest unit;

Chng_time = the time in minutes required to change skyline roads; and

Set_up = the cost of moving the yarding system to the logging site.

The yarding cost per unit of volume is obtained by dividing the total yarding cost by the total cutting-unit volume expressed in cunits (100 cubic feet) or MBF (thousand board feet) .

Model Limitations

As mentioned earlier, SIMYAR was streamlined to allow use of readily available parameters, but doing this introduces several limitations. These limitations generally do not result in erroneous cost and productivity estimates; however, planners should be aware of them so cases where the estimates produced by the model have been affected can be recognized. Limitations associated with regression equations have been discussed. The remaining limitations involve the average skyline-road and turn-building algorithms.

Recall that an average skyline road is used to free the planner from a total design of each yarder and tailhold placement. When yarding to a single landing near but still within the boundary (fig. 9a), the algorithm for skyline-road layouts locates tailholds according to a specified skyline-road spacing. As a result, some corridors have a short external yarding distance (<50 feet) and a lateral yarding distance equal to one-half the skyline-road spacing (fig. 9b). In most instances, this situation does not represent reality. Material close to the landing will be yarded before normal yarding operations begin or the material will be picked up by a loader working from the landing. In addition, the average external yarding distance and area for each skyline road on the unit will be reduced as a result of the short skyline roads. To circumvent this problem, the yarding boundary can be modified as shown in figure 10, which will result in more accurate modeling of the layout because the user can define the first and last tailhold location when the landing is outside the unit.

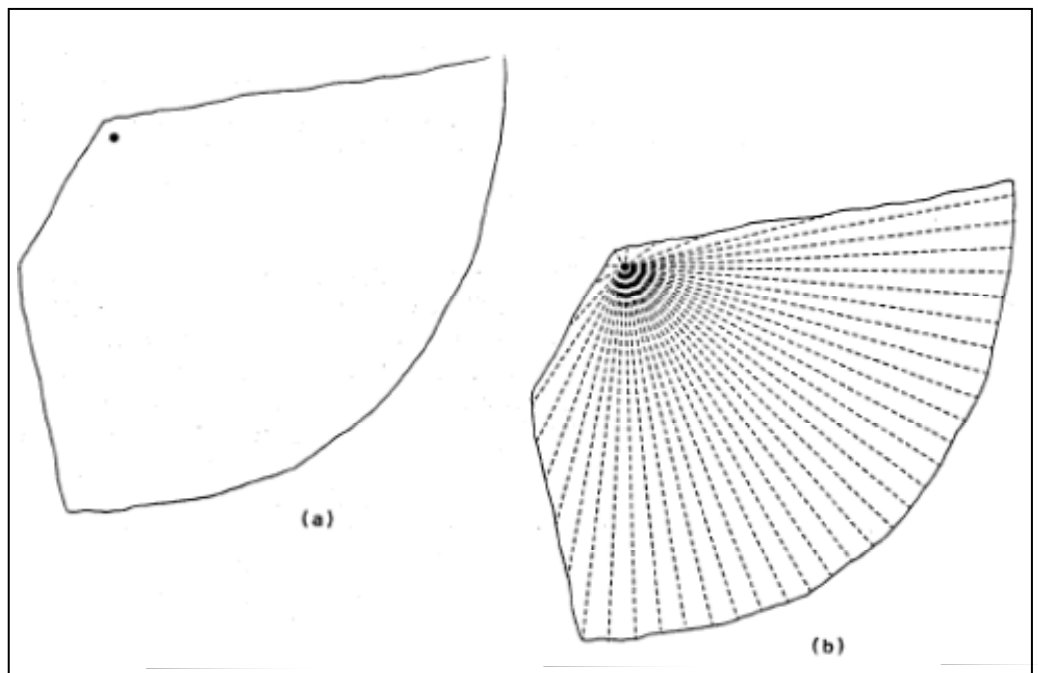


Figure 9—When an area with the landing near the unit boundary but still within the boundary (a) is yarded, the skyline-road layout algorithm produces an unrealistic yarding pattern (b).

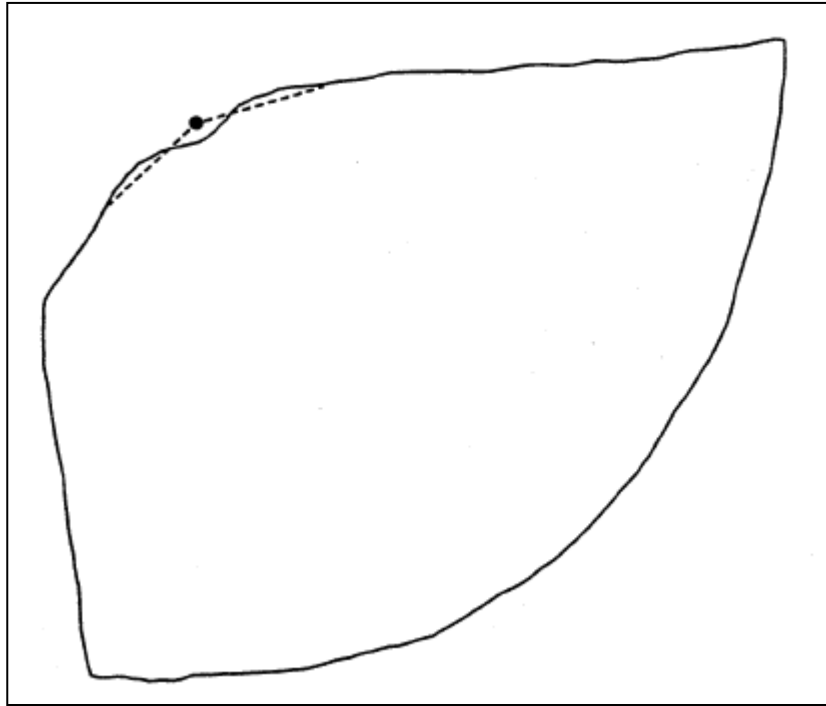


Figure 10—Modifying the unit boundary so that the landing is outside the unit allows the harvest planner to specify the first and last tailhold locations.

A second limitation is that the average skyline-road algorithm produces an abnormal skyline road for units containing a mixture of short (<50 feet) and long (>500 feet) skyline roads and a landing within the unit boundary (fig. 11). The area and average external and lateral yarding distances for the chevron-shaped skyline road (fig. 12) equal the corresponding averages for the harvest unit. Yarding activities will be modeled correctly given the parameters describing the average skyline road; however, the three-pointed, narrow, elongated boundary of the skyline road could result in incorrect statistics describing the entire unit. Comparing results from runs of chevron-shaped average skyline roads with runs from other units with standard-shaped skyline roads would clarify to what extent this peculiarity affects the specific production estimates. One way to ease this problem is to divide the unit into two units with the landing just outside both units (fig. 13), and charge the moving costs to only one unit. Cost estimates for the two-unit area can be obtained by calculating an area-weighted average. Statistics reported in the unit summary can be summed to obtain results for the two-unit area. The results will be valid for area-level analysis.

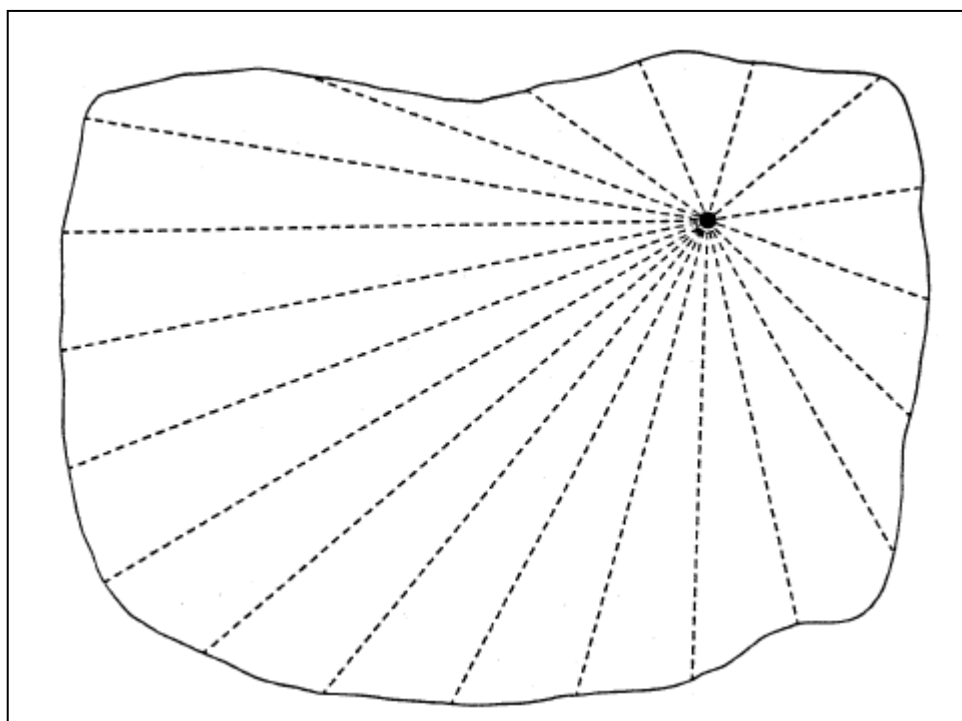


Figure 11—A unit characterized by a central landing and wide variation in external yarding distance can lead to an abnormal average skyline road.

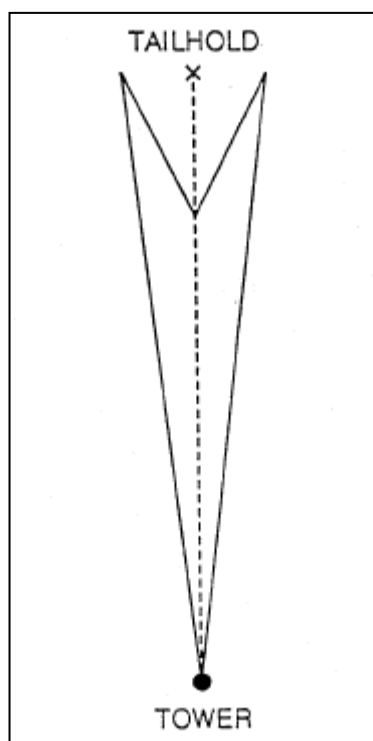


Figure 12—The average skyline road Can take on a chevronlike appearance in some cases.

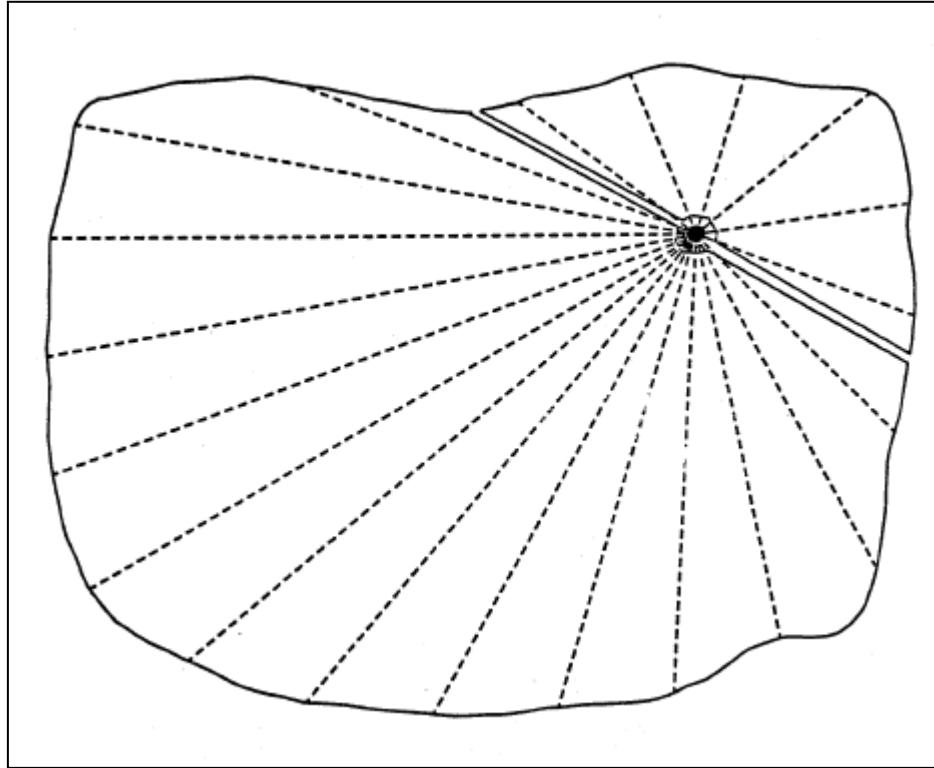


Figure 13—Dividing a unit into two separate units served by the same landing can solve problems caused by a chevron-shaped average skyline road.

The third limitation of the average skyline-road algorithm is sampling an accurate set of stand conditions on a small area. When yarding systems with limited lateral yarding capacity (<25 feet) are simulated, each yarder and tailhold combination may cover only a small area—0.5 acre or less. Experimenting with the model showed that the difference between the inventoried volume of a stand and the sampled volume of a single skyline road can be significant. Figure 14 shows a portion of the stand summary produced by modeling a 0.42-acre average skyline road. The stand being yarded contains 34,230 board feet per acre (Scribner) as inventoried. A standing volume and a yarded volume of 19,241 and 28,764 board feet per acre, respectively, are reported. (Remember that the stand created is much larger than the average skyline road to account for trees falling into the skyline road.) In this case, the calculated average skyline road should more correctly be termed a "typical skyline road." Its volume is typical of a randomly selected skyline road but does not accurately represent an average for the entire unit. A solution is to simulate yarding activities on the average skyline road several times and each time use a different random-number generator seed. This will change the sampled stand conditions and the standing and yarded volumes. Five repetitions result in estimates statistically equal to estimates produced by simulating every skyline road on a unit. Repetitive simulation is easily done and may be warranted whenever the results of a single run are suspicious.

DRY BAY SALE: UNIT 5 1 May 1986

STAND SUMMARY

Diameter- class midpoint	Number of trees per acre	Volume per acre on average setting: Per diameter class		Volume per acre on average setting: Cumulative volume	
		Standing volume	Yarded volume	Standing volume	Yarded volume
inches		bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)
12.00	3.16	163 (49.88)	155 (42.83)	163 (49.88)	155 (42.83)
14.00	3.77	3155 (851.26)	626 (167.04)	3318 (901.14)	781 (209.88)
16.00	12.96	0 (0.00)	4003 (890.15)	3318 (901.14)	4784 (1100.03)
18.00	7.38	3991 (904.61)	4016 (860.83)	7309 (1805.75)	8800 (1960.86)
20.00	4.07	5514 (1178.13)	1102 (245.61)	12823 (2983.88)	9902 (2206.47)
22.00	9.49	2451 (498.76)	5883 (1130.24)	15274 (3482.63)	15784 (3336.71)
24.00	14.62	0 (0.00)	4281 (910.14)	15274 (3482.63)	20066 (4246.85)
26.00	5.42	3967 (748.17)	4124 (765.58)	19241 (4230.81)	24190 (5012.43)
28.00	3.62	0 (0.00)	1244 (305.93)	19241 (4230.81)	25434 (5318.35)
30.00	.60	0 (0.00)	703 (143.66)	19241 (4230.81)	26137 (5462.01)
32.00	2.11	0 (0.00)	2627 (511.94)	19241 (4230.81)	28764 (5973.95)
34.00	0	0 (0.00)	0 (0.00)	19241 (4230.81)	28764 (5973.95)
36.00	.75	0 (0.00)	0 (0.00)	19241 (4230.81)	28764 (5973.95)
Total	67.96			19241 (4230.81)	28764 (5973.95)

Figure 14—A portion of a stand summary showing incorrect standing volume and yarded volume as opposed to the correct, inventoried volume of 34,230 BF/acre.

The final limitation involves the turn-building algorithm; specifically, the decision rule that determines whether or not a group of logs can be hooked as a turn. When checking a possible turn, the model calculates an average coordinate based on the coordinate location of each log in the group. The distance from each log to this average coordinate is compared to the effective choker length (80 percent of the input choker length minus the large-end circumference of the log). If a log that cannot be hooked at the average coordinate is found in the group, the turn is rejected. This approach can reject turns that, in reality, could be hooked. Figure 15 shows a situation where the turn would be rejected using the average coordinate method. In this example, log A cannot be hooked at the average coordinate (X,Y), and logs B, C, D, and E can be hooked at (X,Y). Each dashed circle represents the hook zone for a log—a circular area around the large end

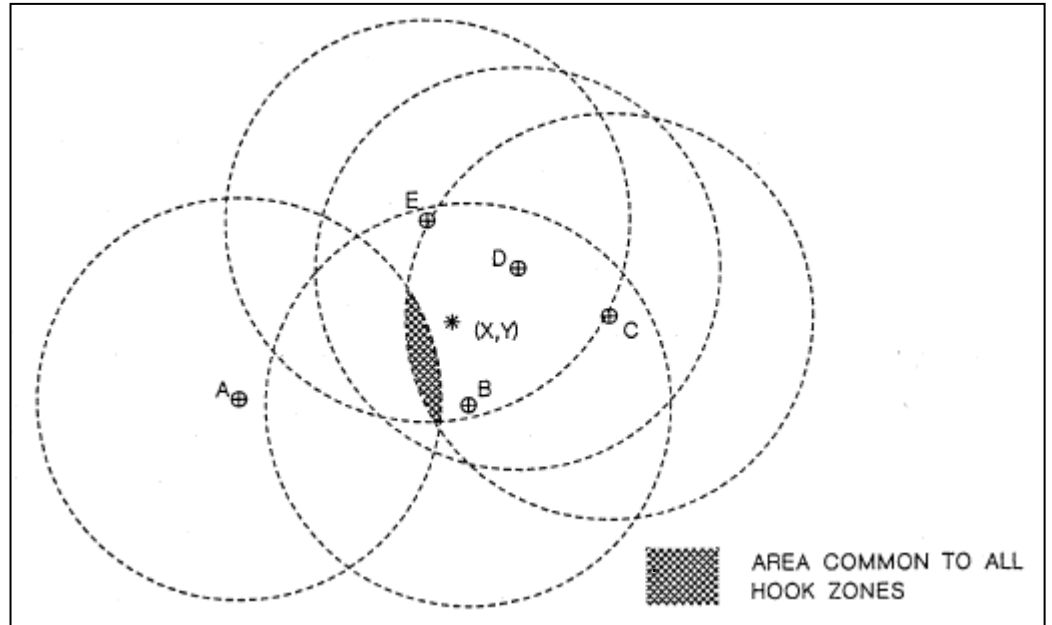


Figure 15—The average coordinate method of checking turns rejects some turns that could be hooked.

of the log with the radius equal to the effective choker length for the log. The shaded area is the intersection of the hook zones for all five logs. The turn could be hooked at any point within the shaded area even though it is rejected by the average-coordinate method. The errors caused by the average-coordinate method are conservative; that is, some turns will be rejected that could be hooked and have no significant effect on the simulation results.

Summary

Timber-harvest operations are being forced onto ground once thought of as inaccessible and unloggable and into smaller, second-growth stands to supply the demands for wood fiber. Harvesting operations run on a fine line between success and failure, and managers are finding that intensive planning is needed to ensure the success of an operation. Thorough planning can increase the ever-elusive profit margin even for those logging operations on accessible sites. The PLANS package and SIMYAR help planners to develop practical harvesting solutions and to compare the solutions economically and operationally. The package reduces the time needed to develop timber-harvest plans while it increases planning quality.

Metric Equivalents

1 inch = 2.54 centimeters

1 foot = 0.3048 meter

1 acre = 0.4047 hectare

1 pound = 0.4536 kilogram

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An appendix to this report containing step-by-step operating instructions for the SIMYAR program is available on request from the Pacific Northwest Research Station. A copy of this appendix can be obtained by photocopying this page, filling in the necessary information, and sending it to:

Forestry Sciences Laboratory
Forest Engineering Systems
4043 Roosevelt Way NE
Seattle, WA 98105

This appendix includes examples of using SIMYAR to estimate yarding cost and productivity and demonstrates many of the options and manipulations that can be exercised during this process.

If you wish to receive the PLANS program set, which includes SIMYAR stored on diskettes, enclose five 5 1/4-inch double-sided, double-density, flexible, mini discs.

Please send supplementary material for the SIMYAR program to:

NAME _____

ADDRESS _____

CITY _____

STATE & ZIP CODE _____

PHONE () _____

McGaughey, Robert J.; Twito, Roger H. 1987. SIMYAR: a cable-yarding simulation model. Gen. Tech. Rep. PNW-GTR-205. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.

A skyline-logging simulation model designed to help planners evaluate potential yarding options and alternative harvest plans is presented. The model, called SIMYAR, uses information about the timber stand, yarding equipment, and unit geometry to estimate yarding cost and productivity for a particular operation. The costs of felling, bucking, loading, and hauling are not considered. Included are a description of the input requirements for SIMYAR, descriptions of the major algorithms, suggested applications, and a discussion of limitations. A users guide is available as an appendix to this publication.

Keywords: Simulation, cable logging, yarding operations, timber harvesting, costs (logging).

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S.W. Pine St.
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Portland; Oregon 97208

SIMYAR Program - Users Instructions

EXAMPLE. 1 : SIMULATION OF FIXED TOWER YARDER.

The planner wants to simulate yarding activities on a live skyline unit to obtain estimates of cost and productivity. The harvest unit, shown in figure 1, is labeled SPEARFISH SALE: UNIT 3.

The planner should tape figure 1 to the digitizer surface, then type:

LOAD "PLANS/BEGIN:CS80,5",1 (followed by the EXECUTE key)

Step 1-1



Please choose one of the following eight PLANS programs:

1. SKYMOBILE Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER..... Analyze payloads and spans for large central landings.
3. HIGHLEAD Analyze direct pull and tightlining limits for highlead.
4. ROUTES..... Project trial grade lines and calculate % sideslopes.
5. SLOPE..... Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL View a terrain model in perspective from desired viewpoint.
7. SIMYAR Simulate yarding activities to estimate yarding cost.
8. MAP..... Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard Input: 7 (followed by the RETURN key)

comment: Any of the PLANS programs can be loaded from this menu. For this example, SIMYAR will be loaded.

Step 1-2

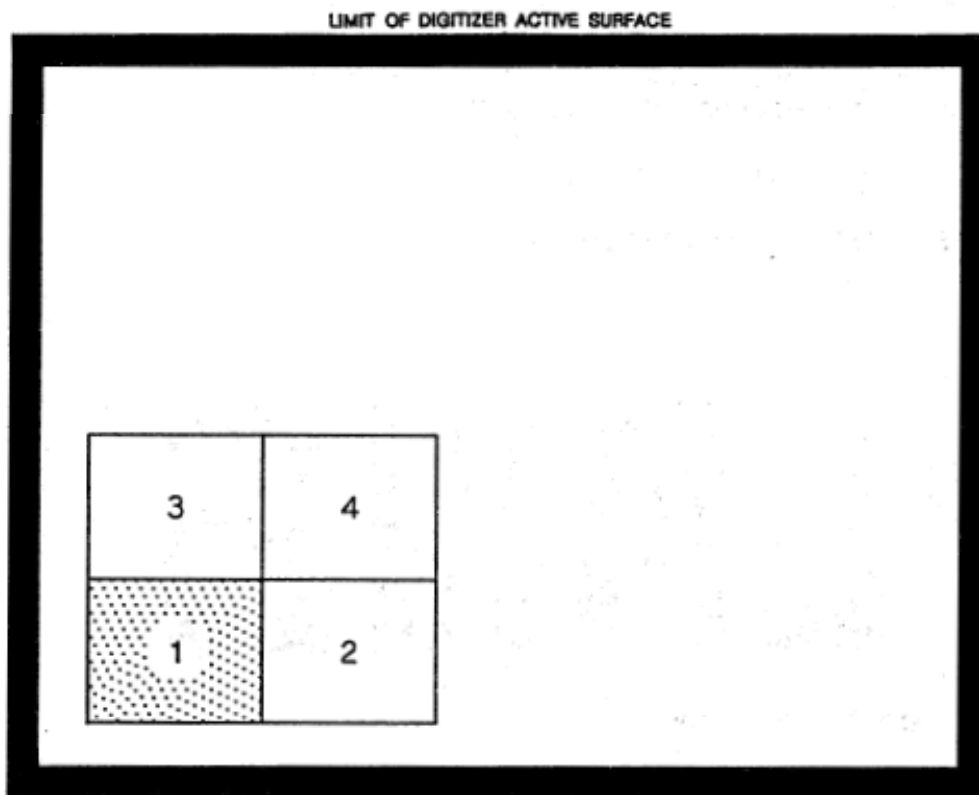
ENTER THE DATA-FILE NAME FOR THE DESIRED DTM UNIT.

Keyboard Input: EXAMPLE_DTM1

Comment: If the requested DTM (digital terrain model) unit is a single-unit DTM, it will be loaded and the program will continue at step 1-4.

If the requested DTM unit is part of a multiunit DTM and other units in the multiunit DTM are available, continue at step 1-3.

Step 1-3



THE SHADED DTM IS EXAMPLE_DTM1 —SELECT THE DESIRED LOADING OPTION—

LOAD ALL DTM UNITS	LOAD ONLY THE SHADED DTM UNITS	
-----------------------	-----------------------------------	--

Softkey Input: **LOAD ONLY THE
SHADED DTM** (press the appropriate softkey)

comment: A maximum of six DTM units can be loaded at one time (three units horizontally and two units vertically). The CRT shows the requested DTM unit (shaded) and all other DTM units that can be loaded.

Step 1-4

DIGITIZE THE LOWER LEFT CORNER OF THE DTM UNIT.

Digitizer input: **Center the crosshairs of the cursor on the lower left corner of the DTM unit and press any cursor button.**

comment: Be sure that figure 1 is taped to the surface of the digitizer. Do NOT move the map during the work session.

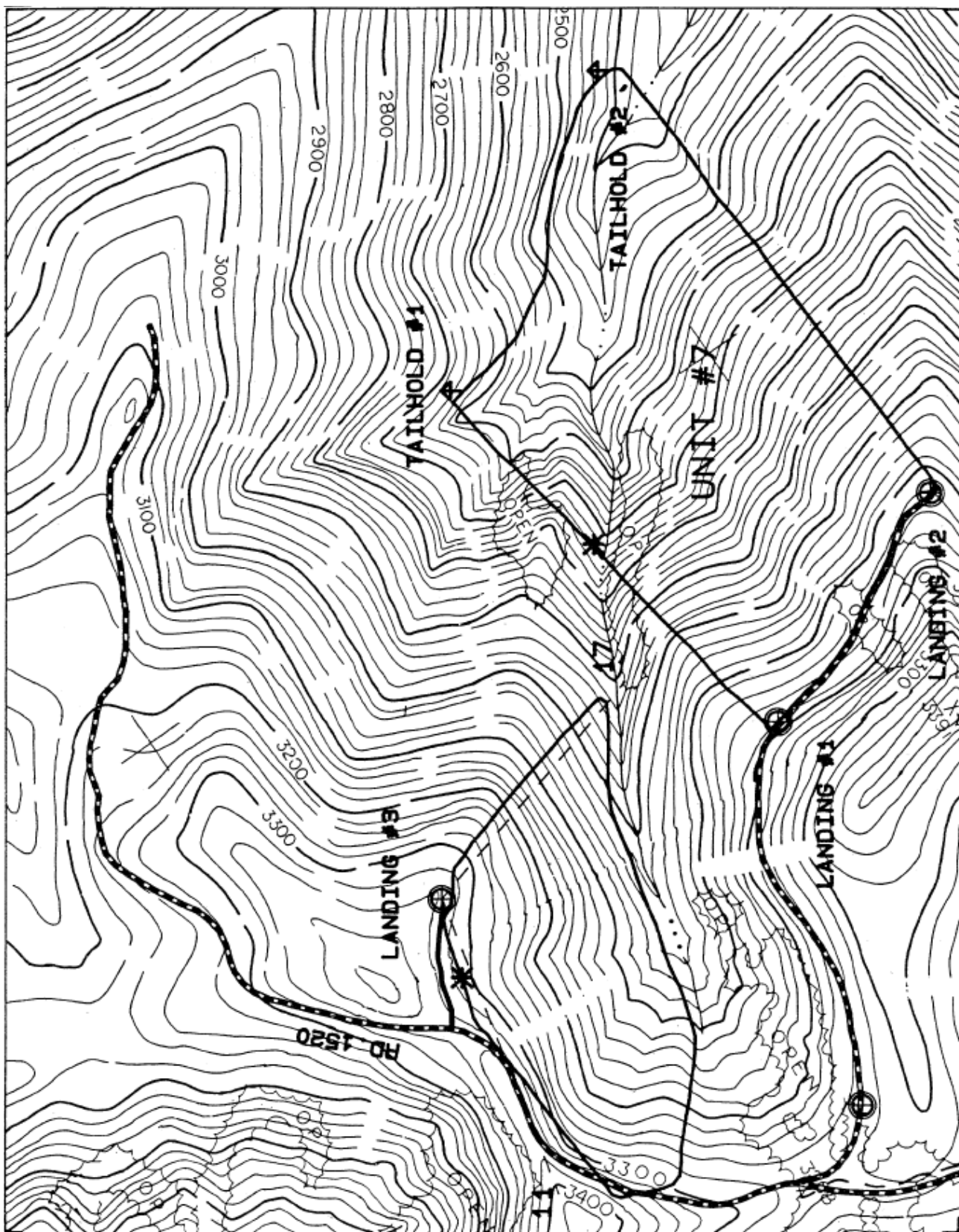


Figure 1—Map for SIMYAR examples.

YARDING SIMULATION ACTIVITIES

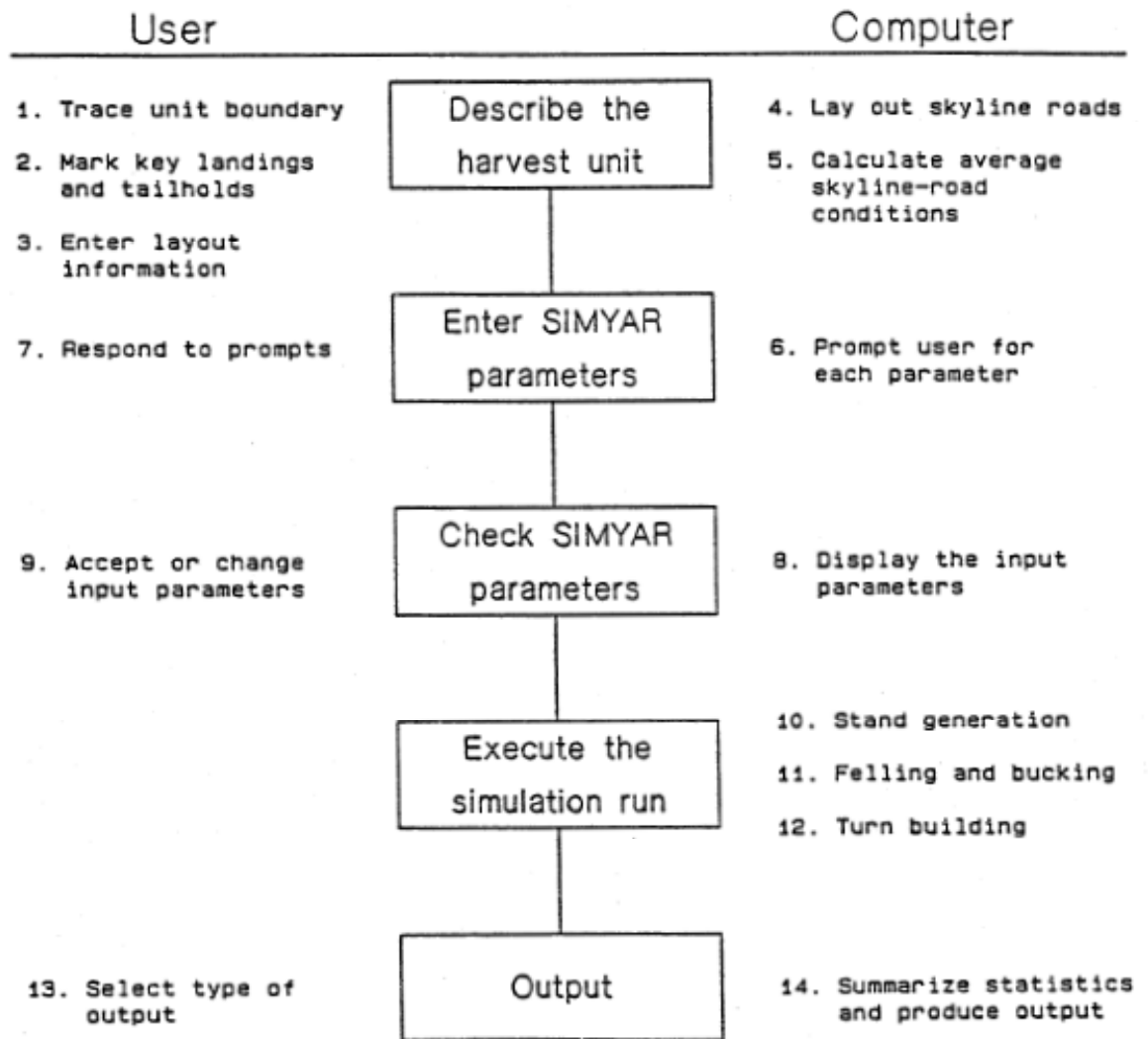


Figure 2—Activities in a run of SIMYAR

Examining the relations between operating conditions and design payload is easy with SIMYAR. By varying the payload and number of chokers for representative timber stands in the planning area, users can estimate maximum and average turn weights. Then, payloads in a realistic range for the stand conditions can be used as bases for planning activities.

Estimating Yarding Cost

Valid yarding-cost estimates can be made with SIMYAR if a suitable regression equation for yarding-cycle time is used. Because cost is directly related to time, a regression equation must be used that accurately represents a yarding system operating on terrain similar to the planning area.

Step 1-5

DIGITIZE THE LOWER RIGHT CORNER OF THE DTM UNIT.

Digitizer Input: *Center the crosshairs of the cursor on the lower right corner of the DTM unit and press any cursor button.*

Step 1..6

ENTER STAND DESCRIPTION	ENTER STAND DESCRIPTION	CONTINUE WITH STAND DESCRIPTION	LOAD A DIFFERENT SIMYAR MENU
----------------------------	----------------------------	------------------------------------	---------------------------------

Softkey Input: *ENTER*
STAND DESCRIPTIONS

Step 1-7

ADD A STAND DESCRIPTION	EDIT A STAND DESCRIPTION	PRINT A STAND DESCRIPTION	RETURN TO SIMYAR MENU
----------------------------	-----------------------------	------------------------------	--------------------------

Soft key Input: *ADD A*
STAND DESCRIPTION

comment: Stand descriptions are stored for later use.

Step 1-8

WHAT IS THE STAND IDENTIFIER?

Keyboard Input: *CARBON RIVER: MT. BAKER-SNOQ. NF*

Step 1-9

WHAT IS THE SPECIES COMPOSITION?

Keyboard Input: *WESTERN HEMLOCK*

Step 1-10

WHAT IS THE LOCATION?

Keyboard Input: SW4,T17N,R7E,WM

Step 1-11

WHAT IS THE COMMENT?

Keyboard Input: 60-ACRE STAND, MT. BAKER-SNOQ. NF

Step 1-12

WHAT IS THE DIAMETER CLASS MIDPOINT IN INCHES (ENTER 0 WHEN DONE)?

Keyboard Input: 8

comment: The diameter class data will be displayed on the CRT as it is entered.

Step 1-13

DIAMETER-CLASS
MIDPOINT (INCHES)

NUMBER OF TREES
PER ACRE

TOTAL TREE
HEIGHT (FEET)

8

HOW MANY TREES PER ACRE IN THIS CLASS?

Keyboard input: 0.12

Step 1-14

DIAMETER-CLASS
MIDPOINT (INCHES)
8

NUMBER OF TREES
PER ACRE
0.12

TOTAL TREE
HEIGHT (FEET)

THE ESTIMATED TOTAL TREE HEIGHT FOR THIS CLASS IS 63 FEET. TO USE THIS HEIGHT, PRESS RETURN—OR ENTER THE DESIRED TREE HEIGHT.

Keyboard Input: 65

comment: Estimates of total tree height are based on limited growth studies in the Pacific Northwest. If total-tree-height data are available, they should be used.

Steps 1-12, 1-13, and 1-14 should be repeated until all data in table 1 have been entered. Then enter 0 in step 1-12 and continue with the example at the next step of the users guide.

Table 1—Stand data for CARBON RIVER, MT. BAKER-SNOQ. NF stand.		
Diameter-class midpoint (inches)	Number of trees per acre	Total tree height (feet)
8	0.12	65
10	0	75
12	3.97	85
14	3.74	93
16	13.22	100
18	7.43	106
20	3.66	111
22	10.10	116
24	11.97	120
26	6.48	124
28	3.76	127
30	1.62	130
32	1.44	133
34	0	135
36	.57	137

Step 1-15

ADD A STAND DESCRIPTION	EDIT A STAND DESCRIPTION	PRINT A STAND DESCRIPTION	RETURN TO SIMYAR MENU
----------------------------	-----------------------------	------------------------------	--------------------------

**Softkey Input: RETURN TO
SIMYAR MENU**

Step 1-16

ENTER STAND DESCRIPTIONS	ENTER REGRESSION EQUATIONS	CONTINUE WITH YARDING SIMULATION	LOAD A DIFFERENT PLANS PROGRAM
-----------------------------	-------------------------------	-------------------------------------	-----------------------------------

Soft key Input: **ENTER**
REGRESSION EQUATIONS

Step 1-17

ADD A REGRESSION EQUATION	EDIT A REGRESSION EQUATION	PRINT A REGRESSION EQUATION	RETURN TO SIMYAR MENU
------------------------------	-------------------------------	--------------------------------	--------------------------

Softkey Input: **ADD A REGRESSION
EQUATION**

comment: Regression equations and their associated descriptions are stored for later use.

Step 1-18

WHAT IS THE EQUIPMENT/SYSTEM IDENTIFIER?

Keyboard Input: **SKAGIT BU.90: LIVE SKYLINE**

comment: This type of prompt will be used to input each of the 26 yarding system and stand condition descriptors shown in table 2.

After all descriptors have been entered, continue with the next step.

Step 1-19

REGRESSION EQUATION ENTRY

THE REGRESSION EQUATION CAN BE ONE OF THE FOLLOWING FORMS:

- 1—LINEAR (EQUATION GIVES CYCLE TIME)
- 2—LOGARITHMIC(EQUATION GIVES THE NATURAL LOG OF CYCLE TIME)
- 3—LOGARITHMIC (EQUATION GIVES THE LOG (BASE 10) OF CYCLE TIME)

WHAT IS THE FORM OF THE REGRESSION EQUATION? (ENTER 1 ,2, OR 3)

Keyboard Input: **1**

**Table 2—Yarding system/condition descriptors
for SKAGIT BU-90: LIVE SKYLINE yarding system**

Descriptor	Keyboard input
EQUIPMENT/SYSTEM IDENTIFIER	SKAGIT BU-90: LIVE SKYLINE
YARDER MODEL	SKAGIT BU-90
CARRIAGE MODEL	?
TOWER MODEL	SKAGIT T-90
TOWER HEIGHT IN FEET	90
SKYLINE DIAMETER IN INCHES	1-1/4
MAINLINE DIAMETER IN INCHES	1
SLACKPULLING-LINE DIAMETER IN INCHES	NA
HAULBACK-LINE DIAMETER IN INCHES	7/8
SYSTEM CONFIGURATION	LIVE SKYLINE: SHOTGUN
STAFF IN THE YARDING CREW	?
YARDING DIRECTION	UPHILL
VOLUME PER ACRE	40-85 MBF
SHAPE OF LOGGED AREA	TRIANGULAR TO RECT.
TOPOGRAPHY DESCRIPTOR	RUGGED & BROKEN
AVERAGE TREE DIAMETER	OLD GROWTH
OVERALL STAND AGE	150-250
NUMBER OF TREES PER ACRE	?
SPECIES COMPOSITION	60-70% DOUGLAS-FIR
SILVICULTURAL PRESCRIPTION	CLEARCUT
AVERAGE SLOPE YARDING DISTANCE	703.6
AVERAGE LATERAL YARDING DISTANCE	NA
AVERAGE CHORDSLOPE	-44.3
AVERAGE GROUNDSLOPE	67.2
AVERAGE NUMBER OF PIECES YARDED PER TURN	2.1
AVERAGE TURN VOLUME	758.8 BF
COMMENT	STUDY CONDUCTED IN 1973 ON THE MOUNT HOOD NF BY D.P. DYKSTRA. REPORTED IN 1975.

.....
Step 1-20

WHAT IS THE REGRESSION EQUATION CONSTANT?

Keyboard Input: 4.6777

Step 1-21

VARIABLE: SLOPE YARDING DISTANCE IN FEET
WHAT IS THE COEFFICIENT (DEFAULT = 0.0)?

Keyboard Input: 0.001462

comment: Pressing the RETURN key without entering a coefficient is the same as entering a coefficient of 0.0 for the variable.

Step 1-22

VARIABLE: SLOPE YARDING DISTANCE IN FEET
WHAT IS THE EXPONENT (DEFAULT = 1.0)?

Keyboard Input: Press the RETURN key to use the default exponent of 1.0

comment: Steps 1-21 and 1-22 will be repeated for all variables shown in table 3. After entering coefficients and exponents, continue with the next step.

**Table 3—Regression equation coefficients and exponents for
SKAGIT BU-90: LIVE SKYLINE yarding system.**

Variable	Coefficient	Exponent
SLOPE YARDING DISTANCE IN FEET	0.001462	1.0
LATERAL YARDING DISTANCE IN FEET	0	0
TURN VOLUME IN CUBIC FEET	0	0
TURN VOLUME IN BOARD FEET	0.0005199	1.0
NUMBER OF PIECES IN THE TURN	0	0
GROUNDSLOPE	0	0
CHORDSLOPE	0	0
TURN WEIGHT IN POUNDS	0	0
NUMBER OF CHOKER SETTERS	0	0
CUBIC-FOOT VOLUME PER LOG	0	0
BOARD-FOOT VOLUME PER LOG	0	0
LN (SLOPE YARDING DISTANCE)	0	0
(LATERAL YARDING DISTANCE)*(GROUNDSLOPE)	0	0
NUMBER OF CHOKERS	0	0
SLOPE YARDING DISTANCE SQUARED	0	0

Step 1-23

WHAT IS THE PERCENTAGE OF DELAY PER CYCLE?

Keyboard Input: 9.2

comment: The percentage of delay per yarding cycle should not be entered as a decimal percentage (that is, 0.092).

Step 1-24

ADD A REGRESSION EQUATION	EDIT A REGRESSION EQUATION	PRINT A REGRESSION EQUATION	RETURN TO SIMYAR MENU
------------------------------	-------------------------------	--------------------------------	--------------------------

**Soft key Input: RETURN TO
SIMYAR MENU**

Step 1-25

ENTER STAND DESCRIPTIONS	ENTER REGRESSION EQUATIONS	CONTINUE WITH YARDING SIMULATION	LOAD A DIFFERENT PLANS PROGRAM
-----------------------------	-------------------------------	-------------------------------------	-----------------------------------

**Softkey Input: CONTINUE WITH
YARDING SIMULATION**

Step 1-26

WILL THE UNIT BE YARDED TO A SINGLE LANDING OR TO
MULTIPLE LANDINGS BY MOBILE YARDING CRANES?

SINGLE LANDING		MULTIPLE LANDING
-------------------	--	---------------------

Step 1-27

DIGITIZE (PRESS ANY CURSOR BUTTON) THE LANDING

Digitizer Input: Center the crosshairs of the cursor on landing 3 and press any cursor button.

Step 1-28

TRACE THE UNIT BOUNDARY
BEGIN BY PRESSING ANY CURSOR BUTTON

Digitizer Input: The CRT shows the DTM boundary and the current position of the digitizer's cursor. Center the crosshairs of the cursor on the lt near landing 3 and press any cursor button. Trace the boundary of the unit. When you reach the lt, a tone will sound indicating boundary closure.

Step 1-29

DIGITIZE THE FIRST EXTERIOR SKYLINE ROAD ON THE UNIT BOUNDARY
BY PRESSING ANY CURSOR BUTTON

Digitizer Input: *Center the crosshairs of the cursor on the unit boundary along corridor 17 and press any cursor button.*

Step 1-30

DIGITIZE THE LAST EXTERIOR SKYLINE ROAD ON THE UNIT BOUNDARY
BY PRESSING ANY CURSOR BUTTON

Digitizer Input: *Center the crosshairs of the cursor on the unit boundary along corridor 11 and press any cursor button.*

Step 1-31

ENTER THE DESIRED SKYLINE-ROAD SPACING IN FEET

Keyboard Input: 90

Step 1-32

ENTER THE AVERAGE PAYLOAD FOR THE UNIT IN POUNDS

Keyboard input: 15000

comment: The computer will lay out skyline roads and determine average skyline-road parameters.

Step 1-33

DESIGN IS ACCEPTABLE CONTINUE		DESIGN UNACCEPTABLE LET ME CHANGE IT
----------------------------------	--	---

Softkey Input: **DESIGN IS ACCEPTABLE**
CONTINUE

comment: The layout summary shown in figure 2 will be printed.

SIMYAR

VERSION HP9020--1.10

10 Mar 1987

AREA = 13.01 ACRES
AYD = 537.72 FEET
LAT AYD = 14.13 FEET
SLOPE AYD = 558.40 FEET
AVERAGE SLOPE = 28 PERCENT
AVERAGE PAYLOAD = 15000 POUNDS

** LAYOUT NOT DRAWN TO MAP SCALE **

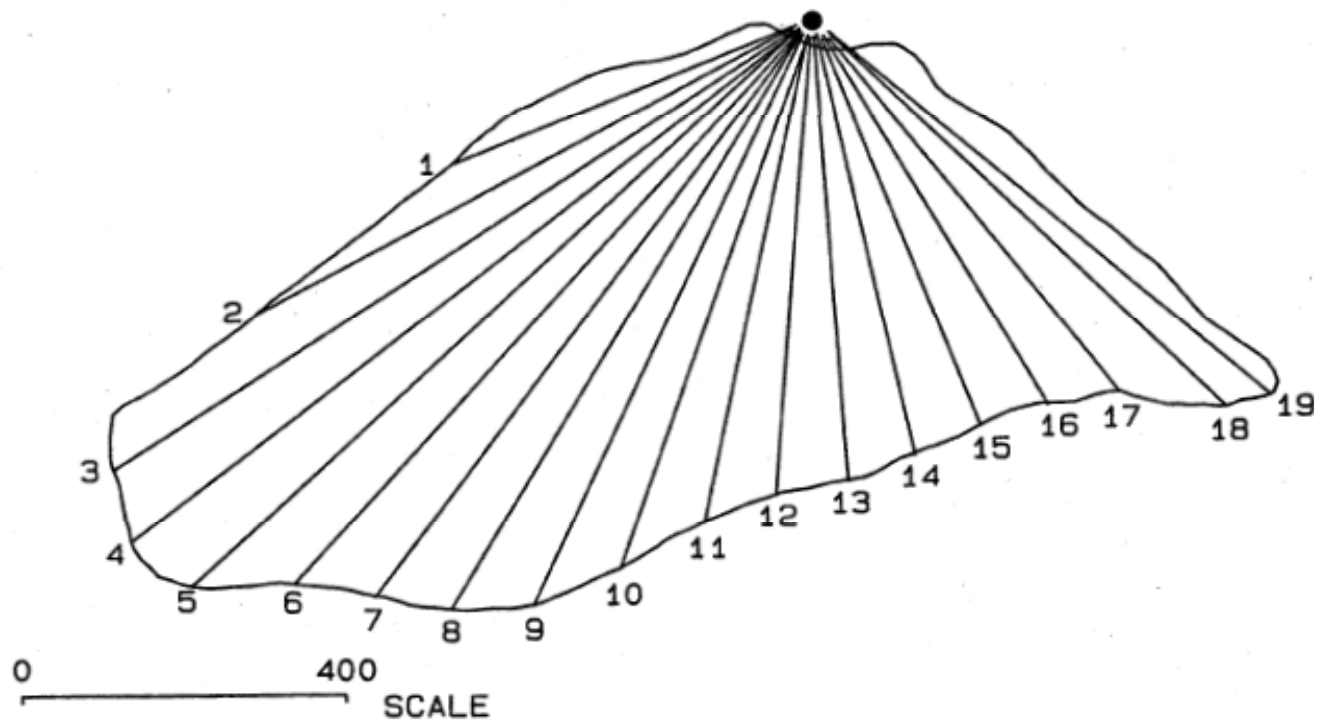


Figure 2—Layout summary for SIMYAR, example 1

Step 1-34

WHAT IS THE RUN NAME?

Keyboard Input: SPEARFISH SALE: UNIT 3

Step 1-35

WHAT TYPE OF YARDING SYSTEM WOULD YOU LIKE TO USE?

1—SKAGIT GT-3: RUNNING SKYLINE

2—SKAGIT BU-90: LIVE SKYLINE

ENTER THE NUMBER TO THE LEFT OF THE DESIRED SYSTEM

Keyboard Input: 2

comment: As regression equations are entered for various yarding systems, they will be added to this list.

Step 1-36

HOW MANY CHOKERS ARE BEING USED? (A MAXIMUM OF 8 CHOKERS CAN BE USED)

Keyboard Input: 5

Step 1-37

HOW LONG ARE THE CHOKERS (FEET)?

Keyboard Input: 26

Step 1-38

WHAT IS THE OPERATING COST PER HOUR FOR THE YARDING SYSTEM (MACHINE RATE)?

Keyboard Input: 203.86

comment: Machine rate is the hourly cost of owning and operating the yarding system. It includes both fixed and variable costs, which are also known as ownership and operating costs.

.....

Step 1-39

THE TIME REQUIRED TO MOVE THE TAILHOLD MAY OR MAY NOT BE NEEDED DEPENDING ON THE REGRESSION EQUATION USED TO ESTIMATE YARDING CYCLE TIMES. IF THE REGRESSION EQUATION DOES NOT ACCOUNT FOR THE TIME REQUIRED TO MOVE THE TAILHOLD (SKYLINE ROAD CHANGE), THE APPROPRIATE TIME IN HOURS SHOULD BE ENTERED. IF THE REGRESSION EQUATION INCLUDES SKYLINE-ROAD CHANGE TIME, ENTER 0 FOR IT.

HOW LONG DOES IT TAKE TO CHANGE SKYLINE ROADS (HOURS)?

Keyboard input: 1.15

comment: A skyline-road change is defined as moving the tailhold around the tower in fan-shaped yarding patterns. .

.....

Step 1-40

WHAT IS THE MOVING COST FOR THE SYSTEM (DOLLARS)?

Keyboard input: 1000

comment: The moving cost should cover all costs for preparing and transporting equipment to the initial landing site. This may be transporting to and from an equipment yard several miles from the unit or simply moving the equipment from a previous landing.

.....

Step 1-41

THE PREFERRED LOG LENGTH SPECIFIES THE LENGTH OF THE LOG MOST COMMONLY CUT BY THE BUCKING ALGORITHM IN THE MODEL. THIS LENGTH SHOULD BE A MULTIPLE OF 2 FEET TO ENSURE THAT FINAL LOG LENGTHS WILL ALSO BE INCREMENTS OF 2 FEET. A TRIM ALLOWANCE OF 6 INCHES PER 16 FEET OF LOG LENGTH WILL BE ADDED.

WHAT IS THE PREFERRED LOG LENGTH (FEET)?

Keyboard input: 40

.....

Step 1-42

THE MINIMUM LOG LENGTH TO BE CUT IS THE LENGTH OF THE SHORTEST LOG THAT WILL BE CUT BY THE BUCKING ALGORITHM IN THE MODEL. THIS LENGTH SHOULD BE A MULTIPLE OF 2 FEET TO ENSURE THAT FINAL LOG LENGTHS WILL ALSO BE INCREMENTS OF 2 FEET. A TRIM ALLOWANCE OF 6 INCHES PER 16 FEET OF LOG LENGTH WILL BE ADDED.

WHAT IS THE MINIMUM LOG LENGTH TO BE CUT (FEET)?

Keyboard input: 12

Step 1-43

WHAT IS THE DENSITY OF THE WOOD BEING HARVESTED (LB/FT³)?

Keyboard input: 50

comment: The density of the wood being harvested is the green weight per cubic foot of wood. If several species are being yarded, a weighted average density should be calculated and used.

Step 1-44

WHAT IS THE MINIMUM MERCHANTABLE TOP-DIAMETER LIMIT (INCHES)?

Keyboard input: 6

comment: The minimum merchantable top diameter is the smallest diameter (outside bark) stems should be bucked to. This limit is often dictated by industrial specifications. In whole-tree logging, the minimum top diameter should equal 0.

Step 1-45

THE FOLLOWING STANDS ARE AVAILABLE:

1-CARBON RIVER: MT. BAKER-SNOQ. NF

ENTER THE NUMBER TO THE LEFT OF THE DESIRED STAND

Keyboard input: 1

comment: As stand descriptions are entered, they will be added to this list.

Step 1-46

THE NAME OF THE SELECTED STAND IS "CARBON RIVER: MT. BAKER-SNOQ. NF." THIS STAND CONTAINS A STANDING VOLUME OF 34230 BOARD FEET PER ACRE (SCRIBNER) TO A 6-INCH TOP.

IS THIS THE STAND YOU WANT TO USE? (Y OR N)

Keyboard input: Y

comment: Stand volumes reported in this step are always calculated to a 6-inch top regardless of the top diameter entered in step 1-44. When trees are placed on the average skyline road, the top diameter entered in step 1-44 is used to calculate the volume of each tree.

Step 1-47

DIAMETER-CLASS MIDPOINT	NUMBER OF TREES PER ACRE	TOTAL TREE HEIGHT (FEET)
12	3.97	85.0
14	3.74	93.0
16	13.22	100.0
18	7.43	106.0
20	3.66	111.0
22	10.10	116.0
24	11.97	120.0
26	6.48	124.0
28	3.76	127.0
30	1.62	130.0
32	1.44	133.0
34	0	135.0
36	.57	137.0
SPEARFISH SALE:	UNIT 3	1 May 1986

HARVEST EQUIPMENT SPECIFICATIONS

- 11—TYPE OF SYSTEM: SKAGIT BU-90: LIVE SKYLINE
- 12—AVERAGE PAYLOAD: 15000 POUNDS
- 13—NUMBER OF CHOKERS: 5
- 14—CHOKER LENGTH: 26 FEET
- 15—MACHINE RATE: \$203.86
- 16—SKYLINE-ROAD CHANGE TIME: 1.15 HOURS
- 17—MOVING COST: \$1000
- 18—PREFERRED LOG LENGTH: 40 FEET
- 19—MINIMUM LOG LENGTH: 12 FEET

HARVEST-UNIT GEOMETRY

- +21—SKYLINE-ROAD GEOMETRY: TRAPEZOIDAL WITH YARDER OUTSIDE UNIT
- +22—EXTERNAL YARDING DISTANCE: 787 FEET
- +23—MAXIMUM LATERAL YARDING DISTANCE: 42 FEET
- +24—AVERAGE CHORDS LOPE: 28 PERCENT
- +25—NUMBER OF SKYLINE ROADS ON THE UNIT: 19
- +26—AVERAGE GROUNDSLOPE: 35 PERCENT
- * 27—NUMBER OF CHOKER SETTERS: 2

TIMBER-STAND CHARACTERISTICS.

- 31—WOOD DENSITY: 50 LB/FT³
- 32—UPPER DIAMETER LIMIT: 6 INCHES
- * 33—ANGLE: 90°
- * 34—RANDOMNESS FACTOR: 1
- 35—STAND NAME: CARBON RIVER: MT. BAKER-SNOQ. NF

GENERAL INFORMATION

- 41—RUN NAME: SPEARFISH SALE: UNIT 3

* PRESET VALUE USED FOR THIS PARAMETER

+ PARAMETER CANNOT BE CHANGED WITHOUT RESTARTING THE MODEL

CHANGE SOME PARAMETERS		CHANGE ALL PARAMETERS		CONTINUE WITH THE SIMULATION
---------------------------	--	--------------------------	--	---------------------------------

**Softkey Input: CHANGE SOME
PARAMETERS**

comment: Values for some model parameters describing the geometry of the harvest unit may differ slightly from those printed above.

Step 1-48

ENTER THE NUMBER TO THE LEFT OF THE VALUE(S) TO BE CHANGED.

Keyboard Input: 13,14

comment: The number of chokers and the choker length are to be changed.

Step 1-49

HOW MANY CHOKERS ARE BEING USED? (A MAXIMUM OF 8 CHOKERS CAN BE USED)

Keyboard input: 4

Step 1-50

HOW LONG ARE THE, CHOKERS (FEET)?

Keyboard Input: 30

Step 1-51

DIAMETER-CLASS MIDPOINT	NUMBER OF TREES PER ACRE	TOTAL TREE HEIGHT (FEET)
12	3.97	85.0
14	3.74	93.0
16	13.22	100.0
18	7.43	106.0
20	3.66	111.0
22	10.10	116.0
24	11.97	120.0
26	6.48	124.0
28	3.76	127.0
30	1.62	130.0
32	1.44	133.0
34	0	135.0
36	.57	137.0

HARVEST-EQUIPMENT SPECIFICATIONS

- 11—TYPE OF SYSTEM: SKAGIT BU-90: LIVE SKYLINE
- *12—AVERAGE PAYLOAD: 15000 POUNDS
- 13—NUMBER OF CHOKERS: 4
- 14—CHOKER LENGTH: 30 FEET
- 15—MACHINE RATE: \$203.86
- 16—SKYLINE-ROAD CHANGE TIME: 1.15 HOURS
- 17—MOVING COST: \$1000
- 18—PREFERRED LOG LENGTH: 40 FEET
- 19—MINIMUM LOG LENGTH: 12 FEET

HARVEST-UNIT GEOMETRY

- +21—SKYLINE-ROAD GEOMETRY: TRAPEZOIDAL WITH YARDER OUTSIDE UNIT
- +22—EXTERNAL YARDING DISTANCE: 787 FEET
- +23—MAXIMUM LATERAL YARDING DISTANCE: 42 FEET
- +24—AVERAGE CHORDSLOPE: 28 PERCENT
- +25—NUMBER OF SKYLINE ROADS ON THE UNIT: 19
- +26—AVERAGE GROUND Slope: 35 PERCENT
- *27—NUMBER OF CHOKER SETTERS: 2

TIMBER-STAND CHARACTERISTICS

- 31—WOOD DENSITY: 50 LB/FT³
- 32—UPPER DIAMETER LIMIT: 6 INCHES
- *33—FELLING ANGLE: 90°
- *34—RANDOMNESS FACTOR: 1
- 35—STAND NAME: CARBON RIVER: MT. BAKER-SNOQ. NF

GENERAL INFORMATION

- 41—RUN NAME: SPEARFISH SALE: UNIT 3

* PRESET VALUE USED FOR THIS PARAMETER

+ PARAMETER CANNOT BE CHANGED WITHOUT RESTARTING THE MODEL

CHANGE SOME PARAMETERS		CHANGE ALL PARAMETERS		CONTINUE WITH THE SIMULATION
---------------------------	--	--------------------------	--	---------------------------------

**Softkey Input: CONTINUE WITH
THE SIMULATION**

.....
Step 1-52

YARDING SUMMARY		ECHO CHECK		STAND SUMMARY			NEXT MENU
--------------------	--	---------------	--	------------------	--	--	--------------

**Softkey input: YARDING
SUMMARY**

comment: Yarding activities will be simulated and various messages will be displayed. Yarding simulation requires about 45 seconds.

The yarding summary shown in figure 3 will be printed.

SPEARFISH SALE: UNIT 3

1 May 1986

Type of system: SKAGIT BU-90: LIVE SKYLINE

Operating cost per hour: \$ 203.86.

Set up cost for the logging system: \$ 1000.00.

Maximum slope yarding distance: 787.53 feet.

Maximum lateral yarding distance: 42.39 feet.

Average system payload: 15000.00 pounds.

Preferred log length: 40.00 feet.

Minimum log length: 12 feet.

Small end merchantable diameter limit: 6.00 inches.

19.00 skyline-road changes are required on the harvest unit.

The average skyline road services 0.73 acres.

Skyline-road change time: 1.15 hours.

The stand contains 34230 board feet per acre (Scribner).

TURN STATISTICS

	Mean	Std dev	Minimum	Maximum
Weight (pounds)	6909.41	3232.55	727.01	14377.02
Volume (cu ft)	138.19	64.65	14.54	287.54
Volume (bd ft)	701.10	403.27	31.00	1745.00
Number of logs	3.39	.92	1.00	4.00
Cycle time (min)	6.45	.39	5.67	7.41

Cycle times determined using user selected regression equations.

DISTRIBUTION OF TURN WEIGHTS

Weight per turn (pounds)		Relative frequency
1 - 1500	***	.0526
1501 - 3000		.0000
3001 - 4500	*****	.1579
4501 - 6000	*****	.2105
6001 - 7500	*****	.1579
7501 - 9000	*****	.1842
9001 - 10500	*****	.1053
10501 - 12000	*	.0263
12001 - 13500	***	.0526
13501 - 15000	***	.0526

Figure 3—Yarding summary for SIMYAR, example 1.

SPEARFISH SALE: UNIT 3 1 May 1986

DISTRIBUTION OF LOGS PER TURN

Number of logs per turn		Relative frequency
1	*	.0263
2	*****	.2105
3	*****	.1053
4	*****	.6579

DISTRIBUTION OF CYCLE TIMES

Time per turn (min)		Relative frequency
0.00 - 0.74		.0000
0.75 - 1.48		.0000
1.49 - 2.22		.0000
2.23 - 2.96		.0000
2.97 - 3.70		.0000
3.71 - 4.44		.0000
4.45 - 5.18		.0000
5.19 - 5.93	*****	.1316
5.94 - 6.67	*****	.5526
6.68 - 7.41	*****	.3158

UNIT SUMMARY

Unit area:	13.80 acres
Number of pieces yarded:	2451.00
Number of turns:	722.00
Total yarding time:	77 hours 38 minutes
Total yarded volume:	997.72 cunits
	506.20 M board feet

YARDING COST

Total yarding cost:	\$ 21044.66
Yarding cost:	\$ 21.09 /cunit
	\$ 41.57 /MBF

.....

Step 1-53

YARDING		ECHO		STAND			NEXT
SUMMARY		CHECK		SUMMARY			MENU

Softkey input: *ECHO*
CHECK

comment: The echo check shown in figure 4, which lists all parameters used for the run, will be printed.

SPEARFISH SALE: UNIT 3		1 May 1986	
HARVEST-EQUIPMENT SPECIFICATIONS			
11--Type of system: SKAGIT BU-90: LIVE SKYLINE			
12--Average payload: 15000.00 pounds			
13--Number of chokers: 4.00			
14--Choker length: 30.0 feet			
15--Machine rate: \$ 203.86			
16--Skyline-road change time: 1.15 hours			
17--Moving cost: \$ 1000.00			
18--Preferred log length: 40.00 feet			
19--Minimum log length: 12.00 feet			
HARVEST-UNIT GEOMETRY			
21--Skyline-road geometry: TRAPEZOID WITH YARDER OUTSIDE THE UNIT			
22--External yarding distance: 787.53 feet			
23--Maximum lateral yarding distance: 42.39 feet			
24--Average chordslope: 28.00 percent			
25--Number of skyline roads on the setting: 19.00			
26--Average groundslope: 35.00 percent			
27--Number of choker setters: 2.00			
TIMBER-STAND CHARACTERISTICS			
31--Wood density: 50.00 lb/cu ft			
32--Upper diameter limit: 6.00 inches			
33--Felling angle: 90.00 degrees			
34--Randomness factor: 1.00			
35--Stand name: CARBON RIVER: MT. BAKER-SNOQ. NF			
GENERAL INFORMATION			
41--Run name: SPEARFISH SALE: UNIT 3			

Figure 4—Echo check for SIMYAR, example 1.

.....

Step 1-54

YARDING		ECHO		STAND			NEXT
SUMMARY		CHECK		SUMMARY			MENU

Softkey Input: *STAND*
SUMMARY

comment: The stand summary shown in figure 5 will be printed.

SPEARFISH SALE: UNIT 3 1 May 1986

STAND SUMMARY

Diameter- class midpoint	Number of trees per acre	Volume per acre on average setting: Per diameter class		Volume per acre on average setting: Cumulative volume	
		Standing volume	Yarded volume	Standing volume	Yarded volume
inches		bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)	bd ft (cu ft)
12.00	4.08	564 (172.78)	547 (153.13)	564 (172.78)	547 (153.13)
14.00	4.85	2815 (759.43)	1209 (309.84)	3379 (932.20)	1756 (462.98)
16.00	14.15	0 (0.00)	2711 (631.75)	3379 (932.10)	4467 (1094.73)
18.00	7.40	1920 (435.16)	1866 (390.21)	5299 (1367.36)	6333 (1484.94)
20.00	3.44	5835 (1246.82)	2299 (487.90)	11134 (2614.18)	8633 (1972.84)
22.00	9.56	3537 (719.78)	5503 (1120.60)	14671 (3333.96)	14136 (3093.44)
24.00	10.84	0 (0.00)	4877 (945.94)	14671 (3333.96)	19013 (4039.39)
26.00	7.14	5724 (1079.72)	4731 (866.73)	20395 (4413.68)	23744 (4906.11)
28.00	3.19	0 (0.00)	2149 (426.96)	20395 (4413.68)	25892 (5333.07)
30.00	1.91	3382 (604.12)	3957 (719.13)	23777 (5017.80)	29850 (6052.20)
32.00	.89	2014 (351.77)	2082 (355.77)	25791 (5369.57)	31932 (6407.97)
34.00	0	0 (0.00)	0 (0.00)	25791 (5369.57)	31932 (6407.97)
36.00	.51	5436 (917.86)	4737 (741.36)	31227 (6287.43)	36668 (7149.33)
Total	67.96			31227 (6287.43)	36668 (7149.33)

Figure 5—Stand summary for SIMYAR, example 1.

LOG LENGTHS

Diameter-class midpoint	Log no.									
	1	2	3	4	5	6	7	8	9	10
<u>Inches</u>										
12.0	30.9	12.8								
14.0	41.3	13.0								
16.0	41.3	22.2								
18.0	41.3	30.3								
20.0	41.3	37.2								
22.0	41.3	30.9	12.9							
24.0	41.3	35.1	14.3							
26.0	41.3	41.3	13.5							
28.0	41.3	41.3	17.8							
30.0	41.3	41.3	22.0							
32.0	41.3	41.3	26.0							
34.0	41.3	41.3	29.1							
36.0	41.3	41.3	32.1							

.....

Step 1-55

YARDING SUMMARY		ECHO CHECK		STAND SUMMARY			NEXT MENU
--------------------	--	---------------	--	------------------	--	--	--------------

**Softkey Input: NEXT
MENU**

.....

Step 1-56

MODIFY PARAMETERS AND RUN AGAIN	DIGITIZE A NEW HARVEST UNIT	LOAD A DIFFERENT PLANS PROGRAM		QUIT
------------------------------------	--------------------------------	-----------------------------------	--	------

**Softkey Input: DIGITIZE A NEW
HARVEST UNIT**

EXAMPLE 2: SIMULATION OF A MOBILE YARDING CRANE.

The planner wants to estimate yarding cost and productivity for part of a running-skyline unit, labeled SPEARFISH SALE: UNIT 7, adjacent to road 1520 on figure 1.

Example 2 begins where example 1 ended.

.....

Step 2-1

ENTER STAND DESCRIPTIONS	ENTER REGRESSION EQUATIONS	CONTINUE WITH YARDING SIMULATION	LOAD A DIFFERENT PLANS PROGRAM
-----------------------------	-------------------------------	-------------------------------------	-----------------------------------

**Softkey Input: CONTINUE WITH
YARDING SIMULATION**

.....

Step 2-2

WILL THE UNIT BE YARDED TO A SINGLE LANDING OR TO MULTIPLE LANDINGS
BY MOBILE YARDING CRANES?

SINGLE LANDING		MULTIPLE LANDINGS
-------------------	--	----------------------

**Softkey Input: MULTIPLE
LANDINGS**

.....

Step 2-3

TRACE THE UNIT BOUNDARY.
BEGIN BY PRESSING ANY CURSOR BUTTON.

CAUTION:
START TRACING ALONG THE SIDES OF THE UNIT.
DO NOT START TRACING BETWEEN THE FIRST AND LAST LANDINGS
OR THE FIRST AND LAST TAILHOLDS.

Digitizer Input: *The CRT shows the DTM boundary and the current position of the digitizer's cursor. Center the crosshairs of the cursor on the * along the boundary of unit 7 and press any cursor button. Trace the unit boundary. When you reach the *, the computer will beep to indicate boundary closure.*

Step 2-4

DIGITIZE THE FIRST LANDING FOR THIS UNIT

Digitizer Input: Center the crosshairs of the cursor on landing 1 and press any cursor button.

Step 2-5

DIGITIZE THE LAST LANDING FOR THIS UNIT

Digitizer Input: Center the crosshairs of the cursor on landing 2 and press any cursor button.

Step 2-6

DIGITIZE THE FIRST TAILHOLD FOR THIS UNIT

Digitizer Input: Center the crosshairs of the cursor on tailhold 1 along the unit boundary and press any cursor button.

Step 2- 7

DIGITIZE THE LAST TAILHOLD FOR THIS UNIT

Digitizer Input: Center the crosshairs of the cursor on tailhold 2 along the unit boundary and press any Cursor button.

Step 2-8

ENTER THE DESIRED SKYLINE-ROAD SPACING IN FEET

Keyboard Input: 120

Step 2-9

DO YOU WANT THE AVERAGE PAYLOAD CALCULATED (Y OR N)?

Keyboard Input: Y

.....

Step 2-10

<i>LIVE SKYLINE</i>		<i>RUNNING SKYLINE</i>		<i>STANDING SKYLINE</i>
-------------------------	--	----------------------------	--	-----------------------------

**Softkey Input: *RUNNING
SKYLINE***

.....

Step 2-11

- 1— CARRIAGE WEIGHT (POUNDS).....
- 2— MINIMUM REQUIRED GROUND CLEARANCE (FEET).....
- 3— TOWER HEIGHT (FEET).....
- 4— TAILHOLD HEIGHT (FEET).....
- 5— ALLOWABLE HAULBACK TENSION (POUNDS).
- 6— HAULBACK-LINE WEIGHT (LB/FT).....
- 7— MAINLINE OR COMBINED MAIN AND SLACKPULLING WEIGHT(LB/FT).....

HOW MUCH DOES THE CARRIAGE WEIGH IN POUNDS?

Keyboard input: 500

.....

Step 2-12

WHAT IS THE MINIMUM REQUIRED GROUND CLEARANCE FOR THE CARRIAGE IN FEET?

Keyboard input: 10

.....

Step 2-13

HOW TALL IS THE TOWER IN FEET?

Keyboard Input: 50

.....

Step 2-14

HOW TALL IS THE TAILHOLD IN FEET?

Keyboard Input: 10

.....

Step 2-15

WHAT IS THE ALLOWABLE HAULBACK TENSION IN POUNDS?

Keyboard Input: 26500

.....

Step 2-16

HOW MUCH DOES THE HAULBACK LINE WEIGH IN POUNDS PER FOOT?

Keyboard Input: 1.42

.....

Step 2-17

MAINLINE (GRABINSKY) OR COMBINED MAIN AND SLACKPULLING WEIGHT (LB/FT)?

Keyboard Input: 2.84

.....

Step 2-18

ENTER THE NUMBER OF THE ITEM YOU WOULD LIKE TO CHANGE (RETURN IF DONE)

Keyboard Input: 4

.....

Step 2-19

HOW TALL IS THE TAILHOLD IN FEET?

Keyboard Input: 20

.....

Step 2-20

ENTER THE NUMBER OF THE ITEM YOU WOULD LIKE TO CHANGE (RETURN IF DONE)

Keyboard Input: Press RETURN

comment: The computer will lay out skyline roads and determine average setting parameters. Then the summary shown in figure 6 will be printed.

SIMYAR		VERSION HP9020--1.10	10 Mar 1987
SKYLINE-ROAD NUMBER	AREA	PAYLOAD	
	<u>Acres</u>	<u>Pounds</u>	
1	3.28	11641	
2	3.28	15406	
3	3.31	20896	
4	3.40	20764	
5	3.56	13938	
6	3.83	17577	
7	4.06	12905	
8	3.57	13705	
9	3.01	9820	

Figure 6—Skyline-road summary for SIMYAR, example 2.

.....
Step 2-21

DESIGN IS ACCEPTABLE CONTINUE		DESIGN UNACCEPTABLE LET ME CHANGE IT
----------------------------------	--	---

**Softkey Input: DESIGN IS ACCEPTABLE
CONTINUE**

comment: The layout summary shown in figure 7 will be printed.

.....
Step 2-22

WHAT IS THE RUN NAME?

Keyboard Input: SPEARFISH SALE: UNIT 7

.....
Step 2.23

WHAT TYPE OF YARDING SYSTEM WOULD YOU LIKE TO USE?

1—SKAGIT GT-3: RUNNING SKYLINE

2—SKAGIT BU-90: LIVE SKYLINE

ENTER THE NUMBER TO THE LEFT OF THE DESIRED SYSTEM

Keyboard Input: 1

AREA = 31.31 ACRES
AYD = 748.08 FEET
LAT AYD = 26.50 FEET
SLOPE AYD = 814.31 FEET
AVERAGE SLOPE = 43 PERCENT
AVERAGE PAYLOAD = 15217 POUNDS

** LAYOUT NOT DRAWN TO MAP SCALE **

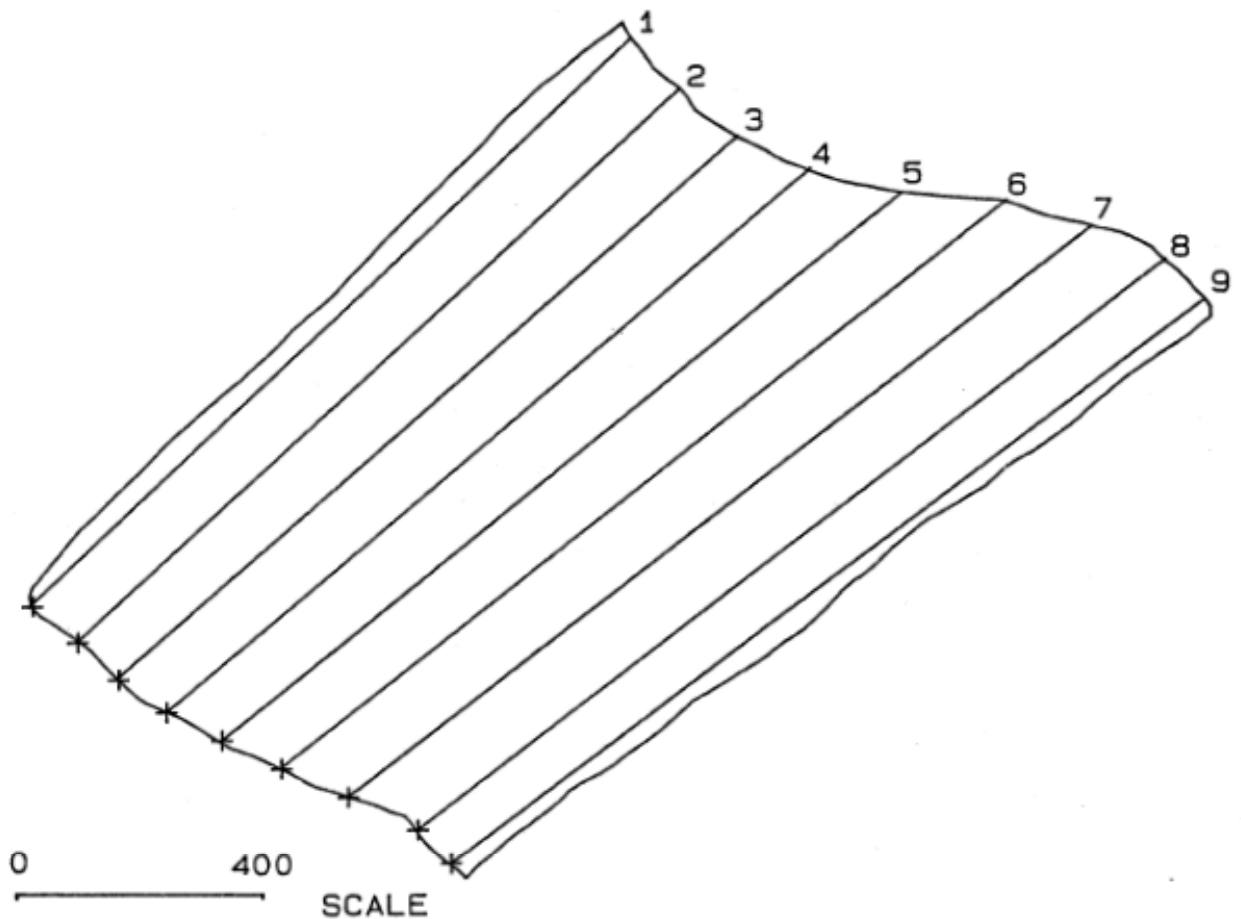


Figure 7—Layout summary for SIMYAR, example 2.

.....

Step 2-24

HOW MANY CHOKERS ARE BEING USED? (A MAXIMUM OF 8 CHOKERS CAN BE USED)

Keyboard Input: 4

.....

Step 2-25

HOW LONG ARE THE CHOKERS (FEET)?

Keyboard Input: 24

.....

Step 2-26

WHAT IS THE OPERATING COST PER HOUR FOR THE YARDING SYSTEM (MACHINE RATE)?

Keyboard Input: 176.00

.....

Step 2-27

HOW LONG DOES IT TAKE TO MOVE EQUIPMENT BETWEEN SKYLINE ROADS (HOURS)?

Keyboard Input: 0.75

comment: A setting change involves moving the yarder, the tailhold, or both for mobile yarding systems.

.....

Step 2-28

WHAT IS THE MOVING COST FOR THE SYSTEM (DOLLARS)?

Keyboard Input: 500

.....

Step 2-29

THE PREFERRED LOG LENGTH SPECIFIES THE LENGTH OF THE LOG MOST COMMONLY CUT BY THE BUCKING ALGORITHM IN THE MODEL. THIS LENGTH SHOULD BE A MULTIPLE OF 2 FEET TO ENSURE THAT FINAL LOG LENGTHS WILL ALSO BE INCREMENTS OF 2 FEET. A TRIM ALLOWANCE OF 6 INCHES PER 16 FEET OF LOG LENGTH WILL BE ADDED.

WHAT IS THE PREFERRED LOG LENGTH (FEET)?

Keyboard Input: 32

.....

Step 2-30

THE MINIMUM LOG LENGTH TO BE CUT IS THE LENGTH OF THE SHORTEST LOG THAT WILL BE CUT BY THE BUCKING ALGORITHM IN THE MODEL. THIS LENGTH SHOULD BE A MULTIPLE OF 2 FEET TO ENSURE THAT FINAL LOG LENGTHS WILL ALSO BE INCREMENTS OF 2 FEET. A TRIM ALLOWANCE OF 6 INCHES PER 16 FEET OF LOG LENGTH WILL BE ADDED.

Keyboard Input: 12

.....

Step 2-31

WHAT IS THE DENSITY OF THE WOOD BEING HARVESTED (LB/FT³)?

Keyboard Input: 50

.....

Step 2-32

WHAT IS THE MINIMUM MERCHANTABLE TOP DIAMETER LIMIT (INCHES)?

Keyboard Input: 6

.....

Step 2-33

THE FOLLOWING STANDS ARE AVAILABLE:

1—CARBON RIVER: MT. BAKER-SNOQ. NF

ENTER THE NUMBER TO THE LEFT OF THE DESIRED STAND

Keyboard Input: 1

.....

Step 2-34

THE NAME OF THE SELECTED STAND IS "CARBON RIVER: MT. BAKER-SNOQ. NF:" THIS STAND CONTAINS A STANDING VOLUME OF 34230 BOARD FEET PER ACRE (SCRIBNER) TO A 6-INCH TOP.

IS THIS THE STAND YOU WANT TO USE? (Y OR N)

Keyboard input: Y

Step 2-35

DIAMETER-CLASS MIDPOINT	NUMBER OF TREES PER ACRE	TOTAL TREE HEIGHT (FEET)
12	3.97	85.0
14	3.74	93.0
16	13.22	100.0
18	7.43	106.0
20	3.66	111.0
22	10.10	116.0
24	11.97	120.0
26	6.48	124.0
28	3.76	127.0
30	1.62	130.0
32	1.44	133.0
34	0	135.0
36	.57	137.0
SPEARFISH SALE:		UNIT 7
		1 May 1986

HARVEST-EQUIPMENT SPECIFICATIONS

- 11—TYPE OF SYSTEM: SKAGIT GT-3: RUNNING SKYLINE
- * 12—AVERAGE PAYLOAD: 15216.86 POUNDS
- 13—NUMBER OF CHOKERS: 4
- 14—CHOKER LENGTH: 24 FEET
- 15—MACHINE RATE: \$176
- 16—SKYLINE-ROAD CHANGE TIME: 0.75 HOURS
- 17—MOVING COST: \$500
- 18—PREFERRED LOG LENGTH: 32 FEET
- 19—MINIMUM LOG LENGTH: 12 FEET

HARVEST-UNIT GEOMETRY

- +21—SKYLINE-ROAD GEOMETRY: TRAPEZOID WITH YARDER ON BOUNDARY
- +22—EXTERNAL YARDING DISTANCE: 1437 FEET
- +23—MAXIMUM LATERAL YARDING DISTANCE: 59 FEET
- +24—AVERAGE CHORDSLOPE: 43 PERCENT
- +25—NUMBER OF SKYLINE ROADS ON THE UNIT: 9
- +26—AVERAGE GROUNDSLOPE: 68.8 PERCENT
- * 27—NUMBER OF CHOKER SETTERS: 2

TIMBER-STAND CHARACTERISTICS

- 31—WOOD DENSITY: 50 LB/FT³
- 32—UPPER DIAMETER LIMIT: 6 INCHES
- * 33—FELLNG ANGLE: 90°
- * 34—RANDOMNESS FACTOR: 1
- 35—STAND NAME: CARBON RIVER: MT. BAKER-SNOQ. NF

GENERAL INFORMATION

- 41—RUNNAME: SPEARFISH SALE: UNIT7

* PRESET VALUE USED FOR THIS PARAMETER

+PARAMETER CANNOT BE CHANGED WITHOUT RESTARTING THE MODEL

CHANGE SOME PARAMETERS		CHANGE ALL PARAMETERS		CONTINUE WITH THE SIMULATION
---------------------------	--	--------------------------	--	---------------------------------

**Softkey Input: CONTINUE WITH
THE SIMULATION**

comment: Values for some parameters may differ slightly from those printed above.

.....
Step 2-36

YARDING SUMMARY		ECHO CHECK		STAND SUMMARY			NEXT MENU
--------------------	--	---------------	--	------------------	--	--	--------------

Softkey Input: YARDING
SUMMARY

comment: Yarding activities will be simulated and various messages will be displayed. Yarding simulation requires about 45 seconds. The yarding summary shown in figure 8 will be printed.

.....
Step 2-37

YARDING SUMMARY		ECHO CHECK		STAND SUMMARY			NEXT MENU
--------------------	--	---------------	--	------------------	--	--	--------------

Softkey Input: NEXT
MENU

.....
Step 2-38

MODIFY PARAMETERS AND RUN AGAIN	DIGITIZE A NEW HARVEST UNIT	LOAD A DIFFERENT PLANS PROGRAM		QUIT
------------------------------------	--------------------------------	-----------------------------------	--	------

Softkey Input: LOAD A DIFFERENT
PLANS PROGRAM

.....
Step 2-39

SKYMOBILE	SKYTOWER	HIGHLEAD	ROUTES	SLOPE	VISUAL	SIMYAR	NEXT MENU
-----------	----------	----------	--------	-------	--------	--------	--------------

comment: Make your program selection from the softkey menu.

SPEARFISH SALE: UNIT 7 10 Mar 1987

SPEARFISH SALE: UNIT 7 10 Mar 1987

Type of system: SKAGIT GT-3: RUNNING SKYLINE

Operating cost per hour: \$ 176.00.

Set up cost for the logging system: \$ 500.00.

Maximum slope yarding distance: 1436.76 feet.

Maximum lateral yarding distance: 59.27 feet.

Average system payload: 15216.86 pounds.

Preferred log length: 32.00 feet.

Minimum log length: 12.00 feet.

Small end merchantable diameter limit: 6.00 inches.

9.00 skyline-road changes are required on the harvest unit.

The average skyline road services 3.48 acres.

Skyline-road change time: 0.75 hours.

The stand contains 34230 board feet per acre (Scribner).

DISTRIBUTION OF LOGS PER TURN

Number of logs per turn	Relative frequency
1	.0000
2	.1289
3	.3299
4	.5361

DISTRIBUTION OF CYCLE TIMES

Time per turn (min)	Relative frequency
0.00 - 1.38	.0000
1.39 - 2.77	.0000
2.78 - 4.15	.0103
4.16 - 5.53	.1031
5.54 - 6.92	.2577
6.93 - 8.30	.2732
8.31 - 9.68	.2216
9.69 - 11.06	.1031
11.07 - 12.45	.0103
12.46 - 13.83	.0155

TURN STATISTICS

	Mean	Std dev	Minimum	Maximum
Weight (pounds)	6124.41	2496.10	540.01	13311.03
Volume (cu ft)	122.49	49.92	10.80	266.22
Volume (bd ft)	610.44	305.33	22.82	1504.09
Number of logs	3.40	.73	1.00	4.00
Cycle time (min)	7.69	1.83	3.89	13.83

Cycle times determined using user-selected regression equations.

DISTRIBUTION OF TURN WEIGHTS

Weight per turn (pounds)	Relative frequency
1 - 1521	.0206
1522 - 3042	.0979
3043 - 4563	.1546
4564 - 6084	.2371
6085 - 7605	.2320
7606 - 9126	.1340
9127 - 10647	.0825
10648 - 12168	.0206
12169 - 13689	.0206
13690 - 15210	.0000

UNIT SUMMARY

Unit area:	31.31 acres
Number of pieces yarded:	5931.00
Number of turns:	1746.00
Total yarding time:	223 hours 43 minutes
Total yarded volume:	2138.64 cunits
	1065.83 M board feet

YARDING COST

Total yarding cost:	\$ 40931.56
Yarding cost:	\$ 19.14 /cunit
	\$ 38.40 /MBF

Figure 8—Yarding summary for SIMYAR, example 2.



November 1987

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