PRODUCTION AND COST ANALYSIS OF A SKYLINE CABLE LOGGING SYSTEM OPERATING IN AN UNEVEN-AGE MANAGEMENT PRESCRIPTION

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"Unless the Lord builds the house, he who builds labors in vain." -King Solomon

ABSTRACT OF THE PAPER OF

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Title: Production and Cost Analysis of a Skyline Cable Yarding System Operating in an Uneven-Age Management Prescription

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Loren D. Kellogg

Forest managers in recent years have begun to re-examine the possibilities of using uneven-age silvicultural systems in the Oregon Coast Range. This increasing interest is being driven by a variety of forest resource management concerns, including wildlife habitat diversity, visual aesthetics, and long-term sustained yield. In an effort to begin systematic exploration of coastal uneven-age silvicultural techniques, Oregon State University (OSU) researchers have established a demonstration site at Forest Peak on OSU's Dunn Forest.

This case study involving a single treatment at a single site reports on the design, performance, and cost of the skyline logging operation during September and October 1992 which was designed to achieve the goals of an uneven-age management prescription prepared by OSU silvicultural and wildlife specialists. The operation harvested 13.9 MBF of 23-inch average dbh Douglas-fir and grand fir timber.

The study tracked the time spent in planning and laying out the logging system. Field and office planning and layout

procedures took 93.75 hours to complete at a cost of $6.47/MBF.

The project also involved detailed time studies and shift-level analyses of both the felling/bucking and the yarding phases of the logging operation. A two-man felling crew produced 6.44 MBF/Hr at a cost of $10.44/MBF. Cutting cycle time averaged 9.22 minutes per tree, with number of logs per tree, cutting method (wedges or no wedges), percent ground slope, and base diameter the most influential factors affecting cutting cycle time.

The six-man yarding crew using a Thunderbird TTY50 yarder and small Danebo MSP carriage yarded 4.7 MBF/Hr at a cost of $58.51/MBF. Yarding cycle time averaged 5.73 minutes per turn, with corridor yarding distance, lateral yarding distance, choker setting method (pre-set or hot-set), and number of logs per turn the most influential factors affecting yrding cycle time.

The six-man crew plus the hook tender averaged 1.82 hours for each change of yarding corridors. Corridor changes involved moving all rigging from one corridor to the next and repositioning the yarder if necessary. The hook tender alone spent an additional 1.31 hours per corridor pre-rigging tail trees, anchors, etc.

Total logging cost including planning and layout, felling and bucking, yarding, loading, and equipment move-in was $104.03/MBF.

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INTRODUCTION

Forest managers in recent years have begun to re-examine the possibilities of using uneven-age silvicultural systems in the Oregon Coast Range. For example, the currently proposed MacDonald/Dunn Forest Plan (OSU 1992) allocates approximately one-third of the Forest's timber management area to uneven-age prescriptions. Also, the USDA Forest Service's current emphasis on Ecosystem Management is bringing uneven-age management into increasingly serious consideration. This increasing interest is being driven by a variety of forest resource management concerns, including wildlife habitat diversity, visual aesthetics, and long-term sustained yield. In an effort to begin systematic exploration of coastal uneven-age silvicultural techniques, Oregon State University (OSU) researchers have established a demonstration site at Forest Peak on OSU's Dunn Forest.

PURPOSE OF THE STUDY

While uneven-age silviculture is an established practice in other locations, little has been attempted in the Coast Range. Fire history of the coastal region has resulted in an almost exclusively even-age natural forest, so there are few natural examples of uneven-age structure. Economics, terrain, and technology have limited most Coast Range timber management to clearcut harvesting and subsequent even-age plantation management. In order to make informed decisions about suitable silvicultural systems for achieving a widening variety of objectives, planners and managers must be able to determine logging feasibility and costs.

This case study involving a single treatment at a single site reports on the design, performance, and cost of the skyline logging operation during September and October 1992 which was designed to achieve the goals of an uneven-age management prescription prepared by OSU silvicultural and wildlife specialists.

Specific goals of the study are:

- Determine prescription-specific harvest unit planning and layout requirements and costs for the current entry.
- Determine cycle times, detailed time elements of each cycle, predictive delay-free cycle time equations, volume production rates, and costs for the following components of the harvesting operation:
  - felling and bucking
  - yarding
  - loading
  - yarding corridor changes
- Compare the production and cost results of this study with results of other studies in similar stand conditions using similar logging systems.

SITE DESCRIPTION

Site Physical Conditions

The 22.8-acre study site is located within OSU's Dunn Forest in section 22, NW 1/4, T.10 S., R.5 W., Willamette baseline and meridian, at the crest of Forest Peak on the Willamette River Valley fringe on the eastern slope of the Oregon Coast Range. Elevation ranges from 860 to 1480 feet, averaging 1170 feet. Aspect ranges from southeast to west, averaging 201 degrees azimuth. Slopes range from 25 to 47 percent, averaging 38 percent. Soil types are 41 percent Price, 31 percent Ritner, 21 percent Witzel, and 7 percent others. Rainfall averages approximately 45 inches per year.

The combination of south to west aspect and the position on a well-drained upper slope make this a "dry" site for the Coast Range. Understory vegetation consists primarily of Oregon-grape (Berberis nervosa), poison-oak (Ruus parviflorus), vinemaple (Acer circunatum), salal (Gaultheria shallon), several blackberries (Rubus spp.), and various grasses and herbs. This plant association is typical of sites with high moisture stress during dry periods. It is considered to be low competition with conifer seedlings.

Forest Peak is a prominent local landmark, and the study site is clearly visible from surrounding rural roads and neighborhoods.

Stand History and Structure

The stand of 75 percent Douglas-fir (Pseudotsuga menzeisii), 14 percent grand fir (Abies grandis), and 11 percent Oregon white oak (Quercus garryanna) and bigleaf maple (Acer macrophylla) had three basic components: 1) 1-2 trees per acre (TPA) of large Douglas-fir "wolf" trees 200 years of age or more and 40 inches diameter at breast height (dbh) or greater; 2) 60 TPA before harvest of 120-year-old Douglas-fir and grand fir with mean dbh of 22.7 inches; 3) 699 TPA before harvest of Douglas-fir, grand fir, and bigleaf maple less than 8 inches dbh.

The largest component is the 120-year-old age class with 60 TPA and mean dbh of 22.7 inches before the cable entry. The origin of this stand propabaly dates to the period in history when native peoples and early Willamette Valley settlers ended their practice of regularly broadcast burning the Coast Range foothills. This stand component was naturally seeded by the few large parent trees which still remain scattered throughout the stand.

A commercial thinning in 1968 removed approximately 12 MBF/acre. The logging was accomplished using a crawler tractor on designated skid trails. This thinning opened the canopy and exposed mineral soil by scarification, allowing direct sunlight to reach the understory and forest floor and creating the bare soil spots needed for natural Douglas-fir regeneration.

The dry site/low competition conditions coupled with the thinning "site preparation" in 1968 resulted in the establishment of the naturally-regenereted understory of mixed Douglas-fir, grand fir, and bigleaf maple at 699 TPA less than 8 inches dbh before harvest in 1992.

This type of understory density is not common in the Coast Range. Most of the Coast Range forest canopy is closed, preventing widespread establishment of even shade-tolerant tree species. In places where the canopy has opened due to catastrophic events or management operations, understory vegetation quickly dominates most sites. Forest Peak was chosen for an uneven-age management demonstration because it typifies the limited areas in the Coast Range where site-specific conditions could allow establishment of a multi-storied conifer stand structure.

Silvicultural Treatment

The objective of the uneven-age management prescription is to establish a conifer stand with a distribution of size classes from seedling to mature in appropriate proportions. Since the stand was initially an even-age structure, the stand will require several harvest entries - each entry removing a portion of the harvestable stems per acre - before reaching the future desired multi-story structure. The 1968 tractor thinning was actually the first entry of this conversion period, although at the time there was no known intention of managing on an uneven-age basis. The cable harvest operation of September/October 1992 which was the subject of this study constituted the second entry of the conversion period.

The silvicultural prescription originally called for removing approximately 40 percent of the stems from the 120-year-old overstory and protecting the 699 TPA understory from damage as much as possible. Table 1 describes actual stand conditions before and after the harvest operation. Complete pre- and post-harvest inventories, including growth information, are included in Appendix B. The increase in post-harvest hardwood 0"-4" TPA is most likely due to sampling error; pre- and post-harvest inventories were taken only one year apart. The decrease in 4"-8" conifers was due mostly to timber felling damage and clearing.

Table 1. Pre- and Post-Harvest Stand Conditions by Diameter Class and Species, from OSU stand exams.

	Trees/Acre.............			Basal Area/Acre
	0"-4"	4"-8"	>8"	Sq.Ft., >8" dbh
Pre-Harvest, 1991				
D-fir	275	6	45	196
grand fir	161	40	8	6
hardwoods	206	12	7	4
TOTAL	642	57	60	206
Post-Harvest, 1992				
D-fir	232	0	27	128
grand fir	92	29	7	4
hardwoods	252	12	7	4
TOTAL	573	40	43	136
Change	-11%	-30%	-28%	-34%

LITERATURE REVIEW

Logging Methods

There is little published literature documenting cable logging systems in uneven-age prescriptions. However, much research has been recorded in shelterwood cable logging, using cable techniques which are applicable to this project. The Forest Peak stand being managed for uneven-age structure was essentially a two-story stand at the beginning of this study. It was a thinned mature even-age stand with an advanced regeneration understory. The cable logging entry which was the subject of this study resembled certain elements of both a shelterwood initial cut and an overstory removal.

Shelterwood management is an even-age silvicultural system with harvest and regeneration accomplished in a two-stage (or sometimes three-stage) process. The first stage, called the initial or shelterwood cut, removes most of the stems in a stand. Approximately 8-15 trees per acre are left standing to provide shading and sometimes a seed source for the even-age stand being regenerated. Seedlings are planted or seeded naturally beneath the shelterwood overstory. When the regeneration becomes established the second stage, or overstory removal, is accomplished. This stage removes any remaining stems not required as permanent leave trees.

Shelterwood management requires protection of residual crop trees during the initial cut and protection of regeneration during the overstory removal. Uneven-age management requires protection of both the next cycle's crop trees and regeneration in the same entry.

Several previous studies have described mechanical methods for protecting the residual stand in shelterwood operations using cable systems. These techniques, which are also applicable to protecting residual trees in an uneven-age prescription, are summarized below.

<u>Logging Planning</u>

Because protection of the residual stand is a major objective of uneven-age logging, planners must consider how many trees can be felled at each entry while maintaining adequate undamaged stocking in the desired size classes. Based on Paine and Hann's (1982) work with crown dimensions, Mann (1985b) simulated how much ground surface area felled trees of various sizes occupy. For example, 14 trees per acre (TPA) of 30 inch diameter at breast height (dbh), 150 foot height, and 44 foot crown width occupy 60 percent of the ground surface area when felled. While more research will be needed to better determine how much stand damage is caused by various cut/leave intensities, Mann's simulation provides a reference point for planning purposes.

In the same article, Mann pointed out the need for estimating the locations of future skyline corridors and leaving trees which can serve as lift or anchor trees. Trees used as tail spars or intermediate supports in the current entry may have weakened root systems and may die by the next entry. This means yarding corridor locations will potentially change to find healthy lift trees in the next entry. Logging planners must be sure silvicultural prescriptions and marking guides account for this logging requirement.

Residual Stand Damage

Logging damage to both existing regeneration and residual mature trees has been studied in various regions and forest types. Tesch, et al.(1986), working in a southern Oregon mixed Ponderosa pine/Douglas-fir shelterwood overstory removal, found 22 percent seedling mortality from felling and 28 percent mortality from cable yarding among seedlings surviving felling, or a total of 41 percent seedling mortality from logging operations. Tail lift trees were not used, resulting in some ground-lead yarding. The overstory consisted of approximately 20 TPA with average dbh of 24 inches. Seedling mortality was lowest in the 60-100 cm (23.6-39.3 inch) height range. Damage was highest directly within yarding corridors and adjacent to corridors with greater than 45 percent cross slope. Tesch recommended spacing yarding corridors as widely as possible, minimizing number of corridors per landing, and not yarding on corridors with greater than 45 percent cross slope.

Youngblood (1990) compared Alaska white spruce seedling damage from shelterwood overstory removal using a rubber-tired skidder and a skyline cable system. The overstory stand conditions were 28-56 cm (11-22 inch) dbh, 29-35 m (95-115 feet) height, and 10.3-12.7 ft^2 basal area. Cable corridors were 38 m (125 feet) apart with tail lift trees to improve deflection and log control. Cable yarding resulted in 15 percent mortality among seedlings, with the lowest mortality in the 70-90 cm (27.6-35.4 inch) height range. Ground skidding resulted in 45 percent mortality .

Benson and Gonsior (1981) measured damage to marked leave trees after an initial shelterwood cut in two Douglas-fir/western larch stands in Montana. Both running skyline and live skyline systems were used to yard the units. Stand 1 averaged 109 TPA greater than 7 inches (17.8 cm) dbh, and Stand 2 averaged 147 TPA greater than 7 inches (17.8 cm) dbh. Both units were leave-tree marked to retain half the volume of trees greater than 7 inches (17.8 cm) dbh. Four utilization standards were compared for differences in percent mortality and percent undamaged:

1) All umarked trees down to 5 inch (12.7 cm) dbh were cut. All material down to 8 feet long by 3 inches top diameter was yarded. Residue was broadcast burned.
2) Umarked trees down to 7 inch (17.8 cm) dbh were cut. Materials down to 6 inch top diameter were yarded. Residue was burned.
3) Unmarked trees down to 1 inch (2.5 cm) dbh were cut and removed. Residue was not burned.
4) Unmarked trees down to 7 inch (17.8 cm) dbh were cut. Materials down to 8 feet long by 3 inches top diameter were yarded. Residue was not burned.

After removal of approximately half the TPA and basal area in both stands, mortality and undamaged trees varied little between treatments within a Stand. In Stand 1, an average of 22 percent of marked leave trees were killed, while 40 percent were undamaged. In Stand 2, an average of 25 percent were killed, while 29 percent were undamaged. Average overall mortality was 23 percent, and average overall undamaged was 34 percent. Benson and Gonsior recommended accounting for expected mortality by marking enough leave trees to compensate for trees killed during felling and yarding.

Logging Methods Summary

The results of these studies reveal important information to be considered when developing both logging plans and silvicultural prescriptions for uneven-age management. Logging plans must provide for protection of the residual stand as much as possible as summarized by Mann (1985a):

- felling trees to lead
- spacing yarding corridors to minimize damage to residual trees, either by reducing lateral yarding distances for improved log control, or by increasing lateral yarding distances to reduce the number of main corridors. This decision is dependent upon site-specific conditions.
- positioning yarding corridors perpendicular to the contour; not yarding on steep (>45%) cross slopes

- using a carriage which can hold its position on the skyline during lateral inhaul and not starting corridor inhaul until the log has actually reached the corridor.
- providing at least single-end log suspension for better log control during yarding
- minimizing lateral cable deflection by using rub trees which are felled and yarded last
- minimizing the number of corridors per landing, using parallel settings if possible
- clearly communicating residual stand protection objectives to the logging operators.

Silvicultural prescriptions must provide means for arriving at the desired stand structure within the limitations of available logging technology. Factors to be considered in developing a prescription and marking guide are:

- compensating for anticipated logging damage and mortality to the residual stand - both seedlings and mature trees - when prescribing residual stand structure
- allowing sufficient numbers of leave trees in suitable locations for future tail spars and intermediate supports as necessary
- considering the impacts of residual stand structure on logging feasibility in the next cycle.

Logging Production and Cost Studies

While documentation of skyline logging systems operating in uneven-age prescriptions is rare, production and cost research in other partial-cut systems is not uncommon. Several pertinent studies have been published describing production and cost data collection and data analysis for a variety of skyline/partial-cut combinations.

Kellogg, Pilkerton, and Edwards (1991) examined skyline and ground skidding systems in three harvest prescriptions in mature Douglas-fir. The cutting prescriptions were clearcut, two-story even-aged (shelterwood), and half-acre group selection patch cuts. A Thunderbird TTY 50 tracked mobile yarder with a Danebo MSP mechanical slack-pulling carriage rigged in a standing skyline slackline configuration was used for cable yarding in this project. Skyline roads were rigged as single spans, with some requiring intermediate supports or tail trees.

Two types of data were collected:

- Logging planning and unit layout time for each management prescription type.
- Shift-level time and volume production data for felling and yarding for each management prescription type.

Logging planning for clearcuts involved unit reconnaissance, flagging landings, surveying skyline ground profiles, performing payload analyses, marking leave trees, and preparing maps. Logging planning on the two-story and patch cut units involved more time than planning a clearcut, due to the increased time required to select and flag designated skyline corridors and lift trees, as well as preparing more detailed maps. Total planning and layout time was tracked for each prescription. Time results for each prescription were reported in man-hours per MBF volume removed and cost was reported in dollars per MBF removed. Both time and cost for the cable system were approximately six times higher for two-story and group selection than for clearcutting.

The felling and yarding time studies followed the shift-level model described in Olsen and Kellogg (1983), summarized in Appendix A. Felling crews consisted of ten cutters, each working equal time in all three prescriptions. Production and cost results for each prescription were reported in units of gross MBF felled per shift hour and dollars per MBF. Felling production was highest for group selection and lowest for two-story. Conversely, cost was lowest for group selection and highest for two-story.

Cable yarding crew consisted of eight men on the site. Production results were again reported in units of MBF volume per yarder shift hour, and costs were reported in units of dollars per MBF yarded. Two-story and group selection yarding production were approximately 80 percent of clearcut production. Costs were approximately 22 percent higher than clearcut.

Total cost figures for each prescription were also calculated, including layout, felling, and yarding. Total cost for both two-story and group selection were approximately 24 percent higher than clearcutting.

Edwards (1992) examined a skyline system operating in five different group selection prescriptions. The study was conducted in stands of approxiamtely 100-year-old Douglas-fir very similar to the stand being treated in the current Forest Peak study. For this project, a Thunderbird TMY 70 mobile yarder with a Danebo S-35 Drumlock mechanical slack-pulling carriage was rigged in a standing skyline with haulback configuration. The six prescriptions were:

1. Clearcut - served as a baseline prescription against which other treatments were compared.
2. Strip cuts removing approximately one-third of the unit area in parallel rectangular strips.
3. 0.5-acre patch cuts in fan settings removing one-third of the unit area in rectangular or polygonal patches.
4. 1.5-acre patch cuts in fan settings removing one-third of the unit area in rectangular or polygonal patches.
5. 2.5-acre wedge cuts in fan settings removing one-third of the unit area in rectangular or polygonal patches.
6. 0.5-acre patch cuts in parallel settings removing one-third of the unit area in rectangular or polygonal patches.

Three types of production data were collected: logging planning and layout time, shift-level time and volume production, and detailed stopwatch study information for felling, yarding, and cable road changes. A hand-held field data recorder with a commercial time study software package was used for collection of detailed time information.

Planning and layout results revealed large increases in time for all five alternative prescriptions. Planning and layout time was measured in units of hours per acre. Increased times above the baseline of 1.69 hours/acre for clearcut ranged from 362 percent for strip cuts to 690 percent for 0.5-acre patch cuts.

Felling results revealed only small differences in MBF production per hour and cost per MBF for all six treatments. Clearcut production was 4.5 MBF/hour and cost was $8.56/MBF. No treatment varied more than 3 percent from clearcut felling in either production or cost.

Yarding results similarly showed little difference among the six treatments. Clearcut yarding production was 7.2 MBF/hour and cost was $48.96/MBF. None of the alternative treatments varied more than 5 percent from this baseline.

Yarding corridor and landing change time results did reveal major differences in treatments. Clearcut results were:

Average corridor/road change time =	1.53 hours
No. changes per 25 acre unit =	12
Cost per road change ($/MBF) =	9.16

The highest average change times were 3.67 hours for the 0.5-acre parallel set patch cuts and 2.96 hours for the strip treatment. These parallel setting treatments required moving the yarder for each corridor change. The wedge treatment required only 1.72 hours per change, the lowest of the five alternatives.

While the clearcut change time was the lowest, the number of changes per unit area was the highest of all the treatments. Others required from 2 to 9 changes per unit area. The wedge prescription only required 2 road chages per 25 acres, resulting in a total cost of $4.36 per change, 52 percent below clearcutting. The 0.5-acre fan setting patch cuts cost 108 percent more than clearcuts.

Total volume production in units of MBF per hour was calculated for scheduled hours, including all road changes and delays. Clearcut production was 6.1 MBF/Hr. Highest production was on the wedge prescription, at 6.8 MBF/Hr, and lowest production was on the 0.5-are fan setting patch cuts, at 5.7 MBF/Hr.

Total costs ranged from a low of $63.58/MBF for clearcut to $80.11/MBF for 0.5-acre fan set patch cuts, a 26 percent difference. The wedge treatment was closest to clearcut at $65.71.

Both of the shift-level analyses reviewed here have applications for the current Forest Peak study. Both studies were conducted on OSU's McDonald Forest in stand conditions very similar to the stand treated at Forest Peak. The yarding equipment and crew size in Kellogg, Pilkerton, and Edwards (1991) were identical to those used at Forest Peak, making it possible to directly compare results of the two yarding studies. While the yarder and carriage used in Edwards 1992 study differed from Forest Peak, it would be possible to make an interesting comparison of relative production rates in the various management prescriptions.

LOGGING OPERATIONS OVERVIEW

Felling and Bucking

A complete logging plan, including profile analyses and payload analyses, is located in Appendix C. This section is a qualitative overview of the several phases of the logging operation which was the subject of this study.

The felling and bucking phase of the logging was accomplished by two cutters working together as a pair. The lead cutter, or feller, had primary responsibility for the felling of the trees. He determined which tree would be felled next and where each tree would be laid. He made most of the face cuts and back cuts. He also helped with a portion of the bucking and limbing. The second cutter, or bucker, assisted with the felling (placing wedges, spotting, etc.) but was primarily responsible for bucking and limbing the tree once it was on the ground. While the bucker was bucking the felled tree, the feller would usually select and move to the next tree to be felled and begin making his cuts. When the bucker finished bucking his tree into logs, he would proceed to the next tree to assist with the felling. Each cutter occaisionally took over the other's duties when there was a mechanical breakdown or the other cutter was occupied at another task.

Each cutter used a Stihl 064 chainsaw with a 36-inch bar. Each carried his own fuel and oil containers, basic tool kit, replacement chains, wedges, single-bit axe, and water.

The bucker kept daily records of the number of trees felled, number of logs bucked from each tree, and total shift hours worked for the crew of 2.

Yarding

Yarding was accomplished using a Thunderbird TTY-50 track-mounted mobile yarder. It was rigged in a standing skyline configuration with a haulback using a Danebo MSP (small model) mechanical slack-pulling carriage.

The yarding required seven full-time men plus occaisional visits by the company owner. The yarding crew consisted of the yarder operator and two chasers on the landing, and a rigging slinger and two choker setters in the brush.

The hook tender, the seventh crew member, only worked at pre-rigging yarding corridors and supervising road changes (moving the skyline and other rigging to the next corridor when one corridor was finished). Pre-rigging involved selecting and preparing tailholds for the skyline, rigging pre-selected tail trees with the necessary blocks and guylines, and rigging pre-selected intermediate support trees with blocks and guylines. Skyline tail holds were either stumps in adjacent units or heavy equipment (an old crawler tractor) when suitable stumps were not available. Because the cable system on this site required tail trees on all all but one corridor, and one corridor required an intermediate support, the hook tender worked full time at pre-rigging the next corridor for yarding. The original logging plan in Appendix C called for intermediate supports on corridors 9-11, but the loggers only used them on corridor 10.

Loading

The loader was a John Deere 892D-LC, a track-mounted, hydraulic heel-boom grapple loader. It was operated by a single crew member in addition to the seven men on the yarding crew. Because the yarding production was low in the partial cut with short roads and relatively frequent road changes, the loader could load trucks faster than the yarder could yard logs in. However, the loader operator had no other operational duties than to run the loader, even during idle periods. The operator did keep daily records of number of logs yarded, number of trucks loaded, and total crew shift hours for both the yarder and the loader.

STUDY METHODS

This study was intended to document the planning and implementation of a skyline logging entry in an uneven-age management prescription. Logging design, field layout, and logging operations were carried out as part of an actual timber sale process on OSU's Dunn Forest. Data was collected observationally as the various work phases progressed through their normal sequence. Because of the range of objectives of this study, data was collected and analyzed using a variety of methods. These methods are described below. All financial calculations were based on 1993 dollars.

Initial Entry Logging Planning and Layout

Selected components of the planning and layout phase of operations were tracked for the time spent in each activity. Activities selected for observation in this study were those which are common to all logging operations but potentially differ in quality or quantity from other management prescriptions. This information was used to determine sale prep time requirements and costs on this site with this prescription. Some activities, such as unit boundary layout or haul route design, were not unique to this treatment and were not tracked.

A daily log of planning and layout activities was kept which recorded the number of man hours spent in each of the individual categories. Because problems or changes did arise during logging operations, planning and layout activities continued to some extent throughout the project.

Plannning and layout activities selected for observation were:

- Field reconnaissance. This was considered to be general unit examination, note-taking, or similar field observations. Not included were any of the specific field tasks listed below. This phase was completed by the principal researcher, OSU faculty researchers, the OSU sale administrator, and two research assistants.
- Office Planning. This included map and inventory analysis, preparation of documents, conferences, and any other administrative or indoor activity directly related to this timber sale. Not included were activities related only to the study or any other activity which was not a part of the normal timber sale process. This phase was accomplished by the principal researcher.
- Ground Profile Surveying and Traversing. This included time spent in the field taking survey measurements. This phase was accomplished by the principl researcher and a technical assistant.
- Logging Plan Development. This included all profile and payload analyses, cable system design, landing and corridor design and location, and all other design procedures contributing to the "paper" logging plan. This was accomplished by the principal researcher.
- Landing and Yarding Corridor Layout. This included field

identification of landings, specific tail trees and/or anchors, taking any necessary measurements, and flagging the corridors from landing to tailhold. This phase was accomplished by the principal researcher.

- Tree Marking. This was the field time it took the crew to accomplish a cut-tree mark. This phase was accomplished by seven OSU faculty researchers, the OSU sale administrator, and the principal researcher.

Total planning and layout time was determined by summing the hours in each of the listed categories. Unit cost was calculated two ways - dollars per MBF and dollars per acre. Total cost was determined by multiplying total hours by total cost per hour. Unit costs were determined by dividing total cost by total volume from scale tickets and by dividing total cost by total unit acreage.

Logging System Performance, Production, and Costs

Tracking and reporting on the logging system involved several data collection and analysis methods. Five time studies were conducted: two tracked the detailed components of the felling/bucking and the yarding operations. Two shift-level analyses tracked daily equipment and personnel time for both the felling/bucking and the yarding operations. Another tracked gross time spent rigging the yarding corridors.

Volume production and costs were calculated for each operation, using data from scale tickets and data collected as described below.

Felling and Bucking Detailed Time Study.

Data from this time study was used to determine an average cutting cycle time for this project and to develop a predictive equation for delay-free cycle time with the given stand conditions and prescription.

The unit was felled by cutters working as a pair. The felling and bucking time study tracked the time the pair of cutters spent felling and bucking logs.

This operation was divided into its procedural components, and each component was timed to the nearest deciminute (100th minute) for each tree. Each cutter was tracked for the duration of the felling and bucking operation which lasted eight days. Three days of data collection were lost for a variety of reasons, including incorrectly recorded data, researchers' schedule conflicts, and an injury to the lead faller, forcing the other cutter to finish the unit alone. The lead faller was timed with a hand-held Husky Hunter field data recorder. The SIWORK3 time data collection program was used. The second cutter, or bucker, was timed by a second researcher with a stop watch and paper spreadsheet. The stopwatch was used because there was only one functional data recorder available. Timed components recorded were:

- Travel and Preparation. This was the time spent between the completion of bucking one tree to the beginning of felling the next tree. This included any brush clearing, sizing up, or felling of tress less than 4" diameter needed to fell the next tree. Time began when the cutter completed his final buck cut on one tree and headed for the next tree.

- Felling. Time began when the saw blade touched the tree to make the undercut or backcut. Time ended when the tree hit the ground. Felling trees less than 4" diameter was not timed.
- Bucking and Limbing. Time began when the tree hit the ground and ended when the cutter completed his final buck cut.
- Delays. Timed delays were recorded for:
  1. Mechanical delays such as saw breakdowns, bar or tuning adjustments, or fueling and oiling.
  2. Personal delays such as lunch or rest breaks.
  3. Procedural delays such as conferences with foreman or administrator, stopping to help with another task, bar hang-ups, etc.
  4. Planning delays. This was the time spent determining felling patterns, discussing how to proceed with a task, etc. This usually occured at the beginning of the day or the beginning of some new portion of the work. This did not include preparations for felling each individual tree.
  5. Other miscellaneous delays.

Other information collected for each tree was:

- Merchantable/Non-merchantable. Non-merchantable conifers were sometimes felled to clear corridors or to facilitate felling the merchantable tree. All hardwood trees were counted as non-merchantable. This was a 0/1 indicator variable with 0 = non-merchantable and 1 = merchantable. Felling any trees less than 4" diameter was recorded as travel/preparation time.
- Inside Bark Butt Diameter. Average of two diameter measurements taken at right angles to each other.
- Number of Logs Cut From Tree. Recorded for each cutter separately.
- Buck Cuts. Number of buck cuts for each cutter, including bucking out defects.
- Method. Denote which felling technique was used: 0 = no wedges and 1 = wedges.
- Slope. Percent slope at the base of the tree.
- Tree Lay Slope. This was the percent slope of the fallen tree from the stump in the direction of the fall. This variable was included as an attempt to determine whether the directional felling up or down the ground slope required in this partial cut had an effect on felling time.

Collected data were entered into a computer spreadsheet for analysis. Cycle time elements were determined for each cutter separately, and a crew time per tree was determined by averaging the individual time elements. For example, if feller felling time = 2.69 minutes and bucker felling time = 2.01 minutes, then averaged crew felling time = 2.35 minutes. Another way of describing this process is if each cutter spent 9 minutes total time per tree, then the averaged crew time per tree would be 9 minutes.

A predictive delay-free felling/bucking time equation was developed using a step-wise regression analysis procedure. This equation described travel, felling, and bucking time per tree as a function of site and operational characteristics: butt diameter, number of logs cut, number of buck cuts, felling method, percent ground slope, and percent log lay slope. Equations were developed for each cutter seperately, and a combined crew equation was developed by averaging the two individual equations.

Felling/Bucking Shift-Level Analysis

The cutting crew kept a daily record of their shift hours, number of trees felled, and number of logs cut per tree. This information was used to help determine production and costs for the operation. Tree production was determined by dividing the total number of trees on the shift-level forms by the total 2-man crew hours worked (2 men working 8 hours each = 8 crew hours). Volume production was determined by dividing the number of logs cut by the crew hours worked. Individual log volume was then determined from the scale tickets by dividing total volume scaled by total number of logs. Multiplying logs per hour by volume per log yielded volume per hour for the felling/bucking operation.

Yarding Detailed Time Study

The yarding time study separated the yarding operation into its procedural components, and each component was timed and recorded. Data was collected using the Husky Hunter field data recorder with the SIWORK3 time data collection program. Two workers were required to collect the necessary information. One worker followed the choker-setting crew to observe, while the second worker remained at the landing to observe and record data. The two were in contact by hand-held radio, so the one recording information knew when activities at the other end of the line began and ended. Timed components were:

- Outhaul. Time began when the carriage left the landing and ended at the carriage stop signal.
- Lateral Outhaul. Time began with the carriage stop signal and ended with the dropline stop signal.
- Hook. Time began with the dropline stop signal and ended with the dropline ahead signal.
- Lateral Inhaul. Time began with the dropline ahead signal and ended with the carriage ahead signal or when the turn reached the corridor and was ready for inhaul.
- Inhaul. Time began with the carriage ahead signal or when

the turn reached the corridor and was ready for inhaul. Time ended when the turn was landed.

- Unhook. Time began when the turn was landed and ended when the carriage started back down the skyline.
- Delays. Delays will be recorded by the following categories:
    1. Rigging. Repair or adjust rigging, including lines, chokers, blocks, anchors, and carriage.
    2. Equipment. Repair or adjust equipment such as the yarder or loader.
    3. Personal delays such as lunch or rest breaks.
    4. Procedural delays. This included a wide variety of possible delays: landing problems, waiting for other equipment, fueling, clearing obstacles, etc.
    5. Repositioning. This included any rigging repositioning, including choker resetting or repositioning the carriage. This did not include yarder repositioning associated with road changes.
    6. Other miscellaneous.

Other recorded components (non-timed) were:

- Yarding Distance. Slope distance between the tower and point where the carriage stopped, estimated to the nearest ten feet. Trees or stumps were marked in fifty-foot increments along the length of the corridor to aid in estimating distance.
- Lateral Distance. Average distance measured perpendicular

to the corridor to the hooking point of the farthest log in the turn, measured to the nearest five feet.

- Preset. Indicator variable (0/1) denoting whether chokers were preset or hotset.
- Merch. Number of merchantable logs in the turn.
- Non-Merch. Number of non-merchantable logs in the turn. All hardwoods were called non-merchantable, regardless of log quality.

Collected data were downloaded to a personal computer for analysis with spreadsheet and statistical software. Yarding cycle time elements were determined by averaging the individual cycle components and summing them for an average total cycle time for this site and prescription. A step-wise regression analysis process yielded a predictive equation which described delay-free time per yarding cycle as a function of the five non-timed operational components listed above.

Yarding and Loading Shift-Level Analysis

The yarding and loading crews kept daily records of their shift hours, number of logs yarded, and number of trucks loaded. This information was used to help determine production rates and costs for the yarding and loading operations.

Yarding and loading production were determined by dividing the total volume from the scale tickets by the total shift hours on the shift-level forms.

Yarding and loading owning and operating costs were determined using the PACE program with cost and procedural information from several sources (USDA 1992, Edwards 1992, Kellog, Olsen, and Hargrave 1986, and Miyata 1980). PACE is a spreadsheet-driven program which utilizes user-supplied cost information to calculate equipment ownership and operating costs in dollars per hour. PACE outputs for the yarding and loading operations are included in Appendix E.

Corridor Rigging Time Study.

Corridor rigging was divided into four phases. Times were kept to the nearest minute using a wristwatch, and data was recorded on a paper spreadsheet. Pre-rigging time was recorded by the hook tender and relayed to the researchers at the end of each shift. This collected information was used to calculate average road change times including pre-rigging.

The four timed phases were:

- Pre-rigging. This was the time the hooktender spent laying out rigging in the next yarding corridor in preparation for the next road change. The hooktender sometimes pre-rigged several corridors ahead, so it was important to keep in close daily contact with him to obtain accurate time data.
- Rig-down. Time began when the last turn in a corridor was unhooked at the landing. Tasks included pulling in lines and guylines, removing blocks or other anchor rigging, etc.

- Move or Reposition Yarder. Some judgement was required to determine when this phase actually began. Rigging a new guyline anchor stump would be part of yarder repositioning, as would raising the yarder outriggers. Moving or repositioning time began before actual yarder movement, but required the researcher to determine the beginning point for each move seperately. This phase did not occur for all road changes since several corridors could be yarded without changing position.
- Rig-up. Beginning time was again a subjective determination. Generally rig-up began when the yarder was set in place and lines were beginning to be pulled down the corridor. However, support tree rig-up may start earlier, so beginning time was judged for each corridor seperately.

RESULTS

Unit Volume Production

Table 2 displays total volume and volume per acre cut from the Forest Peak site. Total volume cut in thousands of board feet (MBF) was determined from the log scale tickets. Saw log scale was read directly from the tickets. Pulp logs were sold by weight, so a conversion calculation was necessary. Pulp logs weighed 105,300 lbs. delivered at the Coastal Fibre mill in Willamina, OR. Pulp log volume was calculated using a conversion ratio from Dilworth (1977) for 14-20 inch Douglas-fir logs of 12,770 lbs. per MBF.

Unit size of 22.8 acres was determined by OSU technicians by digitizing the stereo plotter contour map of the unit.

Volume per acre was figures from pre- and post-harvest inventories of the stand conducted by OSU Forests field technicians were also available. Beginning (1991) volume (Scribner MBF, 32' log, 6" top) was 44.5 MBF/acre of conifers greater than 8" dbh. Post-harvest (1992) volume was 28.8 MBF/acre, for a total of 15.7 MBF/acre of conifers removed.

However, there was a discrepancy between actual scaled log volume and inventoried volume. The inventory figures of 15.7 MBF/acre over 22.8 acres would have yielded 357.96 total MBF removed. The actual scaled volume of 315.06 total MBF was substantially below the inventory estimate. Possible reasons for this discrepancy in volumes were:

- The scaled volume only counted merchantable saw and pulp logs hauled to mill. Some non-merchantable commercial-size logs were left on the ground as large woody debris for wildlife habitat purposes. This volume would be accounted for in the stand exam but not in the commercial scaling.

- The inventories calculated timber volume by the Scribner rule for 32-foot logs to a 6-inch top. Logs were actually bucked to a 4-inch top, contributing to a lower scale volume than the calculated inventory volume.
- Sampling error in the inventory

For purposes of this study, commercially-scaled volume was used in all calculations. This decision was reasonable since economic analyses and management decisions involving timber production and costs must be based on merchantable volume. Processing of non-merchantable logs was considered simply a part of the operating costs of the project. Table 2 values were calculated using scale volumes and digitized unit acres.

Table 2. Volume (MBF) produced from Forest Peak site.

	Total MBF	MBF/acre
Saw Logs	306.81	13.5
Pulp Logs	8.25	0.4
TOTAL	315.06	13.9

Planning and Layout

Table 3 displays the time spent in each of the various components of the unit planning and layout process. The largest single component, field reconnaissance, included field visits by the principle researcher, a technical assistant, OSU faculty researchers, and the OSU sale administrator. Tree marking was completed by a crew of six faculty researchers, the principal researcher, and the sale administrator.

Edwards (1992) derived an hourly cost of $21.74 for planning and layout of a logging operation such as the one which was the subject of this study. This hourly rate included a forest engineer's salary and associated expenses, forestry equipment, and vehicle owning and operating costs. Multiplying total hours worked by this hourly rate yielded total planning and layout cost. Dividing total cost by total volume production of 315.06 MBF yielded cost in $/MBF. Dividing total cost by unit acreage of 22.8 acres yielded cost in $/acre.

Table 3. Planning and Layout Production and Cost.

Activity	Hours	Percent of Total
Field Reconnaissance	22.5	24.0
Office	14.0	14.9
Traverse and Profile	13.75	14.7
Logging Plan	11.5	12.3
Field Layout	16.0	17.1
Tree Marking	16.0	17.1
TOTAL	93.75	100

Total Cost = $6.47/MBF
= $89.39/acre

Felling Time Study

Detailed Time Study

Cycle time elements for each individual cutter are displayed in Figures 1 and 2. Averaged total cycle time elements are displayed in Figure 3.

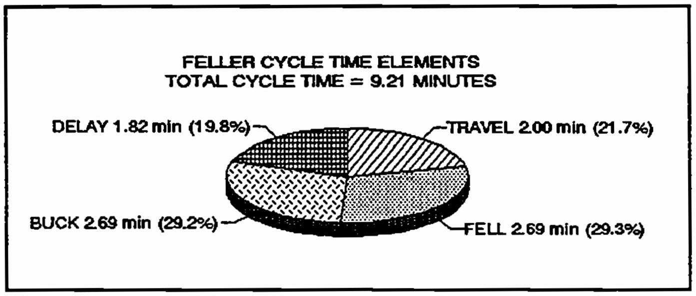

Figure 1

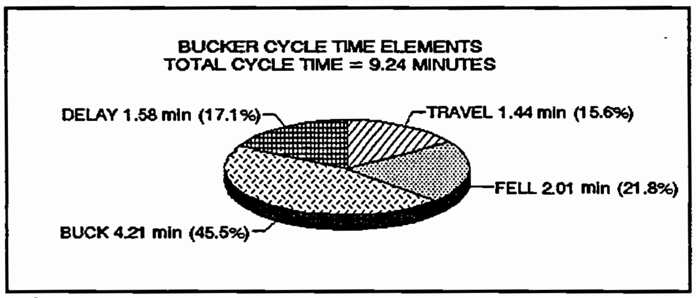

Figure 2

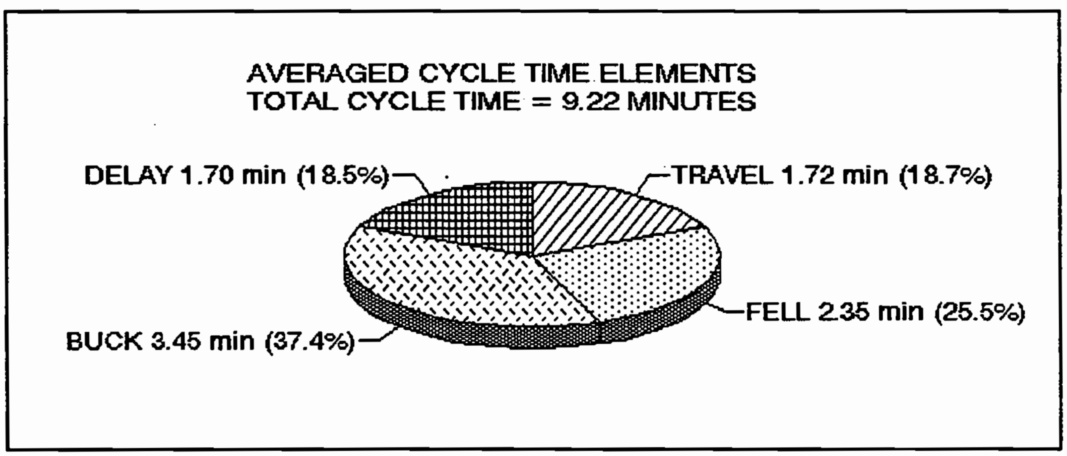

Figure 3

Figure 3 represents crew time spent on each tree. Each cutter was tracked independently, so individual time per tree often differed from the other cutter. Total cycle time elements are the average of the two individual cutters' times elements.

Summary statistics for each cutter and for the average total cycle time elements are listed in Table 4 below.

Table 4. Felling cycle time elements (minutes).

	Travel	Felling	Bucking	Delay	TOTAL
Feller	2.00	2.69	2.69	1.82	9.24
Bucker	1.44	2.01	4.21	1.58	9.21
AVERAGED	**1.72**	**2.35**	**3.45**	**1.70**	**9.22**

Travel time between trees was greater for the feller because he sometimes spent extra time selecting the next tree. The bucker was often still bucking and limbing the previous tree while the feller was travelling to the next tree to begin felling. When the bucker finished with the previous tree, the next tree would already be selected, and he could travel directly there.

Differences in felling and bucking times between the two cutters indicated the proportions of each cycle each cutter spent doing his individual tasks. The feller spent a greater amount of time on the felling process, while the bucker spent a greater amount of time on the bucking and limbing process. The differences in total cycle times for the individual cutters were attributed to slight discrepancies in data collection.

Detailed Delay Time Elements

Averaged delay time elements per cycle are displayed in

Figure 4. Mechanical delays accounted for nearly 60 percent of all delay time.

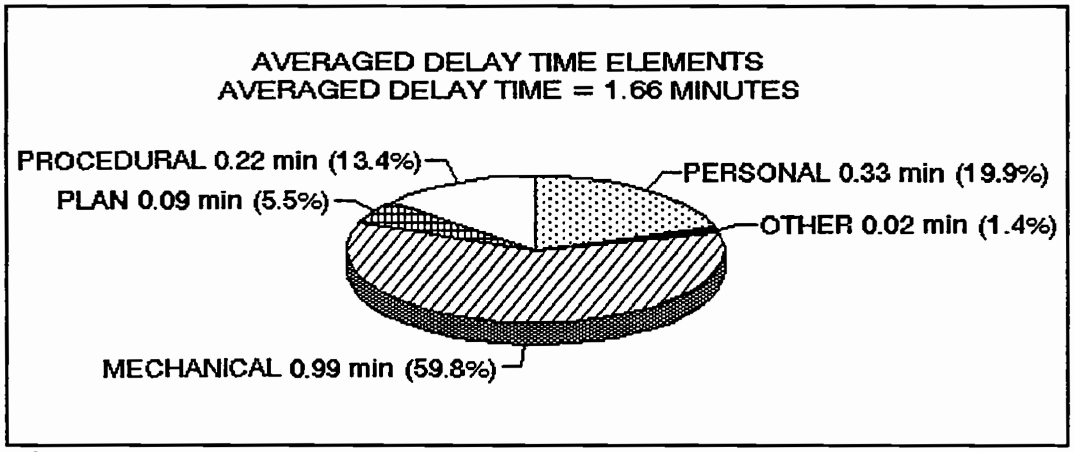

Figure 4

Felling and Bucking Regression Model

Felling delay-free cycle time in centiminutes (productive time only) model is displayed in Table 5 below. Equations shown are the result of a step-wise regression analysis using STATGRAPHICS statistical software. Equations shown here are for each cutter separately and for averaged cycle time for the two-man crew. The final equation was derived by averaging seperate equations for each cutter. Numeric values in the table are the coefficients of variables significant at the .05 level.

Variables which were recorded in the field but dropped out of the step-wise regression analysis were: stump diameter, number of buck cuts, and percent slope of the down log. For the bucker, percent ground slope was also not significant. Diameter squared improved the fit of the equation, replacing diameter. STATGRAPHICS outputs are listed in Appendix D.

Table 5. Felling and Bucking Delay-Free Regression Model.
Delay-Free Cycle Time (centiminutes)=

	Intercept	Logs	Method	Slope%	$Diam^2$
Feller	-240.05	165.82	151.96	4.66	0.80
Bucker	-122.40	137.63	156.20	----	0.84
Average	**-181.23**	**151.73**	**154.08**	**2.33**	**0.82**

Sample Size = 154
R^2 = 0.63
Standard Error = 240.04

Table 6 displays summary statistics for each of the significant independent variables. "$Diameter^2$" was the transformed significant variable in the final equation, but straight diameter is displayed here for simplicity. "Method" was a 0/1 indicator variable for which an average indicates the proportion of felling with wedges and without. The 0.64 value means wedges were used for felling on 64 percent of the trees.

Table 6. Summary statistics for felling and bucking variables.

	Diam	Slope%	Mthd	Feller Logs	Bucker Logs
Average:	23.6	43	0.64	1.25	2.11
Minimum:	7.8	0	0	0	0
Maximum:	45.8	65	1	4	5
Standard Deviation:	5.6	9	-	0.91	1.03

Felling and Bucking Production Rates and Costs

Table 7 summarizes production and costs for the 2-man crew. Volume production is displayed in number of trees and MBF per hour, operating costs in dollars per hour, and production cost in dollars per MBF. Production rates are based on shift-level data and scale volume. The PACE program was used for calculation of hourly costs. A brief description of the Pace program is included with analysis outputs in Appendix E. Cost information and procedures were taken from several sources: the U.S. Forest Service Region 6 Logging Cost Guide (USDA 1992), Edwards (1992), Miyata (1980), Kellogg, Olsen, and Hargrave (1986), and personal investigation of customary local costs.

Table 7. Summary of Felling and Bucking Production and Costs for a 2-man Crew.

Total crew shift hours	38
Hourly Production	
Trees	6.34
MBF	6.44
Operational Costs ($/Hr)	
Saws	3.93
Transportation	3.59
Labor	59.76
TOTAL	67.28
Production Cost ($/MBF)	**10.44**

Yarding and Loading Study

Detailed Yarding Cycle Time Study

Yarding cycle time elements are displayed in Figure 5. Delays were the largest portion of each cycle averaging 1.04 minutes per turn. Lateral inhaul used the least amount of time, averaging 0.36 minute perturn.

Detailed Delay Time Study

Detailed delay time elements are displayed in Figure 6. The "reposition" category refers to repositioning the carriage or resetting chokers during the yarding cycle. The largest single delay - repositioning - was due to the frequent carriage repositions required during lateral inhaul to get the turns around residual trees. The "other" category appears large, but the only major event included was one 47-minute yarder reposition not associated with a road change; without the yarder reposition, "other" decreases to about 1%.

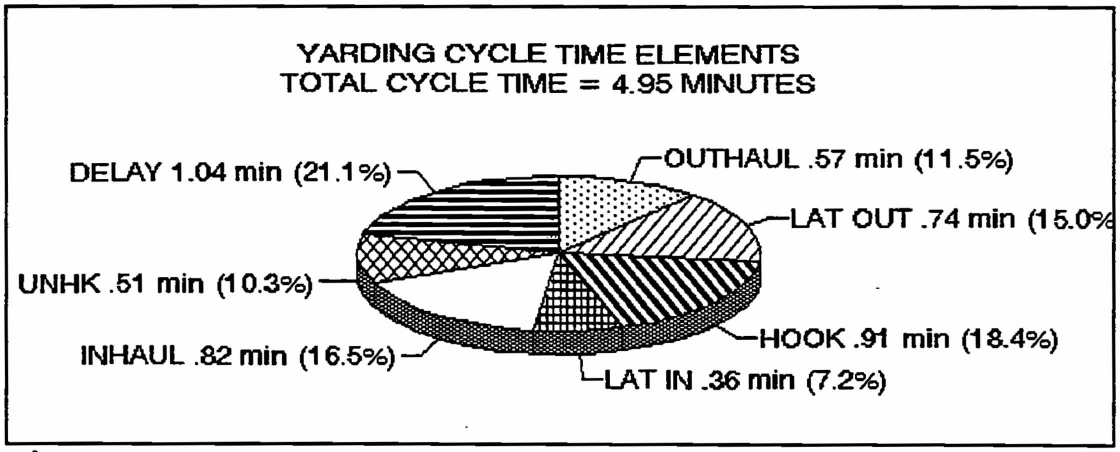

Figure 5

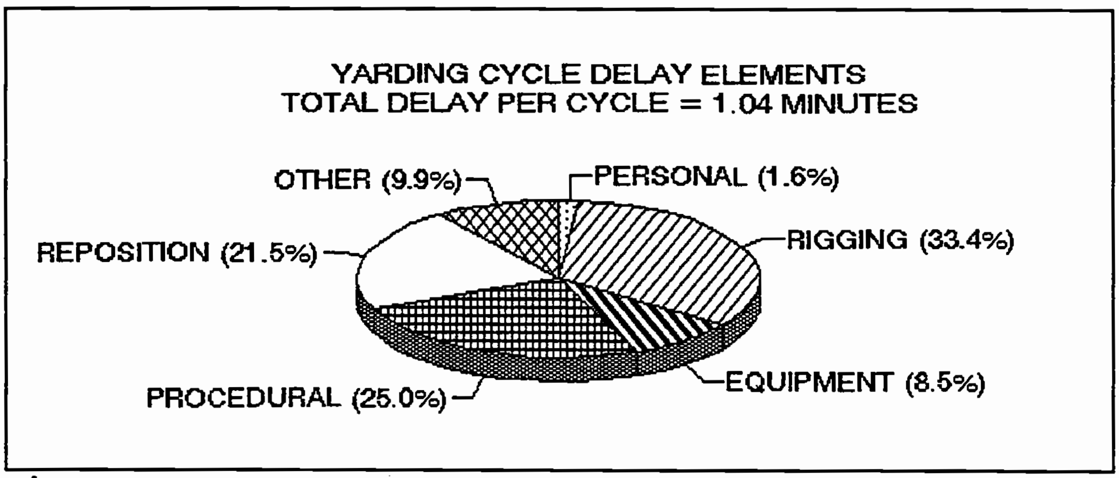

Figure 6

Road Change Time Study

Road change time elements are displayed in Figure 7.

The times displayed included the 6-man yarder crew plus the hook tender. The 1.82 hours per corridor was non-productive time while the whole crew worked to take down rigging and set up rigging in the new corridor. In addition to the crew time displayed in Fig.7, the hook tender spent an average of 1.31 hours per corridor pre-rigging tail trees, anchors, etc. by himself. The "move yarder" element included repositioning the yarder during road changes on the same landing and moving the yarder from the first to the second landing. The yarder moved once to the second landing for a distance of 125 feet.

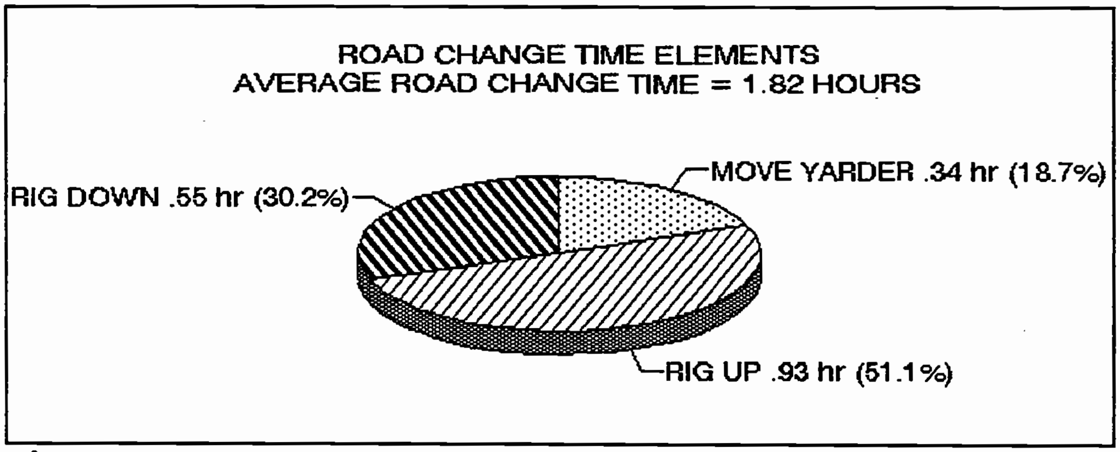

Figure 7

Delay-Free Yarding Cycle Time Regression Model

The regression model for delay-free yarding cycle time in centiminutes is displayed in Table 8. The equation is the result of a step-wise regression analysis process. Numeric values in the table are coefficients of the variables significant at the .05 level. Variables which dropped out of the analysis were number of merchantable and non-merchantable logs per turn. Merch and non-merch were combined to form the new variable "total logs per turn", which proved to be significant. Table 9 displays summary statistics for significant variables in the yarding cycle time regression equation.STATGRAPHICS outputs are listed in Appendix D.

Table 8. Regression Model for Delay-Free Yarding Cycle Time.
Delay-Free Cycle Time (centiminutes) =

Intercept	Yard Dist	Lateral Distance	Pre-set(0) Hot-set(1)	Logs per Turn
168.64	0.19	1.58	50.99	25.41

Sample Size = 258
R^2 = 0.43
Standard Error = 75.46

Table 9. Summary statistics for yarding variables.

	Yard Dist	Lateral Dist	Pre-Set(1) Hot-set(0)	Logs per Turn
Average:	334	36	0.95	2.1
Minimum:	10	0	0	1
Maximum:	640	135	1	5
Standard Dev.:	163	27	-	0.9

Yarding Production and Costs

Table 10 summarizes yarding production and costs. Production cost ($/MBF) is derived by multiplying total operational cost ($/Hr) by total crew hours worked and dividing by total MBF processed.

Loading Production and Costs

Table 11 summarizes loading production and costs. Production cost ($/MBF) is derived by multiplying total operational cost ($/Hr) by total hours worked and dividing by total MBF processed.

Table 10. Summary of Yarding Production and Costs.

Total shift hours = 67
Total MBF processed = 315.06

Hourly Production	
Pieces	14.8
MBF	4.7
Operational Costs ($/Hr)	
Yarder	80.98
Yarder Labor	107.48
Tail Trees, Supports	29.09
2 Crummies	7.78
Skidder	34.47
Tailhold Cat	14.20
Firetruck	1.12
TOTAL	275.12
PRODUCTION COST ($/MBF)	**58.51**

Table 11. Loading Production and Costs.

Total shift hours = 73
Total MBF processed = 315.06

Hourly Production	
Pieces	13.6
MBF	4.3
Operational Costs ($/Hr)	
Loader	60.97
Pickup	3.59
Labor	20.66
TOTAL	85.22
PRODUCTION COST ($/MBF)	**19.74**

Move-in Costs

Table 12 displays move-in costs using cost data from Edwards 1992. Move-in cost for the tracked yarder was considered equal to the cost for the tracked loader. Cost per MBF was calculated by dividing the total move-in cost by the total volume hauled.

Table 12. Move-In Costs ($).

Total MBF processed = 315.06

Yarder	900.00
Loader	900.00
Skidder	420.00
Tailhold Crawler Tractor	480.00
Firetruck	93.00
TOTAL	2793.00
PRODUCTION COST ($/MBF)	**8.87**

Total Logging Production Cost

Total logging production cost is displayed in Table 13. Total production cost is the sum of the planning and layout, felling/bucking, move-in, yarding, and loading production costs in dollars per MBF.

Table 13. Total Logging Production Cost ($/MBF).

Planning and Layout	6.47
Felling and Bucking	10.44
Eqpt. Move-In	8.87
Yarding	58.51
Loading	19.74
TOTAL PRODUCTION COST ($/MBF)	**104.03**

DISCUSSION

Production and Cost Comparisons

Two recent studies described in the Literature Review were appropriate for comparison with the current Forest Peak study. Kellogg, Pilkerton, and Edwards (1991) documented production and costs for logging operations in similar stand conditions using the same equipment and crew as the current Forest Peak study (Alarid 1993) but with different treatments. Edwards (1992) documented logging production and costs in similar stand conditions using similar equipment in five different treatments. While statistically valid comparisons cannot be made between the three studies, summary observations were interesting and useful. Costs in Kellogg, et al. (1991) and Edwards (1992) have been compounded at a .04 rate to 1993 dollars.

Planning and Layout

Table 14 displays comparative values for planning and layout activities for the various treatments in the three studies.

The highest-cost treaments were the patch cuts and the uneven-age partial cut. The higher cost for the uneven-age planning and layout is likely due to the extensive involvement of OSU faculty researchers in this initial attempt to establish a valid demonstration of uneven-age management techniques. For example, marking a 22-acre unit would not normally require a crew of eight. In this case, however, it was desirable to have the seven researchers and the sale administrator working together in order to facilitate discussion and clarification of uneven-age management objectives and methods for this site. Field reconnaissance by researchers also consumed more time than might be necessary when these practices become more established.

Table 14. Planning and Layout Time and Cost Comparisons in 1993 dollars.

TREATMENT	HRS/MBF	$/MBF
Kellogg, et al. (1991)		
Clearcut:	.019	.38
2-Story:	.126	2.73
0.5-ac Patch	.120	2.60
Edwards (1992)		
Clearcut:	-	1.14
Strip	-	4.13
0.5-ac Fan	-	7.87
1.5-ac Fan	-	7.86
Wedge	-	4.37
0.5-ac Parallel	-	6.38
Alarid (1993)		
Uneven-age	.298	6.47

The Forest Peak site also dictated logging practices which added to the planning and layout time. Payload analysis determined the need for tail trees on all but one yarding corridor and the probable need for intermediate supports on three corridors. Each tail tree and intermediate support tree was selected and flagged during unit layout. Each corridor was precisely flagged in order for the marking crew to remove all trees within the corridor. Laying out partial-cut or patch-cut corridors requires more precision than parallel settings in a strip cut or fan settings in a clearcut or wedge cut.

As long as individual tree marking and precise location of tail trees and corridors is required in the silvicultural prescription, high planning and layout costs can be expected at each uneven-age entry. However, the time and costs documented for this uneven-age entry were pobably higher than would be expected under more normal circumstances.

Felling and Bucking

Table 15 displays production and costs for felling and bucking. Both Kellogg, et al. (1991) and Edwards (1992) documented cutters working singly, while Alarid (1993) documented two cutters working together as a pair.

The best comparison between systems is the 2-story prescription in Kellogg et al. (1991), since it was the only other treatment with evenly-distributed leave trees at 13.5 TPA. The 2-man crew (Alarid 1993) showed a 70 percent increase in $/MBF cost and an 84 percent increase in MBF/HR production. The uneven-age prescription had a higher leave tree density and fewer cut trees per acre, both factors contributing to a lower productivity rate than in the 2-story treatment. In addition, the 2-man crew performed most of the limbing process, rather than the landing chasers as in the other studies. The Forest Peak study (Alarid 1993) used a substantially higher labor rate for cost calculations than Kellogg et al. (1991) or Edwards (1992). Future investigation may be able to better determine whether cost differences are a function of crew operations, analysis methods, or differences in treatments.

Table 15. Felling and Bucking Production and Cost Comparisons.

TREATMENT	$/MBF	MBF/HR	Cut TPA	Cut dbh
Kellogg, et al. (1991)				
Clearcut:	5.76	3.89	58	23
2-Story:	6.14	3.50	46.5	23
0.5-ac Patch	5.57	4.03	58.5[1]	23
Edwards (1992)				
Clearcut:	8.90	4.54	75	20
Strip	9.13	4.43	62.5	18
0.5-ac Fan	9.00	4.49	88.5[1]	17
1.5-ac Fan	8.88	4.55	77.5[1]	16
Wedge	9.01	4.49	85.5	17
.5-ac Parallel	8.93	4.52	105.5[1]	16
Alarid (1993) 2-man crew				
Uneven-age	10.44	6.44	17	23

[1]Denotes TPA cut within patch boundaries.

Yarding Production and Costs

Table 16 displays yarding production and costs including road and landing changes for the three studies. Edwards (1992) tracked data for a Thunderbird TMY-70 mobile yarder with a Danebo S-35 drumlock carriage, while Kellogg et al. (1991) and Alarid (1993) tracked data for a Thunderbird TTY-50 yarder with a Danebo MSP carriage.

Table 16 clearly shows that yarding production drops sharply for partial cuts compared with clearcuts of all configurations and opening sizes. Uneven-age hourly production was 58 percent lower and cost was 36 percent higher than the clearcut rates using the same equipment and crew (Kellogg et al. 1991). Both increased road change times and the difficulty of yarding around residual trees make partial-cut production rates lower. Cable yarding in an uneven-age prescription will always necessitate precision, low-production yarding in order to protect residual trees of all size classes.

Table 16. Yarding Production and Cost Comparison.

TREATMENT	$/MBF	MBF/HR	BF/Log	Logs/ Turn	AYD
Kellogg, et al. (1991) TTY-50, MSP carriage					
Clearcut:	43.18	8.10	391	NA[1]	464
2-Story:	52.06	6.51	374	NA[1]	568
0.5-ac Patch	53.36	6.38	391	NA[1]	546
Edwards (1992) TMY-70, S-35 drumlock carriage					
Clearcut:	60.44	6.10	216	3.32	627
Strip	60.49	6.09	171	4.21	424
0.5-ac Fan	68.88	5.71	173	3.80	725
1.5-ac Fan	61.92	5.95	179	3.19	401
Wedge	53.90	6.83	173	3.25	621
.5-ac Parallel	60.49	6.09	169	3.50	404
Alarid (1993) TTY-50, MSP carriage					
Uneven-age	58.51	4.70	318	2.10	334

[1]Information not available.

Table 17. Total Cost Comparison, 1993 dollars.

TREATMENT	$/MBF	Cut TPA	Cut MBF/Ac	AYD
Kellogg, et al. (1991)				
Clearcut:	49.35	58	36.9	464
2-Story:	60.92	46.5	29.6	568
0.5-ac Patch	61.52	58.5	37.2	546
Edwards (1992)				
Clearcut:	70.49	75	40.5	627
Strip	73.75	62.5	33.5	424
0.5-ac Fan	85.75	88.5	30.4	725
1.5-ac Fan	78.66	77.5	26.7	401
Wedge	67.28	85.5	38.5	621
0.5-ac Parallel	75.79	105.5	35.2	404
Alarid (1993)				
Uneven-age	75.42	17	13.9	334

Total Cost Summary

Total costs in Table 17 refer to the planning and layout, felling and bucking, and yarding phases of the operations studied. Other logging parameters are included for comparison purposes.

Summary Conclusions

While the comparisons displayed here have some revealing implications, caution should be used in making final conclusions, keeping in mind the similarities and differences in the studies which produced these results:

Similarities:

- Operations were conducted in similar stand conditions on OSU Research Forest logging units.
- Logging personnel were mostly the same experienced individuals for each operation.
- Shift-level data collection techniques were similar for all studies.
- All cost figures displayed in the Discussion section have been compounded to 1993.

Differences:

- Edwards (1992) documented the use of a larger, more powerful yarder with a more sophisticated carriage than the other two studies. Most of the results were derived from detailed time study data.
- The Forest Peak study (Alarid 1993) used generally higher labor and equipment cost information than the other two

studies, relying heavily on the USDA Forest Service Region 6 Logging Cost Guide (USDA 1992).

- The Forest Peak study (Alarid 1993) documented a felling process using a pair of cutters working as a team rather than as two cutters working separately.
- Stand conditions were not identical in all cases.
- Logging setting conditions such as log sizes, turn sizes, and yarding distances were not identical in all cases.

With these factors in mind, several trends about the cable logging system used to implement the first cable entry of the uneven-age prescription on Forest Peak are still apparent:

- Planning and layout costs for uneven-age management will continue to be as high or higher than other alternative treatments, although costs documented in this study were probably higher than necessary under normal operational conditions. While landing locations may be used repeatedly, each subsequent entry every 15-20 years will require intensive, precise location of anchors, tail trees, intermediate support trees, and yarding corridors, as well as new payload analyses to account for tree growth and a potentially larger design payload.
- Yarding production rate of 4.7 MBF/Hr was at least roughly equivalent to other non-clearcut silvicultural treatments on OSU's McDonald and Dunn Forests documented since 1991 using the same logging equipment.
- Unit volume production of 13.9 MBF/acre was substantially

below what the original silvicultural treatment called for. The Forest Peak prescription originally called for removal of approximately 40 percent of the merchantable stems, but only 28 percent were actually cut. Cutting 40 percent would have yielded approximately 17-18 MBF/acre. With a high-cost, low-production logging system such as the one in this study, it is important to ensure that prescribed cut volumes are achieved. It is important that the silvicultural prescription includes a specific marking guide to ensure the correct amount of stems, volume, or basal area is removed.

Other Considerations

While the felling and bucking predictive cycle time equation is useful with the variables shown, another variable not included in the data collection process may have been useful as well. Distance between cut trees was not measured, but I feel it would improve the final felling and bucking predictive equation. By including a distance element, planners might be able to more accurately determine felling time with a varying number of prescribed cut trees per acre.

As described in published literature on shelterwood harvest planning (Mann 1985b; Tesch, et al. 1986) considerations for future cable entries on this uneven-age study site must include logging feasibility planning. An important requirement of this initial cable entry was to ensure the residual stand would be mechanically feasible to harvest again fifteen to twenty years in the future. One way of accomplishing this was leaving an approximately 100-foot wide unmarked strip along the bottom of the unit. This strip was intended to be a reserve for future entry tail trees and anchor stumps. Tail trees used in the current entry may sustain enough damage or stress that they may not be suitable for use in future entries.

This site required the use of intermediate supports on only one corridor. However, a consideration which may be important on other sites is location of future intermediate support trees. Harvest system planners can identify potential locations of future yarding corridors in order for silvicultural presriptions or marking guides to include a means of leaving adequate support trees for future corridors.

Residual stand damage in this study appeared to be minor. According to the post-harvest inventory, 89.3 percent of trees less than 4" dbh survived, and 70 percent of trees 4"-8" survived. Some trees in the 4"-8" class were felled for clearing or for harvest, so it is not exactly known how much of the mortality in this class was intentional and how much was accidental logging damage. Observation in the unit after harvest revealed many healthy seedlings and saplings surrounded by logging residue and located within a few feet of even the main yarding corridors. Mature timber had little stem damage, with only a few observed fresh butt scars.

Future Research Needs

In order to make accurate future predictions about the economic and logging feasibility of cable logging through the repeated entries of an uneven-age management strategy, it would be necessary to develop a specific silvicultural prescription which described stand characteristics at each entry. During the conversion period from even-age to uneven-age structure, it is especially important to be able to predict stand structure for the next entry. Information such as cut tree diameters and heights, cut volume, and residual stand structure are important to accurately assess logging feasibility, production, and cost.

OSU Research Forest planners are currently developing stand models (Cummings 1993) for the uneven-age management areas described in the proposed OSU Research Forest Plan (OSU 1992). This type of specific model, combined with the information presented in this report, can provide planners with the detailed information necessary to predict future logging feasibility, production, and costs.

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APPENDIX A: RESEARCH METHODS LITERATURE

Time Study Techniques

Olsen and Kellogg (1983) reviewed four time study techniques to analyze their usefulness in determining logging production: Stopwatch studies, activity sampling, shift-level production summaries, and time-lapse photography. Each technique was compared in the yarding phase of a thinning operation. The techniques were described as follows:

The stopwatch method records the time spent in each activity within each yarding cycle. Independent variables, such as percent slope, slope yarding distance, or log diameter are also recorded. Cycle times and independent variables are then used to develop production regression equations or other predictors. The stopwatch study's primary advantage is its suitability for collecting accurate detailed time data, including short delays, for production analysis purposes. This type of study usually requires two observers: one for tracking time elements and another for recording independent variables for each cycle.

Shift-level summaries are records kept by either an operations crew member or an independent observer of pieces produced (trees felled, logs yarded, etc.) and hours worked each day for both men and machines. Delay times per day are also recorded, but detailed times for each phase of an operation are not recorded. Shift-level summaries do not track any factors affecting productivity or delays, therefore production results are only valid for the specific site conditions being studied.

Activity sampling measures the proportion of a work period spent in each observed activity by recording what activity is occuring at either random or fixed time intervals. This technique is suitable for sampling logging operations, provided the sampling interval does not coincide with repetitive work cycles.

Time lapse photography attempts to record activities on film at fixed time intervals throughout a work period. This technique can allow viewing of work operations in less amount of time in proportion to the time intervals used to record. It requires unobstructed views of the operations, adequate lighting, and restricted movement distances by workers and equipment in order to remain in the camera's field of view.

Olsen and Kellogg (1983) also described a method for calculating sample size based on estimated or observed statistical values. This method was used in the current Forest Peak study and is described in detail in the Methods section.

While actual stopwatches and paper spreadsheets mentioned in Olsen and Kellogg (1983) have served perfectly well in the past for tracking detailed time information, more recent computer technology is available which makes data recording and storage much easier and faster. Bettinger (1991) described a technique for using a hand-held field data recorder with software designed specifically for time studies. The SIWORK3 program is capable of timing user-defined cycle elements and recording non-timed independent variables. All recorded data can be transferred directly to a larger computer for use with spreadsheet or other analysis software.

Detailed Time Studies (Stopwatch Studies)

The term "stopwatch" here refers to the technique of recording detailed time information on the seperate elements of a work operation cycle as described in Olsen and Kellogg (1983); it does not necessarily mean a stopwatch was used for doing the timing. Field data recorders are currently being used extensively for gathering time information. The term "stopwatch study" in this report is synonymous with "detailed time study."

Examples of detailed time studies of logging operations are numerous in the literature, although little or nothing has been published on cable systems operating in a partial cut in large timber. Nevertheless, two studies stand out for their techniques of analyzing detailed time data gathered in traditional commercial thinning operations.

Hochrein and Kellogg (1988) examined two yarders, a small Koller K-300 and a mid-size Madill 071, each operating in light and heavy commercial thinning intensities in the Oregon Cascade Range. A fifth treatment involved prebunching with the smaller yarder and swinging turns to the landing with the larger yarder in the lighter intensity prescription. While the results of the study were not directly related to the current Forest Peak project, the methods of data analysis and presentation were worth noting.

Hochrein and Kellogg conducted a detailed yarding time study, gathering information on both effective production time and delay time for each of the five treatments. They also recorded independent variables for each cycle, including slope yarding distance, lateral yarding distance, number of logs per turn, and slope percent. Road change times were tracked as well.

Using owning and operating costs developed in a previous publication, harvest production and cost were displayed for each of the five treatments. Production and cost information displayed included:

- Mean number of logs per turn
- Delay-free production (cunits per machine hour)
- Effective hour (%)
- Adjusted production (cunits per scheduled machine hour)
- Yarding and loading cost ($ per cunit)
- Total logging cost ($ per cunit), including felling, bucking, hauling and stumpage
- Profit ($ per cunit)

This kind of information would be very useful for logging planners or operators wanting to examine an unfamiliar system or compare existing and proposed systems.

Regression analysis of both production rate (ft^3/hr) and cycle time vs. independent variables related to each turn produced equations for each yarder with all variables significant at the .05 level. Thinning prescription was treated as an independent variable, with seperate equations for each yarder or yarding system.

A very interesting and useful line graph displayed yarding and loading cost as a function of varying slope yarding distance at the light thinning intensity and at a light intensity under hypothetical optimum crew size and ground conditions. This result was calculated by holding all independent variables constant while varying slope yarding distance. stop here

In another example of a detailed time study, Kellogg, Olsen, and Hargrave (1986) examined felling/bucking and yarding operations in three commercial thinning prescriptions. Yarding was conducted using a Madill 071 yarder with a Danebo MSP carriage. Information collected included timed productive and delay elements of each felling/bucking and yarding cycle as well as nonproductive independent variables. Road change times were also recorded. Again, the study methods were the main items of interest in their study, and the methods described there served as a model for the current study.

The felling time study results were displayed in pie charts showing average times and relative frequencies of the felling cycle elements. The felling cycle was divided into four basic elements:

- move and select
- cut and wedge
- limb and buck
- delays

In a seperate pie chart, delay categories were displayed as percentages of total delay time. Delay categories were:

- personal
- operating
- repair
- maintenance
- fueling
- miscellaneous other.

Regression equations for production rate (ft^3/hr) and for cycle time (minutes) were displayed in a columnar table listing the coefficients for significant independent variables. Significant independent variables included:

- move distance
- slope%
- tree volume (ft^3)
- tree dbh
- species
- cutter experience
- treatment types

Recorded variables not included in the final regression equation included number of buck cuts and number of limbs. Actual variable values by treatment were also displayed in tabular form listing average, maximum, minimum, standard deviation, and sample size.

Felling production rates included number of trees per hour and ft^3 per hour. Cost was displayed in $/cunit and $/MBF at a conversion rate of 3.4 bd ft per cubic ft. A detailed description of the owning and operating cost calculations was included as an appendix.

Results for the yarding study were presented in much the same way as the felling study. Yarding cycle element times and relative frequencies were displayed in pie chart form. Elements included:

- outhaul
- lateral outhaul
- hook
- lateral inhaul
- inhaul
- unhook
- reset and reposition
- delays
- road changes

Delays displayed in pie chart form included:

- repair
- operating
- personal
- miscellaneous other

Road change times (hours) by treatment were presented in tabular form, showing sample size, total accumulated time, average, maximum, minimum, and standard deviation. It is interesting to note that landing changes with intermediate supports took 2.4 times as long as single span landing changes. Also interesting was the fact that road changes with 20-foot tail lift trees took no longer than changes with tail stumps.

Regression equations for cycle time (minutes) and production rate (ft^3/hr) included independent variables:

- slope distance
- lateral distance
- lateral distance squared
- turn volume
- log angle
- slope percent

Recorded variables not included in the final regression equations were number of carriage repositions, crew size, cutter experience, carriage ground clearance, lead angle, log length, logs per turn, rigging slinger, and yarding resets.

A table of production rates and costs by treatment included production in number of logs per hour and volume (ft^3) per hour, cost in $/cunit and $/MBF, and cycle time (minutes).

APPENDIX B: PRE- AND POST-HARVEST STAND INVENTORIES

****

TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 10, YEAR OF INVENTORY : ~~1992~~ 1991 , GROWTH STAND? FALSE
STAND ACRES = 22.80

	OVERSTORY	UNDERSTORY	
SPECIES	DOUGLAS-FIR	DOUGLAS-FIR	(FROM AERIAL PHOTOS)
SIZE (DBH)	21.1" AND UP, LARGE SAW	5.1"-11.0", POLE TIMBER	(FROM AERIAL PHOTOS)
STOCKING LEVEL (%) (BY CROWN CLOSURE)	10-39, POORLY STOCKED	10-39, POORLY STOCKED	(FROM AERIAL PHOTOS)
TOTAL AGE AT INVENTORY (AVG OF SITE TREES)	120	NONE	(AGES TAKEN FOR SOFTWOODS ONLY)
NUM OF SITE TREES	8		
MAX SITE TREE AGE (BH)	133		
MIN SITE TREE AGE (BH)	102		
YEAR OF ORIGIN	1872		
MAXIMUM DIAMETER	69.0		
KING'S SITE INDEX	97		
KING'S SITE CLASS	3		
MCARDLE SITE INDEX	136		

AVERAGE SLOPE = 21 DEGREES , RANGE = 15 TO 25
AVERAGE ASPECT = 201 DEGREES
NUMBER OF READINGS IN EACH OF THE CARDINAL DIRECTIONS WERE :

N	NW	W	SW	S	SE	E	NE
0	1	2	2	2	3	0	0

SOIL TYPE :

SOIL TYPE		ACREAGE	% OF TOTAL
PRICE	(PR)	9.35	41
RITNER	(R)	7.07	31
WITZEL	(WL)	4.79	21
DIXONVILLE	(DN)	1.14	5
PHILOMATH	(PH)	0.46	2

AVERAGE ELEVATION = 1170 FEET , RANGE = 860 TO 1480

NUMBER OF PLOTS IN STAND = 10
EXPANSION FACTOR (ACRES/NUM OF POINTS) = 2.28

Before harvest

CURTIS'S RELATIVE DENSITY INDEX (BASAL AREA/SQR ROOT OF QUAD MEAN DIAM) = 83.5
MORTALITY EXISTS IN SOFTWOODS OVER 8" DBH? FALSE
MORTALITY EXISTS IN HARDWOODS OVER 8" DBH? FALSE

Preliminary

ALL SPECIES SUMMARY TABLE :

	0"-4" DBH	4"-8" DBH	0"-8" DBH	OVER 8" DBH	OVER STORY	UNDER STORY	TOTAL
PERCENT OF STAND AREA SAMPLED	0.191	0.766					
AVERAGE NUMBER OF TREES COUNTED/POINT			3.8	10.3			
STANDARD DEV FOR NUM OF TREES COUNTED/POINT			3.4	3.7			
NUMBER OF PLOTS UNSTOCKED			1	0			0
NUMBER OF ACRES UNSTOCKED			2.3	0.0			0.0
PERCENTAGE OF STAND AREA UNSTOCKED			10.0	0.0			0.0
NUMBER OF TREES/AC AT INVENTORY	641.7	57.3	699.0	59.8	0.0	0.0	758.8
MEAN DIAMETER (INCHES)				22.7			
QUADRATIC MEAN DIAMETER (INCHES)				25.1			7.4
AVERAGE HEIGHT (FT)				107.1			
AVERAGE HEIGHT OF DOMINANT/CODOMINANT TREES (FT)							126.3
BASAL AREA AT INVENTORY (SQ FT/AC)			21.34	206.00			227.34
BASAL AREA PAI, LAST 5 YR (NON-GROWTH TECH) (SQ FT/AC)			0.00	0.00			0.00

* : ONLY TREES BETWEEN 4.1" DBH AND 0.0" DBH INCLUDED IN CALCULATION

STAND COMPOSITION BY SPECIES AND DIAMETER :

DIAMETER RANGE	SPECIES PRESENT	PERCENT OF TOTAL # OF STEMS IN DIAM RANGE
0" - 4"	DOUGLAS-FIR	43
	BIGLEAF MAPLE	25

	GRAND FIR	25
	PACIFIC DOGWOOD	4
	CHERRY	4
4" - 8"	GRAND FIR	70
	BIGLEAF MAPLE	10
	OREGON WHITE OAK	10
	DOUGLAS-FIR	10
8" PLUS	DOUGLAS-FIR	75
	GRAND FIR	14
	OREGON WHITE OAK	8
	BIGLEAF MAPLE	3

VOLUME/GROWTH TABLE :

	DOUG-FIR	GRAND FIR	OTHER SOFT	HARDWOODS	TOTAL
TOTAL STEM CUBIC FT VOLUME/AC	8687.2	363.7	0.0	155.6	9206.4
SCRIBNER BF VOLUME/AC (32' LOG, 6" TOP)	43804.5	715.4	0.0	0.0	44519.9
TOTAL STEM CUB FT (N) PAI PER AC	0.0	0.0	0.0	0.0	0.0
TOT STEM CUB FT (N) PAI GROWTH PERCENT	0.0	0.0	0.0	0.0	0.0
TOTAL STEM CUB FT (N) MAI PER AC	72.4	3.0	0.0	1.3	76.7
NUMBER OF 2" DIAM CLASSES PRESENT	23	7	0	5	25
NUMBER OF TREES SAMP CONTRIB TO TOP HT	30	1	0	0	

44459.7 → 8"

CROWN CLASS TABLE (DAMAGE IGNORED) : (ONLY TREES OVER 4.0" DBH)

CROWN CLASS	AVERAGE HEIGHT	AVERAGE CROWN LENGTH	AVERAGE DBH	BAS AREA/AC	PERCENT OF STAND BY BASAL AREA	NUMBER OF TREES/AC	PERCENT OF STAND BY TREES/AC
OPEN GROWN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PREDOMINANT	119.1	31.2	69.0	2.0	0.9	0.1	0.1
DOMINANT	138.2	51.5	30.2	146.0	66.6	27.8	23.7
CODOMINANT	108.7	46.3	21.7	50.0	22.8	17.0	14.5
INTERMEDIATE	40.0	27.3	7.4	17.3	7.9	55.1	47.0
SUPPRESSED	29.0	23.1	6.2	3.7	1.7	17.2	14.7

REGENERATION RECORD :

DBH	DOUGLAS FIR			GRAND FIR			OTHER SOFTWOODS			HARDWOODS		
	TREES PER ACRE	PERCENT DAMAGED	AVG HT	TREES PER ACRE	PERCENT DAMAGED	AVG HT	TREES PER ACRE	PERCENT DAMAGED	AVG HT	TREES PER ACRE	PERCENT DAMAGED	AVG HT
0.1-0.5	252.1	27	2.7	45.8	50	2.9	0.0	0	0.0	114.6	60	8.1
0.6-1.0	0.0	0	0.0	22.9	100	6.8	0.0	0	0.0	45.8	0	10.2
1.1-1.5	22.9	0	11.8	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0
1.6-2.0	0.0	0	0.0	22.9	100	11.0	0.0	0	0.0	0.0	0	0.0
2.1-2.5	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0
2.6-3.0	0.0	0	0.0	45.8	50	15.8	0.0	0	0.0	0.0	0	0.0
3.1-3.5	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	22.9	0	35.6
3.6-4.0	0.0	0	0.0	22.9	0	27.4	0.0	0	0.0	22.9	0	39.7

TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 10

STAND SUMMARY TABLE (OVER ALL DCLASSES) BY SPECIES, (SOME VARIABLES EXPLAINED BELOW TABLE)

	DOUGLAS-FIR		GRAND FIR		OTHER SOFTWOODS		HARDWOODS	
	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE
TOTAL NUMBER OF TREES	7427.1	325.8	4764.2	209.0	0.0	0.0	5109.7	224.1
0" - 4"	6270.5	275.0	3657.8	160.4	0.0	0.0	4702.8	206.3
4" - 8"	130.6	5.7	914.4	40.1	0.0	0.0	261.3	11.5
8" AND OVER	1026.1	45.0	192.0	8.4	0.0	0.0	145.6	6.4
5 YR # MORT, 0" - 4"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 YR # MORT, 4" - 8"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 YR # MORT, 8" +	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAX 5 YR MORT DBH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRESENT BASAL AREA	4515.9	198.1	427.5	18.8	0.0	0.0	240.0	10.5
BAS AREA 5 YR (N)PAI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOP HEIGHT OF FATTEST *	129.5	13.2 T	53.0	2.9 T	0.0	0.0 T	0.0	0.0 T
QUAD MEAN DIAM FAT *	28.9	13.2 T	11.2	2.9 T	0.0	0.0 T	0.0	0.0 T
TOTAL STEM VOLUME(CF)	198067.1	8687.2	8292.2	363.7	0.0	0.0	3547.8	155.6
TOTAL CUB 5 YR (N)PAI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL STEM CF MAI	1650.6	72.4	69.1	3.0	0.0	0.0	29.6	1.3
CUBIC VOL, 4" TOP	191334.3	8391.9	6274.3	275.2	0.0	0.0	0.0	0.0
CUB 5YR (N)PAI,4" TOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL CF MAI, 4" TOP	1594.5	69.9	52.3	2.3	0.0	0.0	0.0	0.0
SCRIBNER VOL, 32'-6"	998741.5	43804.5	16311.4	715.4	0.0	0.0	0.0	0.0
SCR 5YR (N)PAI,32'-6"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL SCR MAI, 32'-6"	8322.8	365.0	135.9	6.0	0.0	0.0	0.0	0.0

* THE VALUE IN THE TOTAL COLUMN IS THE PER ACRE VALUE; THE VALUE IN THE PER ACRE COLUMN (FOLLOWED BY T) IS THE NUMBER OF TREES PER ACRE INCLUDED IN THE CALCULATION, IF LESS THAN 40, THEN THERE WERE NOT 40 TREES PER ACRE QUALIFIED TO BE INCLUDED

MORT : MORTALITY TREES - ONES THAT ARE ESTIMATED TO HAVE DIED WITHIN LAST 5 YEARS

CUB, CF : CUBIC FOOT
SCRB,SCR : SCRIBNER
(N) : CALCULATED USING NON-GROWTH STAND TECHNIQUE
(G) : CALCULATED USING GROWTH STAND TECHNIQUE
PAI : PERIODIC ANNUAL INCREMENT, AVG ANNUAL GROWTH OVER LAST 5 YEARS
MAI : MEAN ANNUAL INCREMENT, AVG ANNUAL GROWTH OVER LIFE OF STAND

TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 10

DIAMETER CLASS TABLES BY SPECIES FOLLOW (PER ACRE VALUES) :

DOUGLAS-FIR

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	275.0	0.2	3.4	0.2	1.8	0.0	0.0	0.0	0.0	0.0
6.1- 8.0	5.7	1.9	40.4	7.7	30.2	25.8	14.2	41.7	25.2	63.0
8.1- 10.0	3.7	2.0	44.3	9.9	33.9	31.3	26.3	89.8	53.6	121.7
10.1- 12.0	2.6	2.0	72.7	11.9	57.9	54.8	51.1	224.2	169.9	283.1
14.1- 16.0	1.7	2.0	76.1	14.6	57.9	55.5	54.2	254.3	191.1	308.9
20.1- 22.0	1.6	4.0	124.4	21.5	180.0	173.8	172.5	1017.4	853.8	1138.1
22.1- 24.0	4.1	12.0	116.6	23.1	490.4	473.8	470.3	2746.2	2259.7	3076.1
24.1- 26.0	2.9	10.0	132.9	25.0	457.9	442.5	439.3	2684.7	2263.9	2959.2
26.1- 28.0	6.5	26.0	131.4	27.0	1140.0	1101.9	1094.2	6707.4	5615.8	7376.8
28.1- 30.0	7.8	36.0	145.8	29.1	1719.1	1662.1	1650.4	10470.8	8920.2	11368.7
30.1- 32.0	4.9	26.0	146.7	31.3	1204.6	1164.9	1156.8	7356.7	6241.5	7977.4
32.1- 34.0	1.7	10.0	134.0	33.2	416.2	402.5	399.7	2482.4	2063.2	2716.8
34.1- 36.0	2.1	14.0	148.9	34.6	639.1	618.2	613.8	3935.9	3338.6	4254.7
36.1- 38.0	1.3	10.0	144.1	36.9	431.2	417.1	414.2	2630.4	2211.9	2855.7
38.1- 40.0	0.5	4.0	152.5	38.8	179.0	173.1	171.9	1107.7	939.9	1196.2
40.1- 42.0	1.7	16.0	159.6	41.3	733.3	709.4	704.5	4594.4	3930.5	4940.1
42.1- 44.0	0.6	6.0	163.5	43.0	276.3	267.3	265.4	1737.4	1491.2	1866.5
44.1- 46.0	0.5	6.0	160.3	45.1	266.9	258.2	256.4	1662.7	1420.5	1794.5
46.1- 48.0	0.2	2.0	154.5	47.3	84.2	81.5	80.9	515.6	436.6	561.2
48.1- 50.0	0.1	2.0	146.0	49.5	78.1	75.6	75.0	465.9	389.0	513.6
56.1- 58.0	0.1	2.0	128.3	56.2	64.9	62.8	62.3	359.2	288.7	411.6
60.1- 62.0	0.1	2.0	181.6	60.1	89.7	86.8	86.2	553.7	485.2	605.1
68.1- 70.0	0.1	2.0	119.1	69.0	54.9	53.1	52.7	274.6	214.5	333.3
OVERALL TOTALS	325.8	198.1	20.9	4.0	8687.2	8391.9	8312.4	51913.1	43804.5	56722.3

>32" = 7.3

(43779.3 >8" dbh)

GRAND FIR

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	91.7	0.6	5.9	0.7	2.8	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	68.8	4.0	19.7	3.2	40.5	0.0	0.0	0.0	0.0	0.0
4.1- 6.0	17.2	2.5	28.7	5.2	35.2	20.9	0.0	0.0	0.0	0.0
6.1- 8.0	22.9	5.7	36.4	6.7	89.0	69.9	21.1	58.3	35.0	91.9
8.1- 10.0	4.8	2.0	64.7	8.7	57.8	51.7	37.2	140.4	108.3	197.6
10.1- 12.0	2.9	2.0	53.0	11.2	43.0	40.5	36.8	143.6	97.1	186.8
22.1- 24.0	0.7	2.0	122.7	23.7	95.4	92.2	91.5	559.4	475.0	617.0
OVERALL TOTALS	209.0	18.8	18.0	3.0	363.7	275.2	186.7	901.8	715.4	1093.3

(680.4 >8" dbh)

OTHER SOFTWOODS

NONE OF THIS SPECIES/CATEGORY SAMPLED IN STAND

HARDWOODS

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	160.4	0.2	8.7	0.4	0.7	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	45.8	3.3	37.7	3.7	52.2	0.0	0.0	0.0	0.0	0.0
6.1- 8.0	11.5	3.0	37.5	7.0	42.7	0.0	0.0	0.0	0.0	0.0
8.1- 10.0	4.7	2.0	32.8	8.8	24.1	0.0	0.0	0.0	0.0	0.0
14.1- 16.0	1.7	2.0	49.4	14.9	35.9	0.0	0.0	0.0	0.0	0.0
OVERALL TOTALS	224.1	10.5	16.9	1.7	155.6	0.0	0.0	0.0	0.0	0.0

TOTAL FOR ALL SPECIES (BOARD FT TOTALS ARE FOR SOFTWOODS ONLY)

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	527.1	0.9	5.5	0.3	5.3	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	114.6	7.3	26.9	3.4	92.7	0.0	0.0	0.0	0.0	0.0
4.1- 6.0	17.2	2.5	28.7	5.2	35.2	20.9	0.0	0.0	0.0	0.0
6.1- 8.0	40.1	10.5	37.2	6.9	161.8	95.7	35.3	100.0	60.2	154.8
8.1- 10.0	13.3	6.0	47.6	9.1	115.8	83.0	63.5	230.2	161.9	319.3
10.1- 12.0	5.5	4.0	62.3	11.5	100.9	95.2	88.0	367.8	267.0	469.9
14.1- 16.0	3.4	4.0	63.0	14.7	93.8	55.5	54.2	254.3	191.1	308.9
20.1- 22.0	1.6	4.0	124.4	21.5	180.0	173.8	172.5	1017.4	853.8	1138.1
22.1- 24.0	4.8	14.0	117.4	23.2	585.8	565.9	561.8	3305.6	2734.7	3693.1
24.1- 26.0	2.9	10.0	132.9	25.0	457.9	442.5	439.3	2684.7	2263.9	2959.2
26.1- 28.0	6.5	26.0	131.4	27.0	1140.0	1101.9	1094.2	6707.4	5615.8	7376.8
28.1- 30.0	7.8	36.0	145.8	29.1	1719.1	1662.1	1650.4	10470.8	8920.2	11368.7
30.1- 32.0	4.9	26.0	146.7	31.3	1204.6	1164.9	1156.8	7356.7	6241.5	7977.4
32.1- 34.0	1.7	10.0	134.0	33.2	416.2	402.5	399.7	2482.4	2063.2	2716.8
34.1- 36.0	2.1	14.0	148.9	34.6	639.1	618.2	613.8	3935.9	3338.6	4254.7
36.1- 38.0	1.3	10.0	144.1	36.9	431.2	417.1	414.2	2630.4	2211.9	2855.7
38.1- 40.0	0.5	4.0	152.5	38.8	179.0	173.1	171.9	1107.7	939.9	1196.2
40.1- 42.0	1.7	16.0	159.6	41.3	733.3	709.4	704.5	4594.4	3930.5	4940.1
42.1- 44.0	0.6	6.0	163.5	43.0	276.3	267.3	265.4	1737.4	1491.2	1866.5
44.1- 46.0	0.5	6.0	160.3	45.1	266.9	258.2	256.4	1662.7	1420.5	1794.5
46.1- 48.0	0.2	2.0	154.5	47.3	84.2	81.5	80.9	515.6	436.6	561.2
48.1- 50.0	0.1	2.0	146.0	49.5	78.1	75.6	75.0	465.9	389.0	513.6
56.1- 58.0	0.1	2.0	128.3	56.2	64.9	62.8	62.3	359.2	288.7	411.6
60.1- 62.0	0.1	2.0	181.6	60.1	89.7	86.8	86.2	553.7	485.2	605.1
68.1- 70.0	0.1	2.0	119.1	69.0	54.9	53.1	52.7	274.6	214.5	333.3
OVERALL TOTALS	758.8	227.3	18.9	3.0	9206.4	8667.0	8499.1	52814.9	44519.9	57815.6

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TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 11, YEAR OF INVENTORY : ~~1991~~ 1992 , GROWTH STAND? FALSE
STAND ACRES = 22.80

	OVERSTORY	UNDERSTORY	
SPECIES	DOUGLAS-FIR	DOUGLAS-FIR	(FROM AERIAL PHOTOS)
SIZE (DBH)	21.1" AND UP, LARGE SAW	5.1"-11.0", POLE TIMBER	(FROM AERIAL PHOTOS)
STOCKING LEVEL (%) (BY CROWN CLOSURE)	10-39, POORLY STOCKED	10-39, POORLY STOCKED	(FROM AERIAL PHOTOS)
TOTAL AGE AT INVENTORY (AVG OF SITE TREES)	120	NONE	(AGES TAKEN FOR SOFTWOODS ONLY)
NUM OF SITE TREES	7		
MAX SITE TREE AGE (BH)	134		
MIN SITE TREE AGE (BH)	103		
YEAR OF ORIGIN	1871		
MAXIMUM DIAMETER	69.1		
KING'S SITE INDEX	95		
KING'S SITE CLASS	3		
MCARDLE SITE INDEX	134		

AVERAGE SLOPE = 21 DEGREES , RANGE = 15 TO 25
AVERAGE ASPECT = 201 DEGREES
NUMBER OF READINGS IN EACH OF THE CARDINAL DIRECTIONS WERE :

N	NW	W	SW	S	SE	E	NE
0	1	2	2	2	3	0	0

SOIL TYPE :

SOIL TYPE		ACREAGE	% OF TOTAL
PRICE	(PR)	9.35	41
RITNER	(R)	7.07	31
WITZEL	(WL)	4.79	21
DIXONVILLE	(DN)	1.14	5
PHILOMATH	(PH)	0.46	2

AVERAGE ELEVATION = 1170 FEET , RANGE = 860 TO 1480

NUMBER OF PLOTS IN STAND = 10
EXPANSION FACTOR (ACRES/NUM OF POINTS) = 2.28

CURTIS'S RELATIVE DENSITY INDEX (BASAL AREA/SQR ROOT OF QUAD MEAN DIAM) = 59.8
MORTALITY EXISTS IN SOFTWOODS OVER 8" DBH? FALSE
MORTALITY EXISTS IN HARDWOODS OVER 8" DBH? FALSE

Post. harv.

ALL SPECIES SUMMARY TABLE :

	0"-4" DBH	4"-8" DBH	0"-8" DBH	OVER 8" DBH	OVER STORY	UNDER STORY	TOTAL
PERCENT OF STAND AREA SAMPLED	0.191	0.766					
AVERAGE NUMBER OF TREES COUNTED/POINT			3.2	6.8			
STANDARD DEV FOR NUM OF TREES COUNTED/POINT			2.2	1.4			
NUMBER OF PLOTS UNSTOCKED			1	0			0
NUMBER OF ACRES UNSTOCKED			2.3	0.0			0.0
PERCENTAGE OF STAND AREA UNSTOCKED			10.0	0.0			0.0
NUMBER OF TREES/AC AT INVENTORY	573.0	40.1	613.1	43.2	0.0	0.0	656.2
% loss	10.8	30.0					
MEAN DIAMETER (INCHES)				21.2			
QUADRATIC MEAN DIAMETER (INCHES)				24.0			6.5
% surv.	87.3	70.0					
AVERAGE HEIGHT (FT)				99.4			
AVERAGE HEIGHT OF DOMINANT/CODOMINANT TREES (FT)							131.3
BASAL AREA AT INVENTORY (SQ FT/AC)			16.83	136.00			152.83
BASAL AREA PAI, LAST 5 YR (NON-GROWTH TECH) (SQ FT/AC)			0.00	0.00			0.00

* : ONLY TREES BETWEEN 4.1" DBH AND 0.0" DBH INCLUDED IN CALCULATION

STAND COMPOSITION BY SPECIES AND DIAMETER :

DIAMETER RANGE	SPECIES PRESENT	PERCENT OF TOTAL # OF STEMS IN DIAM RANGE
0" - 4"	BIGLEAF MAPLE	40
	DOUGLAS-FIR	40

	GRAND FIR	16
	CHERRY	4
4" - 8"	GRAND FIR	71
	BIGLEAF MAPLE	14
	OREGON WHITE OAK	14
8" PLUS	DOUGLAS-FIR	68
	GRAND FIR	16
	OREGON WHITE OAK	12
	BIGLEAF MAPLE	4

VOLUME/GROWTH TABLE :

	DOUG-FIR	GRAND FIR	OTHER SOFT	HARDWOODS	TOTAL
TOTAL STEM CUBIC FT VOLUME/AC	5639.6	233.3	0.0	117.2	5990.1
SCRIBNER BF VOLUME/AC (32' LOG, 6" TOP)	28565.7	251.6	0.0	0.0	28817.4
TOTAL STEM CUB FT (N) PAI PER AC	0.0	0.0	0.0	0.0	0.0
TOT STEM CUB FT (N) PAI GROWTH PERCENT	0.0	0.0	0.0	0.0	0.0
TOTAL STEM CUB FT (N) MAI PER AC	47.0	1.9	0.0	1.0	49.9
NUMBER OF 2" DIAM CLASSES PRESENT	18	6	0	5	23
NUMBER OF TREES SAMP CONTRIB TO TOP HT	19	1	0	0	

CROWN CLASS TABLE (DAMAGE IGNORED) : (ONLY TREES OVER 4.0" DBH)

CROWN CLASS	AVERAGE HEIGHT	AVERAGE CROWN LENGTH	AVERAGE DBH	BAS AREA/AC	PERCENT OF STAND BY BASAL AREA	NUMBER OF TREES/AC	PERCENT OF STAND BY TREES/AC
OPEN GROWN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PREDOMINANT	115.0	42.9	69.1	2.0	1.4	0.1	0.1
DOMINANT	141.5	47.5	31.0	106.0	73.3	19.6	23.5
CODOMINANT	101.2	50.7	21.3	18.0	12.4	6.1	7.4
INTERMEDIATE	41.3	25.2	7.8	16.6	11.4	46.0	55.3
SUPPRESSED	17.9	4.3	5.7	2.1	1.5	11.5	13.8

REGENERATION RECORD :

DBH	DOUGLAS FIR TREES PER ACRE	DOUGLAS FIR PERCENT DAMAGED	DOUGLAS FIR AVG HT	GRAND FIR TREES PER ACRE	GRAND FIR PERCENT DAMAGED	GRAND FIR AVG HT	OTHER SOFTWOODS TREES PER ACRE	OTHER SOFTWOODS PERCENT DAMAGED	OTHER SOFTWOODS AVG HT	HARDWOODS TREES PER ACRE	HARDWOODS PERCENT DAMAGED	HARDWOODS AVG HT
0.1-0.5	206.3	22	2.0	22.9	0	2.1	0.0	0	0.0	137.5	17	8.4
0.6-1.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	68.8	33	11.3
1.1-1.5	22.9	0	13.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0
1.6-2.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0
2.1-2.5	0.0	0	0.0	22.9	100	4.7	0.0	0	0.0	0.0	0	0.0
2.6-3.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0
3.1-3.5	0.0	0	0.0	22.9	0	22.6	0.0	0	0.0	0.0	0	0.0
3.6-4.0	0.0	0	0.0	22.9	0	28.7	0.0	0	0.0	45.8	100	22.5

TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 11

STAND SUMMARY TABLE (OVER ALL DCLASSES) BY SPECIES, (SOME VARIABLES EXPLAINED BELOW TABLE)

	DOUGLAS-FIR		GRAND FIR		OTHER SOFTWOODS		HARDWOODS	
	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE	22.8 AC TOTAL	PER ACRE
TOTAL NUMBER OF TREES	5895.5	258.6	2905.6	127.4	0.0	0.0	6161.1	270.2
0" - 4"	5225.4	229.2	2090.2	91.7	0.0	0.0	5747.9	252.1
4" - 8"	0.0	0.0	653.2	28.6	0.0	0.0	261.3	11.5
8" AND OVER	670.2	29.4	162.3	7.1	0.0	0.0	151.9	6.7
5 YR # MORT, 0" - 4"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5 YR # MORT, 4" - 8"	130.6	5.7	130.6	5.7	0.0	0.0	0.0	0.0
5 YR # MORT, 8" +	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAX 5 YR MORT DBH	7.9	7.9	7.8	7.8	0.0	0.0	0.0	0.0
PRESENT BASAL AREA	2923.2	128.2	309.9	13.6	0.0	0.0	251.5	11.0
BAS AREA 5 YR (N)PAI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOP HEIGHT OF FATTEST *	141.7	7.2 T	57.9	2.6 T	0.0	0.0 T	0.0	0.0 T
QUAD MEAN DIAM FAT *	31.0	7.2 T	11.9	2.6 T	0.0	0.0 T	0.0	0.0 T
TOTAL STEM VOLUME(CF)	128582.7	5639.6	5318.8	233.3	0.0	0.0	2672.0	117.2
TOTAL CUB 5 YR (N)PAI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL STEM CF MAI	1071.5	47.0	44.3	1.9	0.0	0.0	22.3	1.0
CUBIC VOL, 4" TOP	124238.3	5449.0	3570.1	156.6	0.0	0.0	0.0	0.0
CUB 5YR (N)PAI,4" TOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL CF MAI, 4" TOP	1035.3	45.4	29.8	1.3	0.0	0.0	0.0	0.0
SCRIBNER VOL, 32'-6"	651299.0	28565.7	5736.9	251.6	0.0	0.0	0.0	0.0
SCR 5YR (N)PAI,32'-6"	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL SCR MAI, 32'-6"	5427.5	238.0	47.8	2.1	0.0	0.0	0.0	0.0

* THE VALUE IN THE TOTAL COLUMN IS THE PER ACRE VALUE; THE VALUE IN THE PER ACRE COLUMN (FOLLOWED BY T) IS THE NUMBER OF TREES PER ACRE INCLUDED IN THE CALCULATION, IF LESS THAN 40, THEN THERE WERE NOT 40 TREES PER ACRE QUALIFIED TO BE INCLUDED

MORT : MORTALITY TREES - ONES THAT ARE ESTIMATED TO HAVE DIED WITHIN LAST 5 YEARS

CUB, CF : CUBIC FOOT
SCRB,SCR : SCRIBNER
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TRACT : 2, COMPARTMENT : 5, STAND NUMBER : 11

DIAMETER CLASS TABLES BY SPECIES FOLLOW (PER ACRE VALUES) :

DOUGLAS-FIR

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	229.2	0.2	3.1	0.2	1.8	0.0	0.0	0.0	0.0	0.0
8.1- 10.0	3.7	2.0	47.2	9.9	36.6	33.8	28.4	99.6	62.5	134.7
12.1- 14.0	2.5	2.0	74.9	12.2	59.5	56.4	53.1	237.2	181.1	297.3
20.1- 22.0	0.8	2.0	121.2	22.0	86.7	83.8	83.1	488.0	406.4	546.3
22.1- 24.0	2.0	6.0	116.9	23.4	245.0	236.7	235.0	1373.9	1130.3	1538.1
24.1- 26.0	1.7	6.0	138.6	25.3	288.2	278.5	276.6	1717.2	1461.6	1881.7
26.1- 28.0	4.4	18.0	127.4	27.3	758.2	732.9	727.8	4420.5	3670.8	4877.0
28.1- 30.0	5.2	24.0	143.3	29.2	1120.4	1083.3	1075.7	6787.1	5757.5	7383.4
30.1- 32.0	2.0	10.0	154.5	30.6	497.3	480.9	477.6	3087.1	2652.9	3328.1
32.1- 34.0	2.0	12.0	143.5	33.1	535.0	517.5	513.8	3255.7	2745.3	3535.5
34.1- 36.0	1.5	10.0	147.5	34.6	451.7	436.9	433.8	2773.6	2347.8	3001.8
36.1- 38.0	1.3	10.0	151.4	37.5	450.5	435.8	432.7	2785.6	2363.4	3008.2
40.1- 42.0	0.6	6.0	160.6	41.6	276.1	267.1	265.2	1732.6	1484.0	1861.9
42.1- 44.0	0.8	8.0	170.9	42.3	388.8	376.2	373.5	2481.5	2149.5	2648.7
44.1- 46.0	0.5	6.0	159.5	45.4	264.8	256.2	254.4	1645.6	1403.9	1778.3
48.1- 50.0	0.1	2.0	116.5	49.9	61.6	59.6	59.2	337.3	263.9	386.6
56.1- 58.0	0.1	2.0	127.3	56.3	64.3	62.2	61.8	354.8	284.4	407.2
68.1- 70.0	0.1	2.0	115.0	69.1	52.8	51.1	50.8	260.3	200.6	318.2
OVERALL TOTALS	258.6	128.2	16.7	3.2	5639.6	5449.0	5402.6	33837.5	28565.7	36933.0
MORTALITY	5.7	2.0	40.4	7.9	31.5	27.3	16.2	48.0	28.8	71.5

GRAND FIR

TOTAL	CUBIC	CUBIC	SCRIB BF VOL	SCRIB BF VOL	INT'L

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	CUBIC VOLUME	VOLUME 4" TOP	VOLUME 6" TOP	16'LOG 6" TOP	32'LOG 6" TOP	BF VOL 6" TOP
0.1- 2.0	22.9	0.0	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	68.8	4.1	18.7	3.2	44.4	0.0	0.0	0.0	0.0	0.0
4.1- 6.0	11.5	1.5	24.2	5.0	17.5	9.2	0.0	0.0	0.0	0.0
6.1- 8.0	17.2	4.0	38.6	6.5	66.9	50.9	10.2	26.4	16.0	44.1
8.1- 10.0	4.5	2.0	64.9	9.0	57.5	52.0	39.3	151.0	116.1	209.2
10.1- 12.0	2.6	2.0	57.9	11.9	47.0	44.5	41.5	170.6	119.6	217.9
OVERALL TOTALS	127.4	13.6	21.3	3.6	233.3	156.6	91.1	348.0	251.6	471.3
MORTALITY	5.7	1.9	38.1	7.8	30.4	26.1	15.0	44.0	26.2	65.9

OTHER SOFTWOODS

NONE OF THIS SPECIES/CATEGORY SAMPLED IN STAND

HARDWOODS

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	SCRIB BF VOL 16'LOG 6" TOP	SCRIB BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	206.3	0.4	9.4	0.5	1.6	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	45.8	3.5	22.5	3.8	33.0	0.0	0.0	0.0	0.0	0.0
6.1- 8.0	11.5	3.2	23.6	7.1	27.2	0.0	0.0	0.0	0.0	0.0
8.1- 10.0	5.1	2.0	33.5	8.5	24.8	0.0	0.0	0.0	0.0	0.0
14.1- 16.0	1.6	2.0	42.9	15.2	30.6	0.0	0.0	0.0	0.0	0.0
OVERALL TOTALS	270.2	11.0	12.9	1.6	117.2	0.0	0.0	0.0	0.0	0.0

TOTAL FOR ALL SPECIES (BOARD FT TOTALS ARE FOR SOFTWOODS ONLY)

SCRIB SCRIB

2 INCH DCLASS	NO OF TREES	BASAL AREA	AVG HT	AVG DBH	TOTAL CUBIC VOLUME	CUBIC VOLUME 4" TOP	CUBIC VOLUME 6" TOP	BF VOL 16'LOG 6" TOP	BF VOL 32'LOG 6" TOP	INT'L BF VOL 6" TOP
0.1- 2.0	458.4	0.6	5.9	0.3	3.4	0.0	0.0	0.0	0.0	0.0
2.1- 4.0	114.6	7.6	20.2	3.4	77.4	0.0	0.0	0.0	0.0	0.0
4.1- 6.0	11.5	1.5	24.2	5.0	17.5	9.2	0.0	0.0	0.0	0.0
6.1- 8.0	28.6	7.1	32.6	6.7	94.1	50.9	10.2	26.4	16.0	44.1
8.1- 10.0	13.3	6.0	48.0	9.1	119.0	85.8	67.7	250.6	178.5	344.0
10.1- 12.0	2.6	2.0	57.9	11.9	47.0	44.5	41.5	170.6	119.6	217.9
12.1- 14.0	2.5	2.0	74.9	12.2	59.5	56.4	53.1	237.2	181.1	297.3
14.1- 16.0	1.6	2.0	42.9	15.2	30.6	0.0	0.0	0.0	0.0	0.0
20.1- 22.0	0.8	2.0	121.2	22.0	86.7	83.8	83.1	488.0	406.4	546.3
22.1- 24.0	2.0	6.0	116.9	23.4	245.0	236.7	235.0	1373.9	1130.3	1538.1
24.1- 26.0	1.7	6.0	138.6	25.3	288.2	278.5	276.6	1717.2	1461.6	1881.7
26.1- 28.0	4.4	18.0	127.4	27.3	758.2	732.9	727.8	4420.5	3670.8	4877.0
28.1- 30.0	5.2	24.0	143.3	29.2	1120.4	1083.3	1075.7	6787.1	5757.5	7383.4
30.1- 32.0	2.0	10.0	154.5	30.6	497.3	480.9	477.6	3087.1	2652.9	3328.1
32.1- 34.0	2.0	12.0	143.5	33.1	535.0	517.5	513.8	3255.7	2745.3	3535.5
34.1- 36.0	1.5	10.0	147.5	34.6	451.7	436.9	433.8	2773.6	2347.8	3001.8
36.1- 38.0	1.3	10.0	151.4	37.5	450.5	435.8	432.7	2785.6	2363.4	3008.2
40.1- 42.0	0.6	6.0	160.6	41.6	276.1	267.1	265.2	1732.6	1484.0	1861.9
42.1- 44.0	0.8	8.0	170.9	42.3	388.8	376.2	373.5	2481.5	2149.5	2648.7
44.1- 46.0	0.5	6.0	159.5	45.4	264.8	256.2	254.4	1645.6	1403.9	1778.3
48.1- 50.0	0.1	2.0	116.5	49.9	61.6	59.6	59.2	337.3	263.9	386.6
56.1- 58.0	0.1	2.0	127.3	56.3	64.3	62.2	61.8	354.8	284.4	407.2
68.1- 70.0	0.1	2.0	115.0	69.1	52.8	51.1	50.8	260.3	200.6	318.2
OVERALL TOTALS	656.2	152.8	16.0	2.6	5990.1	5605.6	5493.7	34185.6	28817.4	37404.3
MORTALITY	11.5	3.9	39.2	7.9	62.0	53.4	31.1	92.0	54.9	137.4

APPENDIX C: LOGGING PLAN

Introduction

A logging plan has been prepared for the Forest Peak uneven-age management unit on Oregon State University's Dunn Forest in T. 10 S., R. 5 W., sec. 22, NW 1/4. The unit is approximately 22.8 acres of mature mixed Douglas-fir and grand fir. Aspect is southeast to west, and slopes vary from 20 to 50 percent.

The plan describes the logging project objectives and design. It includes profile and payload analyses of critical profiles. Refer to the unit map, Figure 8, for operations described below.

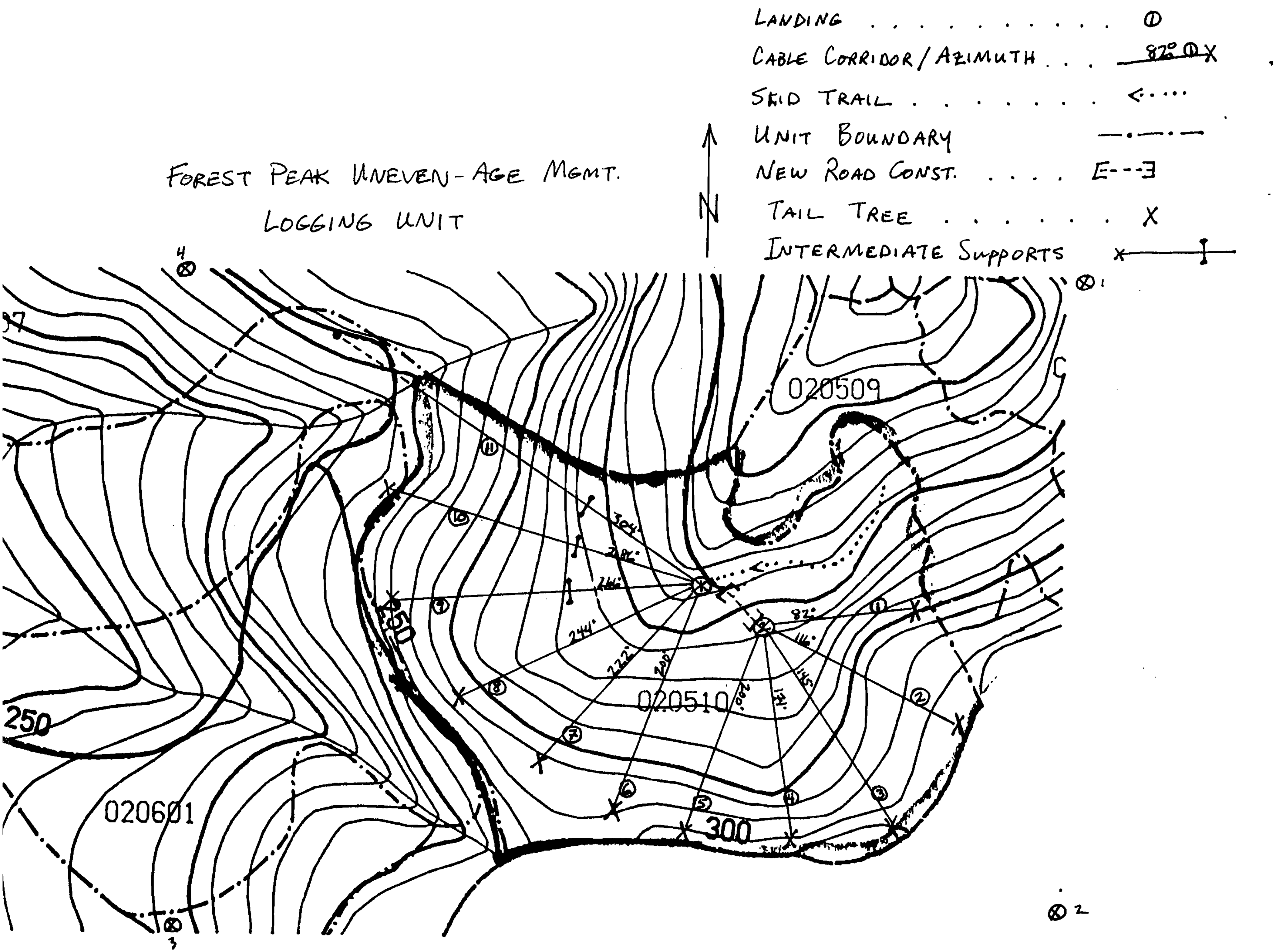
Harvest Plan Objectives

- Implement an uneven-age management strategy by designing a partial-cut cable logging system which can be used for future logging entries.
- Remove marked commercial-size timber while minimizing damage to the residual stand, including understory conifer regeneration.

Stand Characteristics and Cutting Prescription

The pre-harvest stand carried 44.5 MBF per acre and 60 trees per acre (TPA) in grand fir, Douglas-fir, bigleaf maple, and Oregon white oak greater than 8" dbh. There were 700 TPA in less than 8" dbh classes. The stand was marked for cut with blue paint. 17 TPA for 13.8 MBF/acre were removed in this cable

FOREST PEAK UNEVEN-AGE MGMT.
LOGGING UNIT



logging entry. Cut trees were located uniformly throughout the unit.

Unit Plan

Tree Felling.

In order to minimize damage to the residual stand, trees should be felled in a pattern which allows yarding with as little rubbing or rolling as possible. A herringbone pattern was preferable where slope conditions allowed it, however slope conditions usually dictated contour felling. Whenever possible, trees were felled away from conifer regeneration pockets.

Cable Yarding System.

The primary objective during yarding operations was to cause as little damage to the residual stand as possible. Residual stand included all understory conifer regeneration as well as mature trees. The unit was yarded with a Thunderbird TTY50 yarder and Danebo MSP mechanical slack-pulling carriage in a standing skyline configuration.

The unit was cable yarded to two landings at the top of the unit. Landing 1 used six skyline corridors, landing 2 used five skyline corridors.

Skyline corridors were layed out at approximately 250-foot intervals along the lower end, along Roads 250 and 300. Corridors and support trees were flagged with pink ribbon. Tail lift trees were required on all skyline corridors except 11, which anchored to a stump across Rd. 251. Corridors 9-11 required intermediate supports. Corridors 7-10 required a heavy equipment skyline anchor or deadman along Rd. 250. Corridors 2-6 anchored across Rd. 300 to stumps in a recent clearcut unit. Corridor 1 also required a heavy equipment or deadman skyline anchor as there were no suitable anchor stumps available.

Tower guyline anchors were selected with caution. The small trees behind the landings were only marginally suitable as anchors.

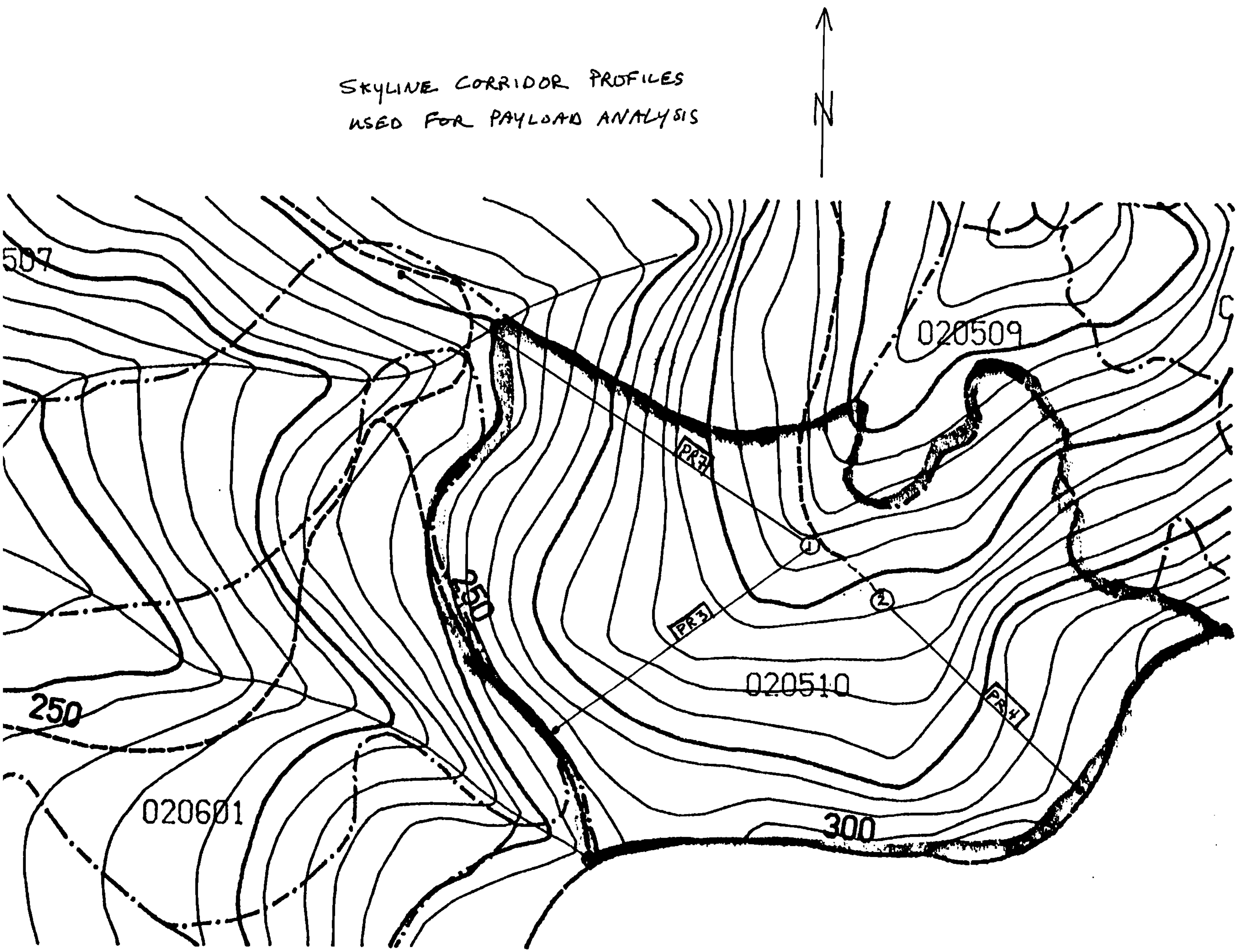
Log Hauling.

Logs were hauled out Road 251 to Road 250 to Tampico Road. The standing skyline was anchored across Road 251 at corridor 11, just north of the 251/250 junction. However, when no load is on the line, there was adequate room for a loaded log truck to pass beneath it. Radio contact between the truck driver and yarder operator was necessary during yarding of corridor 11 to ensure the skyline was bearing no load while trucks were passing underneath it.

Payload Analysis

Payload analysis was conducted using the LoggerPC II program; program outputs are included in Appendix C. Based on a log length of 34 feet and butt diameter of 36 inches, the design payload was approximately 10,000 pounds. Three profiles were selected as representative of the most difficult terrain: PR4 at

SKYLINE CORRIDOR PROFILES
USED FOR PAYLOAD ANALYSIS



144° from Landing 2, PR3 at 244° from Landing 1, and PR7 at 313° from Landing 1, as shown on the profile map, Figure 9. PR4 represents corridors 1-5, PR3 represents corridors 6-8, and PR7 represents corridors 9-11.

Yarder assumptions and detailed specifications are included in this Appendix. The rigging requirements in the following discussion were determined assuming at least one-end suspension of the design payload at all times.

Corridors 9-11 required a 35-foot intermediate support 260 feet slope distance below the tower due to the convex slope. Suggested intermediate support trees were flagged with pink. Corridor 11 anchored to a pink-flagged stump across Rd. 251, however Corridors 9 and 10 required at least 30-foot tail lift trees inside the unit.

All other corridors were single span with tail lift trees. Corridors 6-8 required rigging at 55 feet, while corridors 1-5 were rigged at 50 feet.

YARDER/CARRIAGE INFORMATION...TTY-50, MSP Carriage, Swaged Sky/Main

SPAR HEIGHT (FT)............. 50
CARRIAGE WEIGHT (LB).......... 800

	DIAMETER (IN)	WEIGHT (LB/FT)	SWL (LBS)	LENGTH (FT)
SKYLINE.........	1.13	2.80	50000	2000
MAINLINE........	0.75	1.28	23000	2700
HAULBACK........	0.75	1.04	19600	4400
SLACKPULLING....	0.50	0.46	8900	3100

The following information is required for running skyline analysis:

Haulback Drum Width............. 30.0 in
Haulback Drum Diameter (empty).. 13.0 in
Max Haulback Drum Torque........ 12240 ft-lb

PROFILE: PR4 (Corridors 1-5)

T.P.#	X COORD	Y COORD	SLOPE DIST	% SLOPE
1	0	0		
			20	0
2	20	0		
			75	-26
3	93	-19		
			75	-33
4	164	-42		
			75	-40
5	233	-70		
			75	-40
6	303	-98		
			75	-40
7	373	-126		
			75	-39
8	443	-153		
			75	-38
9	513	-180		
			75	-36
10	583	-205		

---------------------< STANDING SKYLINE LOAD ANALYSIS >----------------

PROFILE: a:\loggerpc\FORPK .PR4 YARDER: a:\loggerpc\TTY50 .YRD

HEADSPAR TP = 1
HEADSPAR HT = 50
LANDING CUT(-)/FILL(+) = 0
SUSPENSION = PARTIAL
PARTIAL LOG CLEARANCE = 2
FULL LOG CLEARANCE = 2
LOG LENGTH = 34

TAILSPAR TP = 10
TAILSPAR HT = 50
YARDING TOWARDS YARDER
TAG LENGTH = 10

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
SKYLINE	870	2000
MAINLINE	645	2700
HAULBACK	1440	4400

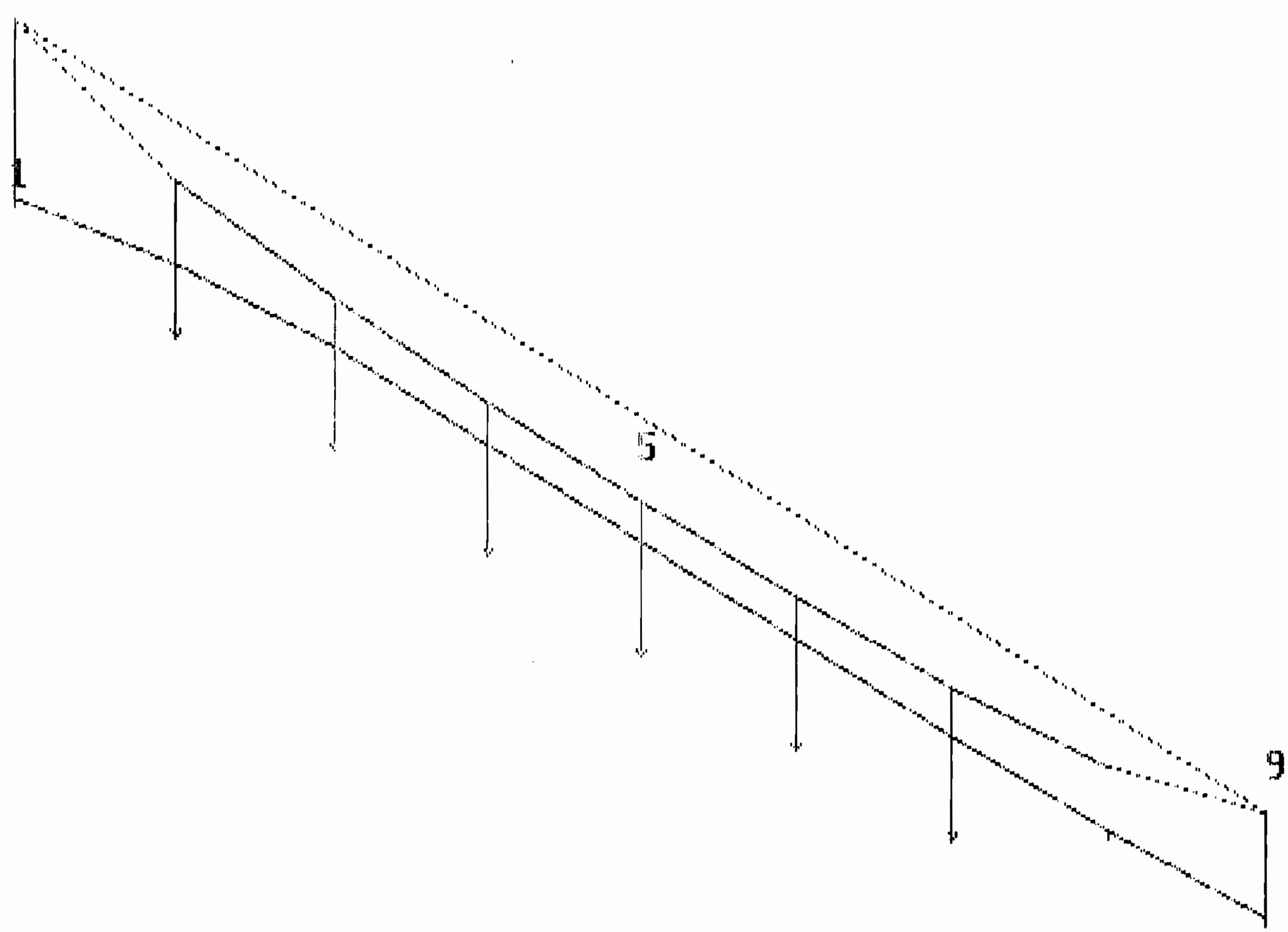
* Indicates the available line length is less than what is required.

TP	PAYLOAD AT TP	PAYLOAD TO YARDER	LINE AT SWL	LINE FOR INHAUL	LOG CLEAR	SKYLINE CLEAR	TYPE OF SUSPENSION
2	35024	35024	SKYLINE	MAINLINE	23.8	32.8	PARTIAL
3	18084	18084	SKYLINE	MAINLINE	9.8	17.1	PARTIAL
4	14091	14091	SKYLINE	MAINLINE	5.0*	11.5	PARTIAL
5	11685	11685	SKYLINE	MAINLINE	6.3	13.0	PARTIAL
6	10388	10388	SKYLINE	MAINLINE	8.9	16.0	PARTIAL
7	9953	9953	SKYLINE	MAINLINE	12.9	20.5	PARTIAL
8	10497	9953	SKYLINE	MAINLINE	17.7	26.0	PARTIAL
9	13155	9953	SKYLINE	MAINLINE	24.3	33.2	PARTIAL

------------------------------< * = Critical pt >-------------------------

PROFILE : FORPK .PR4

SCALE: 100 ft =



PROFILE: PR3 (CORRIDORS 6-8)

T.P.#	X COORD	Y COORD	SLOPE DIST	% SLOPE
1	0	0		
			15	0
2	15	0		
			75	-31
3	87	-22		
			75	-32
4	158	-45		
			75	-30
5	230	-67		
			75	-35
6	301	-91		
			75	-46
7	369	-123		
			75	-58
8	434	-160		
			75	-35
9	504	-185		
			60	-42
10	560	-208		

----------------------< STANDING SKYLINE LOAD ANALYSIS >------------------

PROFILE: a:\loggerpc\FORPK .PR3   YARDER: a:\loggerpc\TTY50 .YRD

HEADSPAR TP = 1   TAILSPAR TP = 9
HEADSPAR HT = 50   TAILSPAR HT = 55
LANDING CUT(-)/FILL(+) = 0   YARDING TOWARDS YARDER
SUSPENSION = PARTIAL
PARTIAL LOG CLEARANCE = 2
FULL LOG CLEARANCE = 2
LOG LENGTH = 34   TAG LENGTH = 10

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
SKYLINE	805	2000
MAINLINE	565	2700
HAULBACK	1290	4400

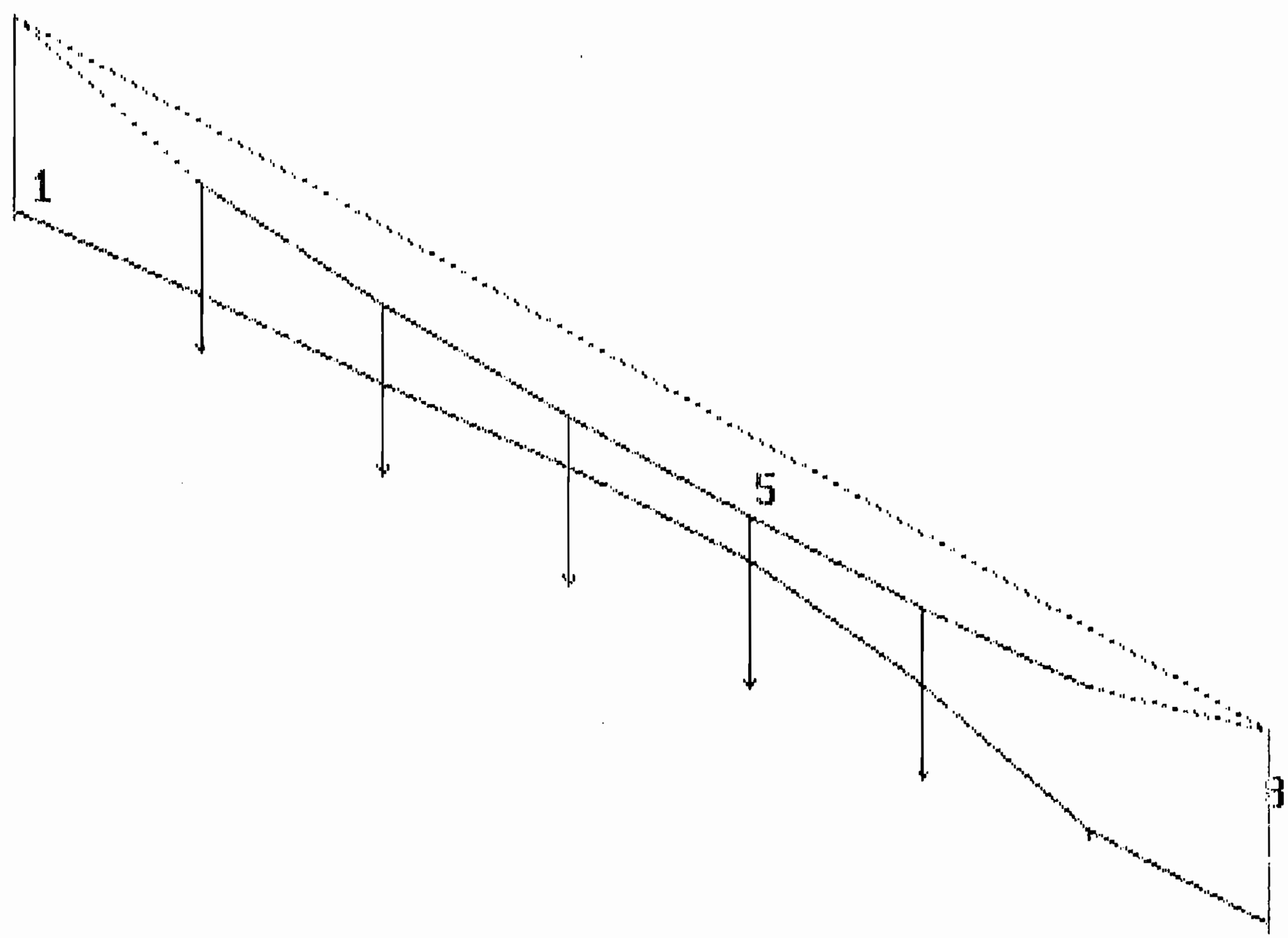
* Indicates the available line length is less than what is required.

TP	PAYLOAD AT TP	PAYLOAD TO YARDER	LINE AT SWL	LINE FOR INHAUL	LOG CLEAR	SKYLINE CLEAR	TYPE OF SUSPENSION
2	35900	35900	MAINLINE	MAINLINE	26.8	36.0	PARTIAL
3	16243	16243	SKYLINE	MAINLINE	15.4	23.4	PARTIAL
4	13952	13952	SKYLINE	MAINLINE	9.6	17.0	PARTIAL
5	13298	13298	SKYLINE	MAINLINE	5.0*	11.6	PARTIAL
6	11790	11790	SKYLINE	MAINLINE	5.2	11.6	PARTIAL
7	10451	10451	SKYLINE	MAINLINE	13.5	20.9	PARTIAL
8	11738	10451	SKYLINE	MAINLINE	30.4	39.9	PARTIAL

-----------------------------< * = Critical pt >-------------------------

PROFILE : FORPK .PR3

SCALE: 100 ft =



CORRIDORS 9, 10

---------------------< MULTISPAN SKYLINE LOAD ANALYSIS >----------------

PROFILE: a:\loggerpc\FORPK .PR7 YARDER: a:\loggerpc\TTY50 .YRD

HEADSPAR TP = 1
HEADSPAR HT = 50
LANDING CUT(-)/FILL(+) = 0
SUSPENSION = PARTIAL
PARTIAL LOG CLEARANCE = 2
FULL LOG CLEARANCE = 2
LOG LENGTH = 34

TAILSPAR TP = 14
TAILSPAR HT = 30
YARDING TOWARDS YARDER

TAG LENGTH = 10

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
SKYLINE	1051	2000
MAINLINE	852	2700
HAULBACK	1742	4400

* Indicates the available line length is less than what is required.

CHORD SLOPES:

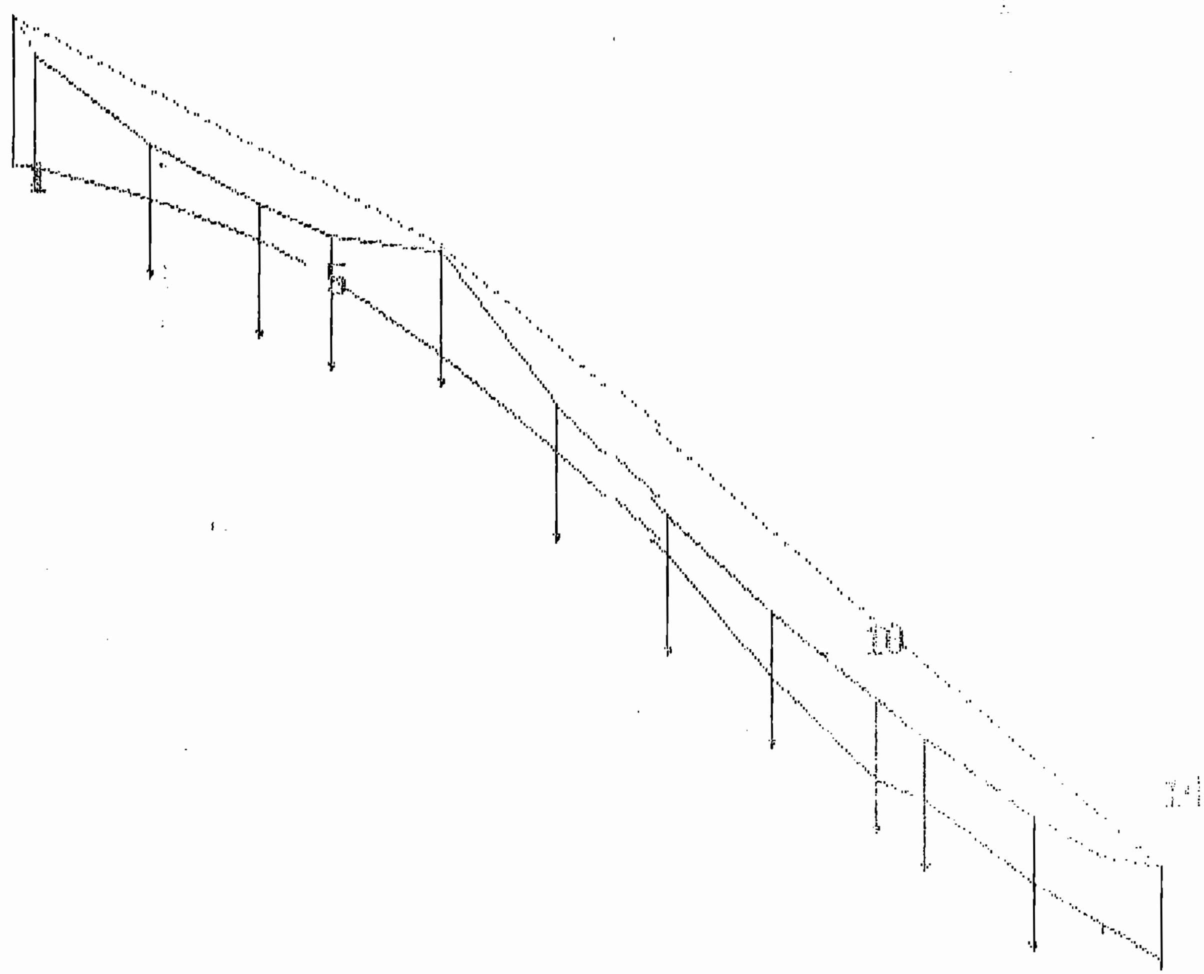
SUPPORT 1	X = 0.0	Y = 0.0	CHORD SLOPE = -28.0
SUPPORT 2	X = 277.1	Y = 76.1	CHORD SLOPE = -44.0
SUPPORT 3	X = 740.8	Y = 278.3	

TP	PAYLOAD AT TP	PAYLOAD TO YARDER	LINE AT SWL	LINE FOR INHAUL	LOG CLEAR	SKYLINE CLEAR	TYPE OF SUSPENSION
2	39274	39274	MAINLINE	MAINLINE	27.3	36.7	PARTIAL
3	24658	24658	SKYLINE	MAINLINE	9.9	17.6	PARTIAL
4	23020	23020	SKYLINE	MAINLINE	4.9*	11.7	PARTIAL
5	22462	22462	SKYLINE	MAINLINE	6.9	13.8	PARTIAL
6 - 35 FT INTERMEDIATE SUPPORT							
7	16411	16411	SKYLINE	MAINLINE	8.1	15.0	PARTIAL
8	12448	12448	SKYLINE	MAINLINE	5.8	12.0	PARTIAL
9	10861	10861	SKYLINE	MAINLINE	13.4	20.9	PARTIAL
10	12730	10861	SKYLINE	MAINLINE	17.3	25.9	PARTIAL
11	12784	10861	SKYLINE	MAINLINE	11.8	19.3	PARTIAL
12	16922	10861	SKYLINE	MAINLINE	14.2	22.2	PARTIAL
13	25356	10861	SKYLINE	MAINLINE	13.8	21.8	PARTIAL

------------------------------< * = Critical pt >------------------------

PROFILE : a:\loggerpc\FORPR .PR?

SCALE: 100 ft =



Corridor 11

MULTISPAN SKYLINE LOAD ANALYSIS

PROFILE: a:\loggerpc\FORPK .PR7   YARDER: a:\loggerpc\TTY50 .YRD

HEADSPAR TP = 1   TAILSPAR TP = 19
HEADSPAR HT = 50   TAILSPAR HT = 2
LANDING CUT(-)/FILL(+) = 0   YARDING TOWARDS YARDER
SUSPENSION = PARTIAL
PARTIAL LOG CLEARANCE = 2
FULL LOG CLEARANCE = 2
LOG LENGTH = 34   TAG LENGTH = 10

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
SKYLINE	1153	2000
MAINLINE	891	2700
HAULBACK	2038	4400

* Indicates the available line length is less than what is required.

CHORD SLOPES:

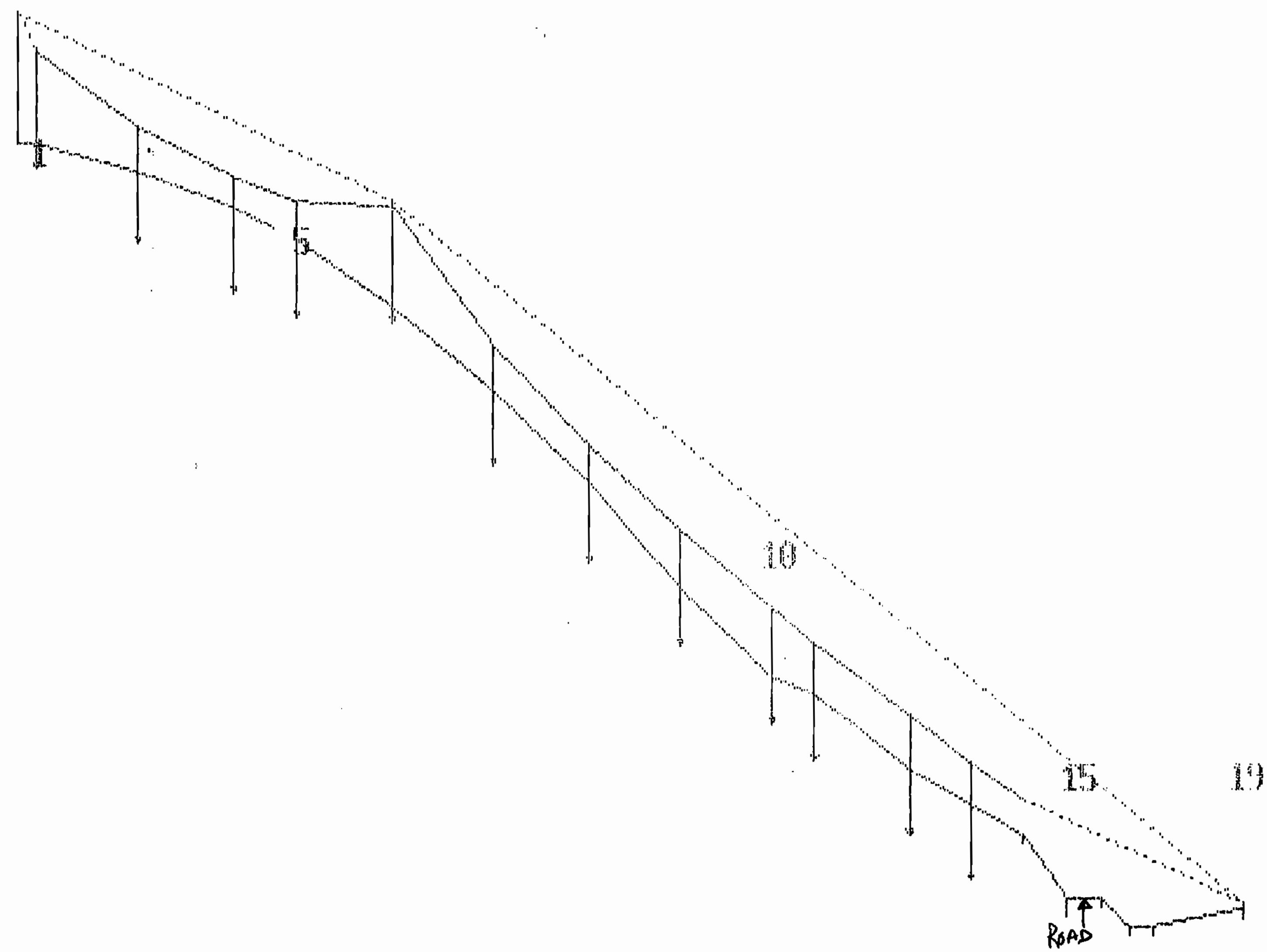
SUPPORT 1	X = 0.0	Y = 0.0	CHORD SLOPE = -26.0
SUPPORT 2	X = 277.1	Y = 71.1	CHORD SLOPE = -42.0
SUPPORT 3	X = 905.8	Y = 334.4	

TP	PAYLOAD AT TP	PAYLOAD TO YARDER	LINE AT SWL	LINE FOR INHAUL	LOG CLEAR	SKYLINE CLEAR	TYPE OF SUSPENSION
2	37777	37777	MAINLINE	MAINLINE	26.0	35.4	PARTIAL
3	30438	30438	SKYLINE	MAINLINE	8.8	16.4	PARTIAL
4	27226	27226	SKYLINE	MAINLINE	4.9*	11.7	PARTIAL
5	25741	25741	SKYLINE	MAINLINE	8.0	15.0	PARTIAL
	6 - 40 FT INTERMEDIATE SUPPORT						
7	17672	17672	SKYLINE	MAINLINE	10.2	17.4	PARTIAL
8	13114	13114	SKYLINE	MAINLINE	7.3	13.8	PARTIAL
9	10961	10961	SKYLINE	MAINLINE	14.4	22.0	PARTIAL
10	11928	10961	SKYLINE	MAINLINE	17.5	26.1	PARTIAL
11	11423	10961	SKYLINE	MAINLINE	11.5	18.8	PARTIAL
12	12697	10961	SKYLINE	MAINLINE	11.6	19.3	PARTIAL
13	14492	10961	SKYLINE	MAINLINE	8.3	15.5	PARTIAL
14	11917	10961	SKYLINE	MAINLINE	6.9	13.1	PARTIAL

* = Critical pt

PROFILE : a:\loggerpc\FORPK .PR7

SCALE: 100 ft =



PROFILE: PR7 (CORRIDORS 9-11)

T.P.#	X COORD	Y COORD	SLOPE DIST	% SLOPE
1	0	0		
			15	0
2	15	0		
			75	-13
3	89	-10		
			72	-20
4	160	-24		
			48	-27
5	206	-36		
			75	-35
6	277	-61		
			80	-43
7	351	-93		
			79	-46
8	422	-126		
			78	-59
9	490	-165		
			75	-50
10	557	-199		
			32	-19
11	588	-205		
			75	-41
12	657	-233		
			48	-30
13	703	-247		
			39	-30
14	741	-258		
			40	-74
15	773	-282		
			27	0
16	800	-282		
			23	-55
17	820	-293		
			18	0
18	838	-293		
			68	10
19	906	-286		

APPENDIX D: REGRESSION ANALYSIS DOCUMENTATION

The following pages are outputs from the STATGRAPHICS program, a statistical software package used for the step-wise regression analysis in this study.

Stepwise Selection for BUCK.Eff

Selection: Backward   Maximum steps: 500   F-to-enter: 4.00
Control: Manual   Step: 0   F-to-remove: 4.00

R-squared: .65487   Adjusted: .63832   MSE: 54766.3   d.f.: 146

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
1. BUCK.diam	-8.87766	.2553			
2. BUCK.logs	107.779	5.3381			
3. BUCK.cuts	26.8398	.5764			
4. BUCK.mth	177.790	23.5937			
5. BUCK.slp	2.30324	1.2285			
6. BUCK.lay	-2.95857	3.1947			
7. BUCK.diam_sq	0.99995	7.9560			

Stepwise Selection for BUCK.Eff

Selection: Backward   Maximum steps: 500   F-to-enter: 4.00
Control: Manual   Step: 1   F-to-remove: 4.00

R-squared: .65427   Adjusted: .64016   MSE: 54488.9   d.f.: 147

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
2. BUCK.logs	106.938	5.2887	1. BUCK.diam	.0418	.255
3. BUCK.cuts	26.2800	.5560			
4. BUCK.mth	173.647	23.8168			
5. BUCK.slp	2.52470	1.5526			
6. BUCK.lay	-2.91051	3.1178			
7. BUCK.diam_sq	0.82461	130.3080			

Stepwise Selection for BUCK.Eff

Selection: Backward   Maximum steps: 500   F-to-enter: 4.00
Control: Manual   Step: 2   F-to-remove: 4.00

R-squared: .65296   Adjusted: .64123   MSE: 54325.4   d.f.: 148

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
2. BUCK.logs	138.622	54.0267	1. BUCK.diam	.0398	.232
4. BUCK.mth	169.134	23.3382	3. BUCK.cuts	.0614	.556
5. BUCK.slp	2.57301	1.6191			
6. BUCK.lay	-3.00350	3.3494			
7. BUCK.diam_sq	0.83287	136.5460			

Stepwise Selection for BUCK.Eff

Selection: Backward   Maximum steps: 500   F-to-enter: 4.00
Control: Manual   Step: 3   F-to-remove: 4.00

R-squared: .64916   Adjusted: .63974   MSE: 54551.2   d.f.: 149

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
2. BUCK.logs	138.811	53.9528	1. BUCK.diam	.0605	.543
4. BUCK.mth	166.132	22.5261	3. BUCK.cuts	.0643	.615
6. BUCK.lay	-3.16896	3.7366	5. BUCK.slp	.1040	1.619
7. BUCK.diam_sq	0.82522	134.4507			

Stepwise Selection for BUCK.Eff

Selection: Backward   Maximum steps: 500   F-to-enter: 4.00
Control: Manual   Step: 4   F-to-remove: 4.00

R-squared: .64036   Adjusted: .63317   MSE: 55546.4   d.f.: 150

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
2. BUCK.logs	137.632	52.1446	1. BUCK.diam	.0531	.421
4. BUCK.mth	156.200	19.9871	3. BUCK.cuts	.0756	.856
7. BUCK.diam_sq	0.83835	137.5311	5. BUCK.slp	.1148	1.990
			6. BUCK.lay	.1564	3.736

Model fitting results for: BUCK.Eff

Independent variable	coefficient	std. error	t-value	sig.leve
CONSTANT	-122.401918	59.009874	-2.0743	0.039
BUCK.logs	137.632307	19.059692	7.2211	0.000
BUCK.mth	156.200032	34.938648	4.4707	0.000
BUCK.diam_sq	0.838347	0.071486	11.7274	0.000

R-SQ. (ADJ.) = 0.6332 SE= 235.682818 MAE= 168.832022 DurbWat= 1.840
Previously: 0.0000 0.000000 0.000000 0.000
154 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Stepwise Selection for FELL.Eff

Selection: Backward	Maximum steps: 500	F-to-enter: 4.00
Control: Manual	Step: 0	F-to-remove: 4.00

R-squared: .63953 Adjusted: .62224 MSE: 60226 d.f.: 146

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
1. FELL.diam	-20.8368	1.2953			
2. FELL.logs	136.332	3.2327			
3. FELL.cuts	27.7732	.1934			
4. FELL.mth	162.011	18.1435			
5. FELL.slp	3.80511	2.8554			
6. FELL.lay	-0.93400	.2887			
7. FELL.diam_sq	1.20967	10.6672			

Stepwise Selection for FELL.Eff

Selection: Backward	Maximum steps: 500	F-to-enter: 4.00
Control: Manual	Step: 1	F-to-remove: 4.00

R-squared: .63905 Adjusted: .62432 MSE: 59895.6 d.f.: 147

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
1. FELL.diam	-20.8571	1.3050	3. FELL.cuts	.0364	.193
2. FELL.logs	168.100	53.3838			
4. FELL.mth	163.105	18.5701			
5. FELL.slp	4.05047	3.4661			
6. FELL.lay	-0.99910	.3346			
7. FELL.diam_sq	1.20878	10.7106			

Stepwise Selection for FELL.Eff

Selection: Backward	Maximum steps: 500	F-to-enter: 4.00
Control: Manual	Step: 2	F-to-remove: 4.00

R-squared: .63823 Adjusted: .62600 MSE: 59626.3 d.f.: 148

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
1. FELL.diam	-20.3526	1.2511	3. FELL.cuts	.0403	.238
2. FELL.logs	168.800	54.2226	6. FELL.lay	.0477	.334
4. FELL.mth	159.768	18.3242			
5. FELL.slp	4.15644	3.6925			
7. FELL.diam_sq	1.20215	10.6516			

Stepwise Selection for FELL.Eff

Selection: Backward　　Maximum steps: 500　　F-to-enter: 4.00
Control: Manual　　Step: 3　　F-to-remove: 4.00

R-squared: .63517　　Adjusted: .62537　　MSE: 59726.8　　d.f.: 149

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
2. FELL.logs	165.820	52.9522	1. FELL.diam	.0916	1.251
4. FELL.mth	151.959	17.1488	3. FELL.cuts	.0399	.236
5. FELL.slp	4.66382	4.8547	6. FELL.lay	.0430	.274
7. FELL.diam_sq	0.79873	113.8609			

Model fitting results for: FELL.Eff

Independent variable	coefficient	std. error	t-value	sig.leve
CONSTANT	-240.054485	108.674009	-2.2089	0.028
FELL.logs	165.819949	22.787406	7.2768	0.000
FELL.mth	151.959441	36.695293	4.1411	0.000
FELL.slp	4.663819	2.116708	2.2033	0.029
FELL.diam_sq	0.798731	0.074854	10.6706	0.000

R-SQ. (ADJ.) = 0.6254　SE= 244.390643　MAE= 148.073289　DurbWat= 2.396
Previously: 0.6332　235.682818　168.832022　1.840
154 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Stepwise Selection for YARD.PROD

Selection: Backward	Maximum steps: 500	F-to-enter: 4.00
Control: Manual	Step: 0	F-to-remove: 4.00

R-squared: .43587 Adjusted: .42695 MSE: 5694.51 d.f.: 253

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Ente
1. YARD.YDIS	0.19459	41.6241			
2. YARD.LDIS	1.57774	74.3193			
3. YARD.SET	50.9863	4.8480			
4. YARD.TURN	25.4097	22.5049			

Model fitting results for: YARD.PROD

Independent variable	coefficient	std. error	t-value	sig.leve
CONSTANT	168.636347	28.684236	5.8791	0.000
YARD.YDIS	0.194592	0.030161	6.4517	0.000
YARD.LDIS	1.577744	0.183015	8.6209	0.000
YARD.SET	50.986348	23.156433	2.2018	0.028
YARD.TURN	25.409688	5.356251	4.7439	0.000

R-SQ. (ADJ.) = 0.4269 SE= 75.462009 MAE= 55.330539 DurbWat= 1.815
Previously: 0.0000 0.000000 0.000000 0.000
258 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

APPENDIX E: OWNING AND OPERATING COST CALCULATIONS

The following pages are outputs from the PACE program, a spreadsheet-driven software package which calculates operating and ownership costs based on user-input values.

------------------------------------ Summary ------------------------------------

*** Felling Crew Labor ***

Ownership		
Depreciable value:	$	0.00
Equipment depreciation:	$	0.00 / Year
Interest expense:	$	0.00 / Year
Taxes, license, insurance and storage:	$	0.00 / Year
Annual ownership cost:	$	0.00 / Year
Ownership cost (Subtotal):	$	0.00 / Hour
Machine operating		
Repairs and maintenance:	$	0.00 / Hour
Fuel and oil:	$	0.00 / Hour
Lines and rigging:	$	0.00 / Hour
Tires or tracks:	$	0.00 / Hour
Equipment operating cost (Subtotal):	$	0.00 / Hour
Labor		
Direct labor cost:	$	51.97 / Hour
Supervision and overhead:	$	7.80 / Hour
Labor cost (Subtotal):	$	59.76 / Hour
OWNERSHIP COST	$	0.00 / Hour
OPERATING COST	$	0.00 / Hour
LABOR COST	$	59.76 / Hour
Machine rate (Ownership + Operating + Labor)	$	59.76 / Hour

*** Press [RETURN] for the menu ***

IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM5 Labor Costs FMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

:->Base wage for 1st crew position (Per hour)	$	20.42
: Base wage for 2nd crew position (Per hour)	$	16.70
: Base wage for 3rd crew position (Per hour)	$	0.00
: Base wage for 4th crew position (Per hour)	$	0.00
: Base wage for 5th crew position (Per hour)	$	0.00
: Base wage for 6th crew position (Per hour)	$	0.00
: Fringe benefits	%	40.00
: Travel time per day (Hours)	#	0.00
: Operating time per day (Hours)	#	6.00
: Percent of direct labor cost for supervision	%	15.00

GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

: Total number of workers:	#	2.00
: Total crew wage (Per hour):	$	37.12
: Direct labor cost:	$	51.97
: Supervision and overhead:	$	7.80
: Labor cost (Subtotal):	$	59.76
: Total operating cost (Operating+Labor):	$	59.76

HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

Current value = 20.42

[ESC]=Menu (Highlight value to change and press return)

------------------------------------ Summary ------------------------------------

*** Four Stihl 064 Falling Saws Owning and Operating costs ***

Ownership		
Depreciable value:	$	1,937.00
Equipment depreciation:	$	1,291.33 / Year
Interest expense:	$	348.62 / Year
Taxes, license, insurance and storage:	$	54.62 / Year
Annual ownership cost:	$	1,694.57 / Year
Ownership cost (Subtotal):	$	1.09 / Hour
Machine operating		
Repairs and maintenance:	$	0.75 / Hour
Fuel and oil:	$	0.85 / Hour
Lines and rigging:	$	0.75 / Hour
Tires or tracks:	$	0.50 / Hour
Equipment operating cost (Subtotal):	$	2.85 / Hour
Labor		
Direct labor cost:	$	0.00 / Hour
Supervision and overhead:	$	0.00 / Hour
Labor cost (Subtotal):	$	0.00 / Hour
OWNERSHIP COST	$	1.09 / Hour
OPERATING COST	$	2.85 / Hour
LABOR COST	$	0.00 / Hour
Machine rate (Ownership + Operating + Labor)	$	3.93 / Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                              $       3,228.00
:    Minus line and rigging cost                         $           0.00
:    Minus tire or track replacement cost                $           0.00
:    Minus residual (salvage) value                      $       1,291.00
:  Life of equipment  (Years)                            #           1.50
:  Number of days worked per year                        #         260.00
:  Number of hours worked per day                        #           6.00
:  Interest Expense                                      %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage                %           1.88
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                    $       1,937.00
:  Equipment depreciation:                               $       1,291.33
:  Average annual investment:                            $       2,905.17
:  Interest expense:                                     $         348.62
:  Taxes, license, insurance and storage:                $          54.62
:  Annual ownership cost:                                $       1,694.57
:  Annual utilization (Hours per year):                  #       1,560.00
:  Ownership cost (Dollars per hour):                    $           1.09
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =      3,228.00
[ESC]=Menu       (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs         %          90.00
:  Fuel amount  (Gallons per hour)                       #           0.23
:  Fuel cost  (Per gallon)                               $           1.46
:  Percent of fuel consumption for lubricants            %          45.00
:  Cost of oil and lubricants  (Per gallon)              $           5.00
:  Cost of lines                                         $         100.00
:  Estimated life of lines  (Hours)                      #         400.00
:  Cost of rigging                                       $          40.00
:  Estimated life of rigging  (Hours)                    #          80.00
:  Cost of tires or tracks                               $         619.00
:  Estimated life of tires or tracks  (Hours)            #       1,238.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                              $           0.75
:  Fuel:                                                 $           0.34
:  Oil and lubricants:                                   $           0.52
:  Lines:                                                $           0.25
:  Rigging:                                              $           0.50
:  Tires or tracks:                                      $           0.50
:  Equipment operating cost  (Subtotal):                 $           2.85
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =         90.00
[ESC]=Menu       (Highlight value to change and press return)
```

------------------------------------ Summary ------------------------------------

*** 1/2-ton 4WD Pickup ***

Ownership			
Depreciable value:	$	16,668.00	
Equipment depreciation:	$	2,083.50	/ Year
Interest expense:	$	1,347.33	/ Year
Taxes, license, insurance and storage:	$	211.08	/ Year
Annual ownership cost:	$	3,641.91	/ Year
Ownership cost (Subtotal):	$	1.75	/ Hour
Machine operating			
Repairs and maintenance:	$	0.50	/ Hour
Fuel and oil:	$	1.14	/ Hour
Lines and rigging:	$	0.00	/ Hour
Tires or tracks:	$	0.20	/ Hour
Equipment operating cost (Subtotal):	$	1.84	/ Hour
Labor			
Direct labor cost:	$	0.00	/ Hour
Supervision and overhead:	$	0.00	/ Hour
Labor cost (Subtotal):	$	0.00	/ Hour
OWNERSHIP COST	$	1.75	/ Hour
OPERATING COST	$	1.84	/ Hour
LABOR COST	$	0.00	/ Hour
Machine rate (Ownership + Operating + Labor)	$	3.59	/ Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                          $      18,520.00
:     Minus line and rigging cost                    $           0.00
:     Minus tire or track replacement cost           $           0.00
:     Minus residual (salvage) value                 $       1,852.00
:  Life of equipment  (Years)                        #           8.00
:  Number of days worked per year                    #         260.00
:  Number of hours worked per day                    #           8.00
:  Interest Expense                                  %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage            %           1.88
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                $      16,668.00
:  Equipment depreciation:                           $       2,083.50
:  Average annual investment:                        $      11,227.75
:  Interest expense:                                 $       1,347.33
:  Taxes, license, insurance and storage:            $         211.08
:  Annual ownership cost:                            $       3,641.91
:  Annual utilization (Hours per year):              #       2,080.00
:  Ownership cost (Dollars per hour):                $           1.75
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =      18,520.00
[ESC]=Menu        (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs     %          50.00
:  Fuel amount  (Gallons per hour)                   #           0.83
:  Fuel cost  (Per gallon)                           $           1.28
:  Percent of fuel consumption for lubricants        %           1.75
:  Cost of oil and lubricants  (Per gallon)          $           5.00
:  Cost of lines                                     $           0.00
:  Estimated life of lines  (Hours)                  #           0.00
:  Cost of rigging                                   $           0.00
:  Estimated life of rigging  (Hours)                #           0.00
:  Cost of tires or tracks                           $         480.00
:  Estimated life of tires or tracks  (Hours)        #       2,400.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                          $           0.50
:  Fuel:                                             $           1.06
:  Oil and lubricants:                               $           0.07
:  Lines:                                            $           0.00
:  Rigging:                                          $           0.00
:  Tires or tracks:                                  $           0.20
:  Equipment operating cost  (Subtotal):             $           1.84
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =          50.00
[ESC]=Menu        (Highlight value to change and press return)
```

```
---------------------------------- Summary ----------------------------------------
                       *** Yarding Crew Labor Only ***
Ownership
    Depreciable value:                                  $          0.00
    Equipment depreciation:                             $          0.00 / Year
    Interest expense:                                   $          0.00 / Year
    Taxes, license, insurance and storage:              $          0.00 / Year
    Annual ownership cost:                              $          0.00 / Year
    Ownership cost (Subtotal):                          $          0.00 / Hour
Machine operating
    Repairs and maintenance:                            $          0.00 / Hour
    Fuel and oil:                                       $          0.00 / Hour
    Lines and rigging:                                  $          0.00 / Hour
    Tires or tracks:                                    $          0.00 / Hour
    Equipment operating cost  (Subtotal):               $          0.00 / Hour
Labor
    Direct labor cost:                                  $         93.46 / Hour
    Supervision and overhead:                           $         14.02 / Hour
    Labor cost (Subtotal):                              $        107.48 / Hour

OWNERSHIP COST                                          $          0.00 / Hour
OPERATING COST                                          $          0.00 / Hour
LABOR COST                                              $        107.48 / Hour
Machine rate (Ownership + Operating + Labor)            $        107.48 / Hour
                     *** Press [RETURN] for the menu ***
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM5 Labor Costs FMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Base wage for 1st crew position  (Per hour)     $        11.93
:  Base wage for 2nd crew position  (Per hour)     $        10.34
:  Base wage for 3rd crew position  (Per hour)     $        10.34
:  Base wage for 4th crew position  (Per hour)     $        12.45
:  Base wage for 5th crew position  (Per hour)     $        10.85
:  Base wage for 6th crew position  (Per hour)     $        10.85
:  Fringe benefits                                 %        40.00
:  Travel time per day (Hours)                     #         0.00
:  Operating time per day (Hours)                  #         8.00
:  Percent of direct labor cost for supervision    %        15.00
:
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:
:  Total number of workers:                        #         6.00
:  Total crew wage (Per hour):                     $        66.76
:  Direct labor cost:                              $        93.46
:  Supervision and overhead:                       $        14.02
:  Labor cost (Subtotal):                          $       107.48
:  Total operating cost (Operating+Labor):         $       107.48
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =       11.93
[ESC]=Menu      (Highlight value to change and press return)
```

------------------------------------ Summary ------------------------------------

*** TTY50 Yarder/Danebo MSP Carriage Owning and Operating Costs ***

Ownership		
Depreciable value:	$	323,790.00
Equipment depreciation:	$	40,473.75 / Year
Interest expense:	$	37,095.68 / Year
Taxes, license, insurance and storage:	$	7,202.74 / Year
Annual ownership cost:	$	84,772.16 / Year
Ownership cost (Subtotal):	$	40.76 / Hour
Machine operating		
Repairs and maintenance:	$	9.73 / Hour
Fuel and oil:	$	12.06 / Hour
Lines and rigging:	$	17.19 / Hour
Tires or tracks:	$	1.25 / Hour
Equipment operating cost (Subtotal):	$	40.23 / Hour
Labor		
Direct labor cost:	$	0.00 / Hour
Supervision and overhead:	$	0.00 / Hour
Labor cost (Subtotal):	$	0.00 / Hour
OWNERSHIP COST	$	40.76 / Hour
OPERATING COST	$	40.23 / Hour
LABOR COST	$	0.00 / Hour
Machine rate (Ownership + Operating + Labor)	$	80.98 / Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                              $     475,000.00
:     Minus line and rigging cost                        $      47,340.00
:     Minus tire or track replacement cost               $       8,000.00
:     Minus residual (salvage) value                     $      95,870.00
:  Life of equipment  (Years)                            #           8.00
:  Number of days worked per year                        #         260.00
:  Number of hours worked per day                        #           8.00
:  Interest Expense                                      %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage                %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                    $     323,790.00
:  Equipment depreciation:                               $      40,473.75
:  Average annual investment:                            $     309,130.62
:  Interest expense:                                     $      37,095.68
:  Taxes, license, insurance and storage:                $       7,202.74
:  Annual ownership cost:                                $      84,772.16
:  Annual utilization (Hours per year):                  #       2,080.00
:  Ownership cost (Dollars per hour):                    $          40.76
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                         Current value =    475,000.00
[ESC]=Menu       (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs         %          50.00
:  Fuel amount  (Gallons per hour)                       #          13.00
:  Fuel cost  (Per gallon)                               $           0.84
:  Percent of fuel consumption for lubricants            %           1.75
:  Cost of oil and lubricants  (Per gallon)              $           5.00
:  Cost of lines                                         $      31,299.00
:  Estimated life of lines  (Hours)                      #       2,375.00
:  Cost of rigging                                       $      16,041.00
:  Estimated life of rigging  (Hours)                    #       4,000.00
:  Cost of tires or tracks                               $       8,000.00
:  Estimated life of tires or tracks  (Hours)            #       6,400.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                              $           9.73
:  Fuel:                                                 $          10.92
:  Oil and lubricants:                                   $           1.14
:  Lines:                                                $          13.18
:  Rigging:                                              $           4.01
:  Tires or tracks:                                      $           1.25
:  Equipment operating cost  (Subtotal):                 $          40.23
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                         Current value =          50.00
[ESC]=Menu       (Highlight value to change and press return)
```

---------------------------------- Summary --

*** Yarding Crew Crummies 1/2-ton 4WD PU + 4WD Suburban ***

Ownership			
Depreciable value:	$	36,108.00	
Equipment depreciation:	$	4,513.50	/ Year
Interest expense:	$	3,020.58	/ Year
Taxes, license, insurance and storage:	$	586.50	/ Year
Annual ownership cost:	$	8,120.58	/ Year
Ownership cost (Subtotal):	$	3.90	/ Hour
Machine operating			
Repairs and maintenance:	$	1.08	/ Hour
Fuel and oil:	$	2.27	/ Hour
Lines and rigging:	$	0.00	/ Hour
Tires or tracks:	$	0.52	/ Hour
Equipment operating cost (Subtotal):	$	3.88	/ Hour
Labor			
Direct labor cost:	$	0.00	/ Hour
Supervision and overhead:	$	0.00	/ Hour
Labor cost (Subtotal):	$	0.00	/ Hour
OWNERSHIP COST	$	3.90	/ Hour
OPERATING COST	$	3.88	/ Hour
LABOR COST	$	0.00	/ Hour
Machine rate (Ownership + Operating + Labor)	$	7.78	/ Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                               $      41,520.00
:     Minus line and rigging cost                         $           0.00
:     Minus tire or track replacement cost                $       1,260.00
:     Minus residual (salvage) value                      $       4,152.00
:  Life of equipment  (Years)                             #           8.00
:  Number of days worked per year                         #         260.00
:  Number of hours worked per day                         #           8.00
:  Interest Expense                                       %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage                 %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                     $      36,108.00
:  Equipment depreciation:                                $       4,513.50
:  Average annual investment:                             $      25,171.50
:  Interest expense:                                      $       3,020.58
:  Taxes, license, insurance and storage:                 $         586.50
:  Annual ownership cost:                                 $       8,120.58
:  Annual utilization (Hours per year):                   #       2,080.00
:  Ownership cost (Dollars per hour):                     $           3.90
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                         Current value =     41,520.00
[ESC]=Menu       (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs          %          50.00
:  Fuel amount  (Gallons per hour)                        #           1.66
:  Fuel cost  (Per gallon)                                $           1.28
:  Percent of fuel consumption for lubricants             %           1.75
:  Cost of oil and lubricants  (Per gallon)               $           5.00
:  Cost of lines                                          $           0.00
:  Estimated life of lines  (Hours)                       #           0.00
:  Cost of rigging                                        $           0.00
:  Estimated life of rigging  (Hours)                     #           0.00
:  Cost of tires or tracks                                $       1,260.00
:  Estimated life of tires or tracks  (Hours)             #       2,400.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                               $           1.08
:  Fuel:                                                  $           2.12
:  Oil and lubricants:                                    $           0.15
:  Lines:                                                 $           0.00
:  Rigging:                                               $           0.00
:  Tires or tracks:                                       $           0.52
:  Equipment operating cost  (Subtotal):                  $           3.88
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                         Current value =          50.00
[ESC]=Menu       (Highlight value to change and press return)
```

------------------------------------ Summary ------------------------------------

*** John Deere 648 Grapple Skidder ***

Ownership			
Depreciable value:	$	97,316.00	
Equipment depreciation:	$	32,438.67	/ Year
Interest expense:	$	11,528.00	/ Year
Taxes, license, insurance and storage:	$	2,238.35	/ Year
Annual ownership cost:	$	46,205.02	/ Year
Ownership cost (Subtotal):	$	22.21	/ Hour
Machine operating			
Repairs and maintenance:	$	9.36	/ Hour
Fuel and oil:	$	1.03	/ Hour
Lines and rigging:	$	0.00	/ Hour
Tires or tracks:	$	1.87	/ Hour
Equipment operating cost (Subtotal):	$	12.26	/ Hour
Labor			
Direct labor cost:	$	0.00	/ Hour
Supervision and overhead:	$	0.00	/ Hour
Labor cost (Subtotal):	$	0.00	/ Hour
OWNERSHIP COST	$	22.21	/ Hour
OPERATING COST	$	12.26	/ Hour
LABOR COST	$	0.00	/ Hour
Machine rate (Ownership + Operating + Labor)	$	34.47	/ Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                                 $     131,000.00
:     Minus line and rigging cost                           $           0.00
:     Minus tire or track replacement cost                  $       7,484.00
:     Minus residual (salvage) value                        $      26,200.00
:   Life of equipment  (Years)                              #           3.00
:   Number of days worked per year                          #         260.00
:   Number of hours worked per day                          #           8.00
:   Interest Expense                                        %          12.00
:   Percent of average annual investment for:
:   Taxes, License, Insurance, and Storage                  %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:   Depreciable value:                                      $      97,316.00
:   Equipment depreciation:                                 $      32,438.67
:   Average annual investment:                              $      96,066.66
:   Interest expense:                                       $      11,528.00
:   Taxes, license, insurance and storage:                  $       2,238.35
:   Annual ownership cost:                                  $      46,205.02
:   Annual utilization (Hours per year):                    #       2,080.00
:   Ownership cost (Dollars per hour):                      $          22.21
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                          Current value =     131,000.00
[ESC]=Menu      (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs            %          60.00
:   Fuel amount  (Gallons per hour)                         #           1.11
:   Fuel cost  (Per gallon)                                 $           0.84
:   Percent of fuel consumption for lubricants              %           1.75
:   Cost of oil and lubricants  (Per gallon)                $           5.00
:   Cost of lines                                           $           0.00
:   Estimated life of lines  (Hours)                        #           0.00
:   Cost of rigging                                         $           0.00
:   Estimated life of rigging  (Hours)                      #           0.00
:   Cost of tires or tracks                                 $       7,484.00
:   Estimated life of tires or tracks  (Hours)              #       4,000.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:   Repairs and maintenance:                                $           9.36
:   Fuel:                                                   $           0.93
:   Oil and lubricants:                                     $           0.10
:   Lines:                                                  $           0.00
:   Rigging:                                                $           0.00
:   Tires or tracks:                                        $           1.87
:   Equipment operating cost  (Subtotal):                   $          12.26
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                          Current value =          60.00
[ESC]=Menu      (Highlight value to change and press return)
```

------------------------------------ Summary ------------------------------------

*** Tailhold Crawler Tractor ***

Ownership		
Depreciable value:	$	60,000.00
Equipment depreciation:	$	15,000.00 / Year
Interest expense:	$	6,300.00 / Year
Taxes, license, insurance and storage:	$	1,223.25 / Year
Annual ownership cost:	$	22,523.25 / Year
Ownership cost (Subtotal):	$	10.83 / Hour
Machine operating		
Repairs and maintenance:	$	2.88 / Hour
Fuel and oil:	$	0.49 / Hour
Lines and rigging:	$	0.00 / Hour
Tires or tracks:	$	0.00 / Hour
Equipment operating cost (Subtotal):	$	3.38 / Hour
Labor		
Direct labor cost:	$	0.00 / Hour
Supervision and overhead:	$	0.00 / Hour
Labor cost (Subtotal):	$	0.00 / Hour
OWNERSHIP COST	$	10.83 / Hour
OPERATING COST	$	3.38 / Hour
LABOR COST	$	0.00 / Hour
Machine rate (Ownership + Operating + Labor)	$	14.20 / Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                             $      75,000.00
:     Minus line and rigging cost                       $           0.00
:     Minus tire or track replacement cost              $           0.00
:     Minus residual (salvage) value                    $      15,000.00
:  Life of equipment  (Years)                           #           4.00
:  Number of days worked per year                       #         260.00
:  Number of hours worked per day                       #           8.00
:  Interest Expense                                     %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage               %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                   $      60,000.00
:  Equipment depreciation:                              $      15,000.00
:  Average annual investment:                           $      52,500.00
:  Interest expense:                                    $       6,300.00
:  Taxes, license, insurance and storage:               $       1,223.25
:  Annual ownership cost:                               $      22,523.25
:  Annual utilization (Hours per year):                 #       2,080.00
:  Ownership cost (Dollars per hour):                   $          10.83
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =      75,000.00
[ESC]=Menu        (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs        %          40.00
:  Fuel amount  (Gallons per hour)                      #           0.53
:  Fuel cost  (Per gallon)                              $           0.84
:  Percent of fuel consumption for lubricants           %           1.75
:  Cost of oil and lubricants  (Per gallon)             $           5.00
:  Cost of lines                                        $           0.00
:  Estimated life of lines  (Hours)                     #           0.00
:  Cost of rigging                                      $           0.00
:  Estimated life of rigging  (Hours)                   #           0.00
:  Cost of tires or tracks                              $           0.00
:  Estimated life of tires or tracks  (Hours)           #           0.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                             $           2.88
:  Fuel:                                                $           0.45
:  Oil and lubricants:                                  $           0.05
:  Lines:                                               $           0.00
:  Rigging:                                             $           0.00
:  Tires or tracks:                                     $           0.00
:  Equipment operating cost  (Subtotal):                $           3.38
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =          40.00
[ESC]=Menu        (Highlight value to change and press return)
```

------------------------------- Summary -------------------------------

*** Fire Truck Owning and Operating Costs ***

Ownership		
Depreciable value:	$	9,000.00
Equipment depreciation:	$	1,125.00 / Year
Interest expense:	$	727.50 / Year
Taxes, license, insurance and storage:	$	141.26 / Year
Annual ownership cost:	$	1,993.76 / Year
Ownership cost (Subtotal):	$	0.96 / Hour
Machine operating		
Repairs and maintenance:	$	0.16 / Hour
Fuel and oil:	$	0.00 / Hour
Lines and rigging:	$	0.00 / Hour
Tires or tracks:	$	0.00 / Hour
Equipment operating cost (Subtotal):	$	0.16 / Hour
Labor		
Direct labor cost:	$	0.00 / Hour
Supervision and overhead:	$	0.00 / Hour
Labor cost (Subtotal):	$	0.00 / Hour
OWNERSHIP COST	$	0.96 / Hour
OPERATING COST	$	0.16 / Hour
LABOR COST	$	0.00 / Hour
Machine rate (Ownership + Operating + Labor)	$	1.12 / Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                               $     10,000.00
:    Minus line and rigging cost                          $          0.00
:    Minus tire or track replacement cost                 $          0.00
:    Minus residual (salvage) value                       $      1,000.00
:  Life of equipment  (Years)                             #          8.00
:  Number of days worked per year                         #        260.00
:  Number of hours worked per day                         #          8.00
:  Interest Expense                                       %         12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage                 %          2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDL
:  Depreciable value:                                     $      9,000.00
:  Equipment depreciation:                                $      1,125.00
:  Average annual investment:                             $      6,062.50
:  Interest expense:                                      $        727.50
:  Taxes, license, insurance and storage:                 $        141.26
:  Annual ownership cost:                                 $      1,993.76
:  Annual utilization (Hours per year):                   #      2,080.00
:  Ownership cost (Dollars per hour):                     $          0.96
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =     10,000.00
[ESC]=Menu       (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs          %         30.00
:  Fuel amount  (Gallons per hour)                        #          0.00
:  Fuel cost  (Per gallon)                                $          0.00
:  Percent of fuel consumption for lubricants             %          0.00
:  Cost of oil and lubricants  (Per gallon)               $          0.00
:  Cost of lines                                          $          0.00
:  Estimated life of lines  (Hours)                       #          0.00
:  Cost of rigging                                        $          0.00
:  Estimated life of rigging  (Hours)                     #          0.00
:  Cost of tires or tracks                                $          0.00
:  Estimated life of tires or tracks  (Hours)             #          0.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                               $          0.16
:  Fuel:                                                  $          0.00
:  Oil and lubricants:                                    $          0.00
:  Lines:                                                 $          0.00
:  Rigging:                                               $          0.00
:  Tires or tracks:                                       $          0.00
:  Equipment operating cost  (Subtotal):                  $          0.16
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        Current value =         30.00
[ESC]=Menu       (Highlight value to change and press return)
```

---------------------------------- Summary ----------------------------------

*** Ownership and Labor for Tail/Int Support/Anchor Rigging and Tools ***

Ownership			
Depreciable value:	$	35,673.00	
Equipment depreciation:	$	14,269.20	/ Year
Interest expense:	$	2,996.53	/ Year
Taxes, license, insurance and storage:	$	581.83	/ Year
Annual ownership cost:	$	17,847.56	/ Year
Ownership cost (Subtotal):	$	8.58	/ Hour
Machine operating			
Repairs and maintenance:	$	0.00	/ Hour
Fuel and oil:	$	0.00	/ Hour
Lines and rigging:	$	0.00	/ Hour
Tires or tracks:	$	0.00	/ Hour
Equipment operating cost (Subtotal):	$	0.00	/ Hour
Labor			
Direct labor cost:	$	17.84	/ Hour
Supervision and overhead:	$	2.68	/ Hour
Labor cost (Subtotal):	$	20.51	/ Hour
OWNERSHIP COST	$	8.58	/ Hour
OPERATING COST	$	0.00	/ Hour
LABOR COST	$	20.51	/ Hour
Machine rate (Ownership + Operating + Labor)	$	29.09	/ Hour

*** Press [RETURN] for the menu ***

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                            $      35,673.00
:    Minus line and rigging cost                       $           0.00
:    Minus tire or track replacement cost              $           0.00
:    Minus residual (salvage) value                    $           0.00
:  Life of equipment  (Years)                          #           2.50
:  Number of days worked per year                      #         260.00
:  Number of hours worked per day                      #           8.00
:  Interest Expense                                    %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage              %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                  $      35,673.00
:  Equipment depreciation:                             $      14,269.20
:  Average annual investment:                          $      24,971.10
:  Interest expense:                                   $       2,996.53
:  Taxes, license, insurance and storage:              $         581.83
:  Annual ownership cost:                              $      17,847.56
:  Annual utilization (Hours per year):                #       2,080.00
:  Ownership cost (Dollars per hour):                  $           8.58
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                             Current value =     35,673.00
[ESC]=Menu         (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM5 Labor Costs FMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Base wage for 1st crew position  (Per hour)         $          12.74
:  Base wage for 2nd crew position  (Per hour)         $           0.00
:  Base wage for 3rd crew position  (Per hour)         $           0.00
:  Base wage for 4th crew position  (Per hour)         $           0.00
:  Base wage for 5th crew position  (Per hour)         $           0.00
:  Base wage for 6th crew position  (Per hour)         $           0.00
:  Fringe benefits                                     %          40.00
:  Travel time per day (Hours)                         #           0.00
:  Operating time per day (Hours)                      #           8.00
:  Percent of direct labor cost for supervision        %          15.00
:
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:
:  Total number of workers:                            #           1.00
:  Total crew wage (Per hour):                         $          12.74
:  Direct labor cost:                                  $          17.84
:  Supervision and overhead:                           $           2.68
:  Labor cost (Subtotal):                              $          20.51
:  Total operating cost (Operating+Labor):             $          20.51
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                             Current value =         12.74
[ESC]=Menu         (Highlight value to change and press return)
```

---------------------------------- Summary --

*** John Deere Log Loader JD 892D-LC ***

Ownership			
Depreciable value:	$	216,300.00	
Equipment depreciation:	$	27,037.50	/ Year
Interest expense:	$	22,542.00	/ Year
Taxes, license, insurance and storage:	$	4,376.90	/ Year
Annual ownership cost:	$	53,956.41	/ Year
Ownership cost (Subtotal):	$	23.06	/ Hour
Machine operating			
Repairs and maintenance:	$	7.51	/ Hour
Fuel and oil:	$	7.42	/ Hour
Lines and rigging:	$	0.00	/ Hour
Tires or tracks:	$	2.33	/ Hour
Equipment operating cost (Subtotal):	$	17.26	/ Hour
Labor			
Direct labor cost:	$	17.96	/ Hour
Supervision and overhead:	$	2.69	/ Hour
Labor cost (Subtotal):	$	20.66	/ Hour
OWNERSHIP COST	$	23.06	/ Hour
OPERATING COST	$	17.26	/ Hour
LABOR COST	$	20.66	/ Hour
Machine rate (Ownership + Operating + Labor)	$	60.97	/ Hour

*** Press [RETURN] for the menu ***

IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM5 Labor Costs FMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

:->Base wage for 1st crew position (Per hour)	$	12.83
Base wage for 2nd crew position (Per hour)	$	0.00
Base wage for 3rd crew position (Per hour)	$	0.00
Base wage for 4th crew position (Per hour)	$	0.00
Base wage for 5th crew position (Per hour)	$	0.00
Base wage for 6th crew position (Per hour)	$	0.00
Fringe benefits	%	40.00
Travel time per day (Hours)	#	0.00
Operating time per day (Hours)	#	9.00
Percent of direct labor cost for supervision	%	15.00

GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

Total number of workers:	#	1.00
Total crew wage (Per hour):	$	12.83
Direct labor cost:	$	17.96
Supervision and overhead:	$	2.69
Labor cost (Subtotal):	$	20.66
Total operating cost (Operating+Labor):	$	37.91

HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

Current value = 12.83

[ESC]=Menu (Highlight value to change and press return)

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Ownership Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Delivered equipment cost                            $     289,000.00
:    Minus line and rigging cost                       $           0.00
:    Minus tire or track replacement cost              $      14,900.00
:    Minus residual (salvage) value                    $      57,800.00
:  Life of equipment  (Years)                          #           8.00
:  Number of days worked per year                      #         260.00
:  Number of hours worked per day                      #           9.00
:  Interest Expense                                    %          12.00
:  Percent of average annual investment for:
:  Taxes, License, Insurance, and Storage              %           2.33
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Depreciable value:                                  $     216,300.00
:  Equipment depreciation:                             $      27,037.50
:  Average annual investment:                          $     187,850.00
:  Interest expense:                                   $      22,542.00
:  Taxes, license, insurance and storage:              $       4,376.90
:  Annual ownership cost:                              $      53,956.41
:  Annual utilization (Hours per year):                #       2,340.00
:  Ownership cost (Dollars per hour):                  $          23.06
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                           Current value =     289,000.00
[ESC]=Menu        (Highlight value to change and press return)
```

```
IMMMMMMMMMMMMMMMMMMMMMMMMM5 Equipment Operating Costs FMMMMMMMMMMMMMMMMMMMMMMMMM
:
:->Percent of equipment depreciation for repairs       %          65.00
:  Fuel amount  (Gallons per hour)                     #           8.00
:  Fuel cost  (Per gallon)                             $           0.84
:  Percent of fuel consumption for lubricants          %           1.75
:  Cost of oil and lubricants  (Per gallon)            $           5.00
:  Cost of lines                                       $           0.00
:  Estimated life of lines  (Hours)                    #           0.00
:  Cost of rigging                                     $           0.00
:  Estimated life of rigging  (Hours)                  #           0.00
:  Cost of tires or tracks                             $      14,900.00
:  Estimated life of tires or tracks  (Hours)          #       6,400.00
GDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
:  Repairs and maintenance:                            $           7.51
:  Fuel:                                               $           6.72
:  Oil and lubricants:                                 $           0.70
:  Lines:                                              $           0.00
:  Rigging:                                            $           0.00
:  Tires or tracks:                                    $           2.33
:  Equipment operating cost  (Subtotal):               $          17.26
:
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                           Current value =          65.00
[ESC]=Menu        (Highlight value to change and press return)
```