Session 6
Paper (a)

COMPUTER MODELS TO ASSIST PLANNERS AND LOGGERS IN DECISION-MAKING

Paper presented to the LIRA 1989 "Cable Logging" Seminar by

Glen Murphy
Harvest Planning Group, Forest Research Institute

INTRODUCTION

The number and range of computer models to assist planners and loggers in decision-making has grown at a remarkable rate over the last decade. Machine costing, budget forecasting and control, short-term harvest scheduling, skyline payload analysis, landing layout and design, and production estimation are examples of the many types of problems for which computer models have been developed. It would be impossible to review all of them in this paper – instead I have selected a sample of those I am familiar with to reflect the range available.

For ease of description the models will be split into two categories – those that require a digitizer as part of their operation, and those that do not. Some new approaches are also described.

NON-DIGITIZER BASED APPLICATIONS

LOGGERPC

LOGGERPC is a skyline analysis program written for the IBM PC and compatible computers. The analysis procedures are adapted from the US Forest Service program LOGGER.

LOGGERPC computes the skyline payloads for the following cable hauler systems; live skyline, standing skyline, running skyline, and multispan skyline. Payload capability is based on the safe working load of the lines.

The user creates the ground profile he wishes to analyse, describes the hauler in terms of specifications such as tower height, carriage weight and safe working loads of the lines, and inputs yarding parameters (headspar height, tailspar height, terrain point step size, yarding direction, carriage clearance, log length, suspension category, and strop length).

DRAFT COPY ONLY

LOGGERPC is an easy-to-use menu-driven program which has good graphics capability. It has been widely tested in the US and New Zealand and is well accepted. Although imperial units are specified in the program the planner can use metric units as long as he is consistent, e.g., for weight use kilograms, for length or height use metres, and for line weight use kilograms/metre. A copy of LOGGERPC is available from LIRA.

PROYARD

The PROYARD computer model was developed in 1987 by Joosang Chung, a Forest Engineering Master's graduate from Oregon State University. The program estimates cable hauler payload capability. It expands the applicability of existing packages (such as LOGGERPC) and is user friendly. It has six system options: live skyline, standing skyline, running skyline, slackline, multispan and highlead. In the standing skyline and multispan analyses, load path analysis, as well as payload analysis, are available as options.

Specifically, PROYARD considers the following systems or options which are not available in LOGGERPC:

1. The information to tension the unloaded skyline of the standing skyline.
2. The layload capability of the running skyline including consideration of the torque capability of the haulback drum.
3. The slackline system analysis for specified skyline and haulback tensions.
4. The analysis of multispan considering jack friction and carriage passage over the support jack.
5. The highlead system analysis considering mainline drag on the ground.
6. Options to consider the leading and trailing log end diameters, and the distance of the hook point from the leading end.
7. Options to specify the log-to-ground friction.
8. Summation of horizontal and vertical components of the cable tensions at the spars for use in guyline analysis.

TABLE 1: Differences in payload capability estimates from using the LOGGERPC and PROYARD models

Model	Log dimensions (inches)	Average payload (lbs)	% difference from LOGGERPC
LOGGERPC	R1 = R2	38042	—
PROYARD	R1 = 32, R2 = 40	39328	+ 3.4
PROYARD	R1 = 40, R2 = 32	36340	- 4.5
PROYARD	R1 = 20, R2 = 40	41947	+ 10.3
PROYARD	R1 = 40, R2 = 20	33567	- 11.8

Results of the live skyline analysis by varying the log dimensions, where R1 = diameter of leading end and R2 = diameter of trailing end of log.

	LOGGERPC		PROYARD	
Terrain point	Payload (lbs)	Limiting factor	Payload (lbs)	Limiting factor
1	33790	mainline	33790	mainline
2	32560	mainline	26038	yarder
3	28340	mainline	17889	yarder
4	28340	mainline	17889	yarder
•	•	•	•	•
•	•	•	•	•
10	28340	mainline	17889	yarder

Comparison of running skyline payload zone analyses: (1) analysis without considering the yarder payload capability, e.g., LOGGERPC and (2) analysis considering the yarder payload capability, e.g., PROYARD.

Terrain point	Live skyline payload (lbs)	Slackline payload (lbs)
1	59258	59258
2	46891	52881
3	34284	43747
4	34284	43747
•	•	•
•	•	•
10	34284	43747

Comparison between the live skyline analysis and slackline analysis. Note: LOGGERPC cannot model slackline systems but PROYARD can.

A copy of PROYARD may be available from Dr J. Sessions, Forest Engineering Department, Oregon State University.

The main advantage LOGGERPC has over PROYARD is greater graphics capability.

The following three tables show the differences in estimated payload capability that a logging planner might find if PROYARD were used instead of LOGGERPC (Chung, 1987).

WILBANKS's Running Skyline Model

Many running skyline analysis models require the user to specify maximum allowable line tensions. Often the safe working load of the line is chosen. This assumes that the tensioning capability of the hauler is not a limiting factor. Wilbanks and Session (1985) have shown that payloads estimated by using design tensions equal to the safe working load of the line can be significantly higher than payloads estimated by using the tensioning capacity of the hauler.

Wilbanks's model is written in Microsoft BASIC for the IBM-PC. Three categories of running skyline are modelled: non-regenerative brake, mechanical interlock, and variable ratio hydraulic interlock. In order to estimate performance each component of the hauler is modelled. These include the engine, the torque converter, gearbox, and drum set. Full suspension and partial suspension conditions are also modelled.

Wilbanks and Sessions (1985) showed the potential size of error involved when predicting payloads using design tensions unrelated to the tensioning capability of the hauler. If the safe working load (one-third of the breaking strength) of a 19 mm haulback line were used as the limiting haulback tension for the mechanical interlock hauler the payload capability would be overestimated by as much as 86%.

A copy of Wilbanks' model may be obtained from Dr J. Sessions, Forest Engineering Department, Oregon State University.

COLCO2

Many of the decisions logging planners and loggers make are related to economics. The costing program COLCO2 (Duggan, 1988) developed by LIRA is a good example of such computer models, although many other such models do exist, e.g., RATESETTER (Rawlins *et al.*, 1986), COSTS (Gilchrist, unpublished), and PACE (Sessions, 1986).

COLCO2 is written on the SUPERCALC4 spreadsheet program but is also available on LOTUS 1,2,3. The program is divided into four sections: machine costing, labour costing, operating supplies costs, and costs summary and unit rate calculation. Specific machine types which can be costed at present include skidders, front-end loaders, tractors, and haulers.

The ability to test the sensitivity of any input on total cost is a particularly useful feature of COLCO2.

TARGET

TARGET is a hauler target setting template written by the author for the LOTUS 1,2,3 spreadsheet which runs on IBM compatible personal computers.

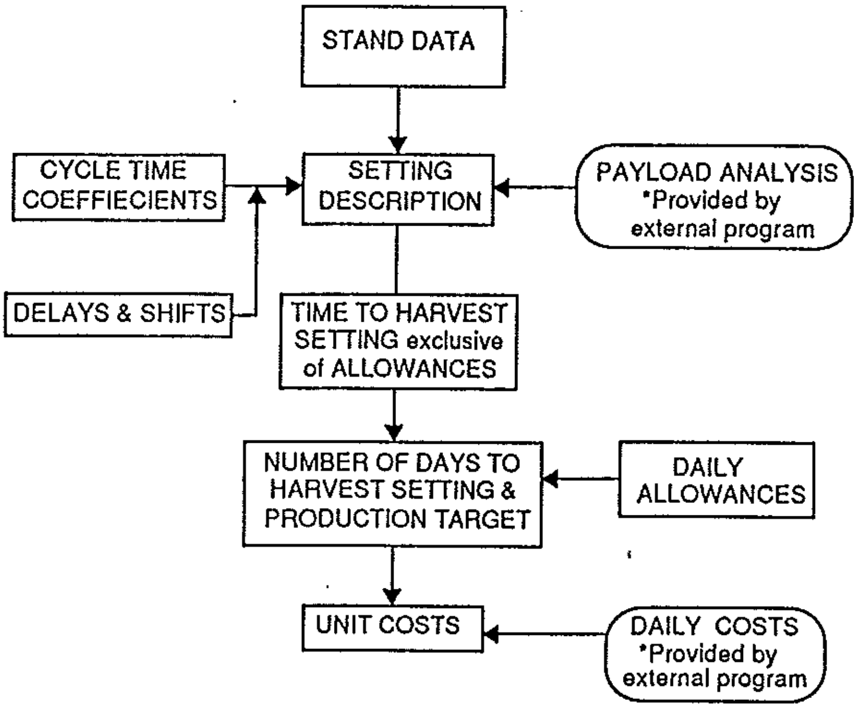


FIGURE 1: Structure of the TARGET spreadsheet

TARGET calculates a daily production target and unit costs for a complete logging setting based on stand, terrain and logging system information. It is menu-driven, so the user can quickly move to various parts of the spreadsheet.

The user must first provide and enter hauler production work-study information and resave the spreadsheet in a working format. Time coefficients (distance, volume, number of pieces) must be provided for each of the hauler systems likely to be used. Coefficients for up to six systems may be specified.

DRAFT COPY ONLY

Times for the various delays associated with cable logging systems can then be entered, e.g., cycle time delays, rope shifting times, guyline shift times, hauler set-up times, carriage changes and so on. The user also enters the average distance between back anchors for each system.

Finally the user enters the average scheduled numbers of minutes per day on site and daily allowances for such things as rest breaks, repairs and maintenance and access time. The daily allowances are subtracted from scheduled time to arrive as a 'productive' time per day.

The normal use of TARGET would probably follow in five steps.

First, in the **stand description** section the data on volume (cu m/ha), average piece size to be extracted (cu m) and the conversion factor (cu m/tonne) are entered.

In the **cost summary** section the gang day cost for a specified machine is entered. This can be derived from one of many personal computer-based logging cost programs.

Third, in the **setting description** section segment data are entered. A segment is a contiguous portion of the setting covered by one or more rope shifts, logged by the same system (e.g., highlead, shotgun or mechanical slack-pulling) and has similar terrain and distance to the backline.

TARGET allows up to 20 segments. For each segment the system to be used, the number of rope shifts, the number of guyline or hauler relocations and the number of carriage set-ups required are entered. Then the distance between terrain points, the slope from one terrain point to the next and the payload that could be carried past that terrain point are entered.

An estimate of the layload data could be obtained from one of the cable payload analysis programs available in minicomputers of microcomputers. TARGET allows up to 10 terrain points per segment.

In the fourth step the **target summary** section determines the production target and the unit cost. Other information provided is the productive time per day, the total time (including delays) to log the setting and the total volume extracted from the setting.

Finally a paper printout of the target and **cost summary** is obtained (Table 2).

The TARGET program is being used on a limited scale in New Zealand and is available from the author.

DRAFT COPY ONLY

Time to yard the setting	
Productive time per day (minutes)	435
Hauling time plus delays (minutes)	3920
Number of days to log the setting	9
Conversion factor (cu m/tonne)	0.9
Total volume (cu m)	902
Target (tonnes/day)	111
Costs	
Gang day cost ($/day)	2250
COST ($/tonne)	20.27

Harvest Scheduling Spreadsheets

Logging planners will increasingly face the difficult task of scheduling settings for harvest within the framework of environmental guidelines and production constraints.

The FRI Harvest Planning Group has recently developed interactive harvest scheduling spreadsheets using the Lotus SYMPHONY packages. The scheduling spreadsheet could include volume growth functions, logging productivity production equations, and cost and revenue estimates. The planner enters setting and logging system information and selects a harvest year. The spreadsheet then "looks up" a table to determine volume per hectare, calculates logging production, and determines setting and unit volume ($/m^3) logging costs. Other constraints such as volume harvested for each year and percentage area clearfelled in a given catchment could also be monitored.

The effect of delaying to advancing the time of harvest on product yields could also be easily included within the spreadsheet format.

An example of the output from a harvest scheduling spreadsheet is shown in Table 3.

TABLE 3: Example of output from Harvest Scheduling Spreadsheet

```
                 HARVEST SCHEDULING SPREADSHEET
                 ==============================
                            G. Murphy
                   Forest Research Institute

                                Catchment Name    =       Whakatipu
FOREST NAME =    Whakaroa       Catchment Area    =         355.4
                                % Logged          =           33
-----------------------------------------------------------------------------------
INVENTORY AND PRICING DATA
==========================
                                Volume per hectare

                0        1        2        3        4        5        6        7        8        9
           Year
       0    Cpt          5       12       13       14       15       18       19       22       23
       1   1990        728      580      765      680      626      616      605      575      534
       2   1991        739      603      786      699      649      639      629      597      556
       3   1992        747      622      804      720      668      658      650      619      578
       4   1993        755      643      830      738      689      679      669      642      600
       5   1994        763      661      856      764      707      697      690      661      623
       6   1995        771      677      870      780      723      713      708      682      642


                                Stocking
                Cpt      5       12       13       14       15       18       19       22       23
                       325      330      400      450      225      245      280      330      535

Prices on                       Product percentages
  truck         Cpt      5       12       13       14       15       18       19       22       23
     75      Peeler     30       35       25       15       15       15       25       25       25
     55      Sawlog     60       50       55       60       65       70       65       60       55
     15        Pulp     10       15       20       25       20       15       10       15       20
```

LOGGING SETTING DATA

Compt.	Year	Landing	System	Area	AHD	APS	Daily Prodn.	Daily Cost	Unit Cost	Setting Cost	Setting Revenue
5	1990	1	2	5.1	220	2.24	261	4040	15.46	57382	211630
5	1991	2	2	4.0	170	2.27	269	4040	15.00	44337	168492
5	1991	3	3	4.8	161	2.27	222	4960	22.32	79173	202190
5	1991	4	2	5.6	154	2.27	270	4040	14.96	61911	235889
5	1991	5	4	5.3	163	2.27	285	7090	24.87	97426	223252
12	1992	6	2	5.1	197	1.88	230	4040	17.58	55778	177643
12	1992	7	2	3.5	161	1.88	232	4040	17.40	37872	121912
12	1992	8	4	5.0	149	1.88	240	7090	29.59	92023	174160
12	1994	9	2	4.6	139	2.00	244	4040	16.53	50260	170274
12	1992	14	2	5.7	184	1.88	231	4040	17.50	62044	198542
13	1992	16	2	4.5	222	2.01	243	4040	16.63	60185	188136
18	1992	17	2	3.3	110	2.69	290	4040	13.92	30216	112913
18	1992	1	1	1.4	80	2.69	501	2690	5.37	4947	47902
18	1992	2	3	4.8	130	2.69	245	4960	20.23	63901	164237
19	1992	3	1	3.7	133	2.32	386	2690	6.97	16772	134680
19	1993	4	1	2.0	92	2.39	434	2690	6.20	8300	74928
5	1991	11	1	1.8	113	2.27	394	2690	6.83	9080	75821
14	1994	9	1	1.8	100	1.70	303	2690	8.89	12222	66010
15	1995	10	1	2.8	130	3.21	537	2690	5.01	10136	101220
15	1993	11	1	6.9	144	3.06	498	2690	5.41	25704	237705
14	1993	12	1	2.3	71	1.64	312	2690	8.61	14615	81475
14	1992	13	5	6.5	330	1.00	105	3870	36.89	172591	224640
19	1992	14	1	6.4	83	2.32	430	2690	6.26	26022	232960
18	1995	15	6	7.7	135	1.00	692	32170	46.47	255125	285485
18	1995	16	1	2.2	75	2.91	549	2690	4.90	7683	81567
18	1992	22	1	3.4	165	2.69	419	2690	6.43	14375	116334
19	1992	18	2	2.2	96	2.32	261	4040	15.45	22096	80080
19	1993	Road edge	1	3.4	40	2.39	491	2690	5.48	12459	127378
SUMS				116						1404634	4317456

```
FINANCIAL SUMMARY
=================                                          Catchment  Per ha
Revenue                                                     4317456   37284
MINUS
Logging costs                                               1404634   12130
Landing construction costs                                    24300     210
Roading and contour tracking costs                            57314     495


NET REVENUE (excl. growing costs, admin costs, etc.)        2831207   24449
------------------------------------------------------------------------------

VOLUME SUMMARIES
=================
                                  Volumes  (m^3)
          Year             Peeler  Sawlog  Pulp      Totals

             1990            1114    2228     371     3713
             1991            4767    9533    1589    15889
             1992            9080   21939    5767    36786
             1993            1871    6457    1736    10064
             1994            1270    2345     800     4416
             1995            1362    6257    1464     9083
------------------------------------------------------------------------------

SYSTEM SUMMARIES
================
                   Skidder  Highlead Madil071     TY90  Gantner Helicopt.
     1990                0      3713        0        0        0        0
     1991             1330      7094     3547     3917        0        0
     1992             9723     16114     3158     3110     4680        0
     1993            10064         0        0        0        0        0
     1994             1375      3041        0        0        0        0
     1995             3593         0        0        0        0     5490
------------------------------------------------------------------------------
```

DRAFT COPY ONLY

A simplified copy of the harvest scheduling spreadsheet is available from the author.

Landing Construction

Surfacing of landings and spur roads to landings can be a significant cost on steep terrain where ground strength is weak or the cost of importing aggregate high. Several computer models have been developed to assist logging planners determine the aggregate thickness required for unpaved roads and the reduction in thickness that results from geotextile reinforcement. With experience and an understanding of the underlining principles the models could also be used for the structural design of landings.

GIROUD is one such computer model developed by Julie Kliewer, a Civil Engineering graduate student, at Oregon State University. The program uses a method described by Giroud and Noiray to evaluate the reduction in required aggregate thickness resulting from the use of geotextile-reinforcement. The total required aggregate is also calculated using an empirical method developed from research conducted by US Corp of Engineers.

The features of GIROUD include:

- Interactive data input
- Operates on IBM compatible PC's
- Printed output
- Metric units can be used
- User may specify up to two types of traffic (axle load and number of passages)
- Determines the required aggregate thickness, with and without geotextile reinforcement, and determines the reduction in aggregate requirements when geotextile reinforcements are utilised
- Alerts the user to excessive strains in the geotextile.

The main limitations of GIROUD are that it is

- Applicable only to purely cohesive subgrade soils
- Applicable to "roads" subjected to less than 10,000 passages
- Evaluates the risk of failure of the foundation soil and the geotextile, but not the aggregate layer.

A copy of GIROUD may be available from J. Kliewer, Forest Engineering Department, Oregon State University.

DIGITIZER-BASED APPLICATIONS

First of all, what is a digitizer. A digitizer consists of a control box (which passes "information" to and from the computer), a cursor and a digitizer tablet. Behind the surface of a digitizer tablet, is a grid network of thousands of fine wires and as the cursor passes over these the cursor path becomes stored in the computer as a series of coordinates. The accuracy of the digitizer is commonly measured to within a fraction of a millimetre. Digitizer tablets commonly range in size from 30 x 30 cm to 100 x 120 cm but experience by Harvest Planning Group staff and overseas logging planners would suggest that a minimum size of 60 x 85 cm is acceptable for detailed harvest planning.

DIGI-FRAME

DIGI-FRAME is a software/hardware package designed and marketed by Don Robinson, Rotorua, New Zealand. DIGI-FRAME makes quick work of map measurements such as:

- average haul distance
- areas
- lengths of roads, streams, etc.
- road, stream and cable hauler profiles.

DIGI-FRAME also produces output for cable hauler profiles which load directly into LOGGERPC.

It runs on IBM compatible PC's which have MS-DOS and an RS232 serial port.

Cable Hauler Planning Package

The Cable Hauler Planning Package (CHPP) was developed in 1983 at the FRI by the Harvest Planning Group. The package consists of a series of computer programs that run on a small stand-alone computer facility referred to as the Forest Engineering Workstation.

The programs provide engineering tools for the logging planner to evaluate future hauler operations. They relieve much of the burden of repetitious and complex calculation, and therefore provide more time to formulate and evaluate a more complete range of harvesting options. The programs include:

MAPIN – Used to produce a digital terrain model (DTM) from a topographical map of the area to be harvested. The maps must be of good quality and have scales in the order of 1:5000 with 6 m or closer contour intervals.

PROFILES – Used to estimate the extraction limits, in terms of volume and distance, of a cable logging system over any extraction profile the planner wishes to examine.

The PROFILES program together with the DTM's can be used to identify the best hauler settings and most appropriate setting boundaries. It can also be used to identify areas of obvious difficulty within settings and enable testing of various options for overcoming these difficulties, e.g., rigging tail trees beyond the setting boundary, flying logs over sensitive stream beds, and using intermediate supports.

AREAS – Used to measure the area, average haul distance, and total volume to be extracted for each setting, to enable estimates of hauler production and the time required to harvest the setting.

DISTANCES – A general utility programme used to measure the length of forest roads and tracks required to be upgraded, plus the length of new roading required.

SLOPES – Used to measure slopes quickly off the DTM.

The CHPP is currently only resident on a desktop facility at the FRI.

The CHPP was initially used predominantly by researchers at the FRI. Lately, however, it has been used by some logging managers to plan difficult sites on the Coromandel Peninsula. It has also been used to plan several thousand hectares of harvest settings at Woodhill, Riverhead, Tairua, Maramarua, Whangapoua, Mangatu, Patunamu, Whakarewarewa, and Marlborough Forests.

PLANS (Preliminary Logging Analysis System)

PLANS is a family of computer programs that focuses on harvest planning. A major feature of PLANS is that it uses a stored digital terrain model (DTM), the equivalent of the planning area maps, to supply the topographic data needed to design the timber harvest plan.

PLANS was developed by research engineers and foresters at the US Forest Service's Pacific Northwest Research Station in Seattle, Washington. PLANS allows the planner, aided by an interactive graphics computer system, to examine a wide range of design and planning options.

An early version of PLANS ran on the Hewlett-Packard 9845 computer. It was then enhanced and implemented on the Hewlett-Packard 9020 computer which had greater operational convenience and faster computing speeds (Twito *et al.*, 1987). PLANS is currently being converted for use on IBM compatible personal computers and should be available in the US by the end of 1989 (McGauhey, 1988).

PLANS consists of eight programs:

The MAP program – used to produce DTM's with a grid pattern by manually tracing contour lines from a topographic map mounted on the digitizer.

The SKYMOBILE and SKYTOWER programs – analyse the load carrying capacity of skyline hauler systems. Terrain profiles of skyline corridors are obtained from the DTM. SKYMOBILE is used to analyse individual profiles and is best suited for planning harvest areas where the hauler is moved with each corridor change. SKYTOWER is used to analyse settings that will be yarded in a fan-shaped pattern to a central landing.

The HIGHLEAD program – analyses highlead settings. The yarding limit is established either by blind lead along the profile or by the maximum reach of the hauler.

The ROUTES program – allows the planner to rapidly identify road gradelines and to develop a road pattern within the harvest area. The program uses the DTM as a source for terrain data.

The SLOPES program – produces overlays at map scale that delineate topographic attributes (e.g., slope, evaluation) within ranges set by the planner.

The VISUAL program – produces perspective views of terrain, roads, and harvest boundaries from user-selected viewpoints. These perspective views provide a preview of the visual impact of proposed harvest activities.

The SIMYAR program – is a cable logging simulation model that uses a harvest unit's geometry, timber stand characteristics, and equipment specifications to estimate the cost and productivity of extraction.

In my opinion the PLANS package is a very comprehensive and valuable planning tool. It's main limitation for New Zealand operation is that it currently uses imperial units of measurement.

DRAFT COPY ONLY

PROSIM

PROSIM was originally developed by the author to determine the system costs for alternative processing options – cutting trees into logs at the stump, or on a large landing or at a centralised processing yard. An example of the output from PROSIM is shown in Table 4.

PROSIM (Processing Options Simulation) has a wide range of features. It:

- Uses a digital terrain model (DTM), taken from a map with a digitizing tablet, to describe the harvest unit area.
- Carries out machine and cable payload analyses for the selected hauler and rigging system.
- Randomly distributes logs from a selected cutting pattern on the DTM.
- Simulates the extraction of the logs and calculates production using New Zealand-based production equations.
- Calculates the total time required to harvest the setting.
- Calculates the stump-to-mill costs for the various phases of the operation.

PROSIM was originally written in HP-BASIC for a Hewlett-Packard 9020 computer with a Calcomp 9000 digitizing tablet.

By the end of 1989 FRI's Harvest Planning Group plans to convert PROSIM to run on a personal computer and be used with either a map on a digitizing tablet or aerial photographs on an analytical stereoplotter.

PROSIM is similar to the SIMYAR program in the PLANS package. The main differences are:

- PROSIM uses metric units.
- SIMYAR determines setting production and costs based on a single "average" skyline road. PROSIM simulates the logging of all skyline roads.
- SIMYAR determines extraction costs only, PROSIM determines stump-to-mill door costs.
- The user specifies log and stem-size distributions in PROSIM.
- Yarder mechanics, as well as, cable mechanics are incorporated in PROSIM analyses.

DRAFT COPY ONLY

```
                         ****************************
                         PROCESSING OPTIONS SIMULATION
                         ****************************

   OSA1_009_E1                                          26_January_1987


System information
******************

Log processing partially carried out at the stump and then completed at a
Central Processing Yard.
Yarding machine was a Madill 009 rigged as a Grabinski skyline.
Loading was with a medium-sized hydraulic boom loader.

Stand and setting information
*****************************

Mean diameter breast height (cm) =       55.0
Stocking (stems per hectare)     =       200.0
Mean tree volume (cubic metres)  =       3.1
Live stand volume (m^3/ha)       =       620.0
Pungas per hectare               =       300.0

The setting was irregular shaped and was   9.4 hectares in area.



Yarding and cycle statistics
****************************

Daily yarding production was 194.5 cubic metres.
It took  29.2 days to harvest the setting.
The number of skyline road changes was   46.0
The number of yarding cycles was         1334.0
The average log weight was  1239.3 kilograms
 39 logs (totalling  89.0 cubic metres) were too big to be yarded oncut.
The average yarding distance was 198.4 metres.
Total volume extracted was   5671.4 cubic metres.


                             Mean     Std dev   Minimum   Maximum


      Cycle volume (m^3)     4.25     2.38        .82     13.56
      Number of logs         3.43     1.54       1.00      6.00
      Cycle time   (Min)     6.45     1.06       3.93      8.49
```

```
                         ****************************
                         PROCESSING OPTIONS SIMULATION
                         ****************************

   OSA1_009_E1                                          26_January_198


Trucking information
********************

One-way lead distance for              ALL                 logs was
 30.0              kilometres.
 100.0             % of the total volume was trucked as this product typ


Cost information
****************

                         Setting     Hectare     Cubic metre


Falling                    7546         799          1.33
Yarding                   91953        9731         16.21
Processing                 3587         380           .63
Loading                   37614        3980          6.53
Trucking                  50779        5374          8.95
Sortyard                  41118        4351          7.25
Move in/Move out           3619         383           .64
Landing Construction       2500         265           .44


Total                    238715       25262         42.09
```

DRAFT COPY ONLY

NEW APPROACHES

Analytical Stereoplotters

The first requirement for detailed cable logging planning is the need for up-to-date, accurate and relatively large-scale topographical maps (1:10,000 or larger), complete with closely spaced contour intervals (e.g., 5 m), roads, forest boundaries and streams. Unfortunately maps of this type, particularly for steep country areas, may not be readily available. An alternative is to obtain the topographical information required for the planning process directly from aerial photographs. This approach has the advantage that a more accurate end product is possible because of the whole of the map construction and map digitizing phases are by-passed.

In order to do this, the Harvest Planning Group uses an AP190 which is a PC-based analytical stereoplotter manufactured by Carto Instruments Ltd of Norway. As the data is collected from the photographs, it is stored in the form of x, y, z coordinates which can then be used to create a DTM for direct input to the planning package, or to create maps and perspective views at any desired scale or look angle.

The early developmental work for the AP190 was undertaken at FRI by Dr Ward Carson, a senior National Research Advisory Council fellow.

The system uses a mirror stereoscope positioned above a stereo-pair of photos mounted on movable photo-carriers. After completing a series of photogrammetric 'orientation' procedures (common to all analytical plotters), an electronic drive system automatically adjusts the photos to maintain a correct stereo image wherever the photo-carriers are positioned. The operator can use a small dot of light, positioned accurately on the 'ground' to record x, y, and z coordinates at that point or in a continuous mode for contouring. Photo coordinate accuracy of 20 microns means, in practical terms, photos taken at a height of 2 km can provide ground measurements to an accuracy of better than 1 m.

The AP190 system software enables measurement to be made of areas, grades, distances, azimuths, heights and cross-sectional profiles. Additional software operations enable new road lines to be determined and circular plots of a specified radius to be laid out. this type of information can then be transferred directly (as digitized photo data) to other computing systems for further processing as as input for geographic information systems.

Output from the analytical stereoplotter has been used as input to the FRI Cable Hauler Planning Package for some consultancy projects.

DRAFT COPY ONLY

Reutebuch (1987) also reports that analytical stereoplotters have been field tested in forestry offices in Alaska and other parts of the US.

GIS (Geographic Information System)

GIS is a geographical data base system for land use management. GIS differs from the general application data base packages in that it incorporates spatial (map) data (Lemkow, 1985). It manages a library of geographical units. Each unit (varying in size up to several hundred hectares) is composed of a number of user definable attributes and layer information. Attributes can be either qualitative or quantitative descriptions which are associated with each particular unit. GIS lends itself well to harvest planning. Layers of information can be combined to answer a range of questions often asked by logging planners, for example,

> "How much radiata pine volume, broken down by log grade, is there in elevations above 200 m, not more than 50 km from the export port, that could be logged with a multispan skyline system" (Figure 2).

The answer is obtained by overlaying the layers and finding the polygon intersection that meets the above criterion.

The layers of information, which are entered into the computer by using a digitizer could include such information as:

Stand data:
- species and log grade percentages
- volume per hectare
- planting age
- treatment (pruning history)

Logging systems:
- productivity per day
- daily cost
- fixed costs, e.g., roads, landings
- trucking distance and cost

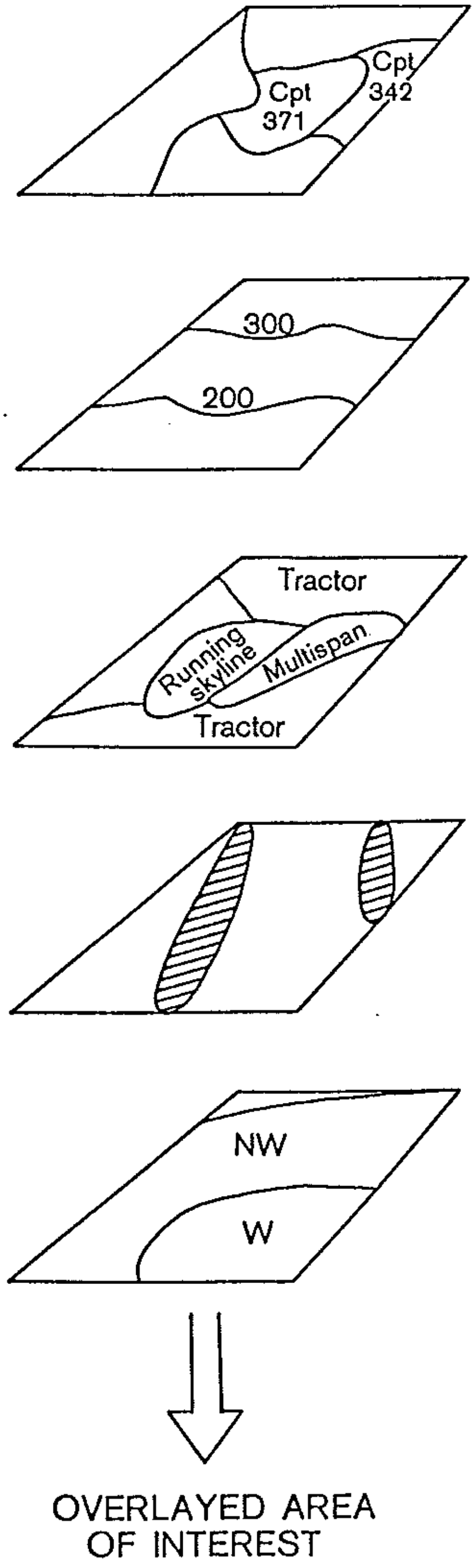
Special concerns:
- ground slope
- wildlife habitat
- elevation
- soil types

- stability ratings

Felled areas:
- by what contractor
- date

There is estimated to be more than 1,000 GIS systems now installed in North America alone with 4,000 systems projected by 1990. A recent issue of Photogrammetric Engineering and Remote Sensing (August 1988, pp. 1207-1208) summarised GIS software available for Personal Computers. Eleven packages were described – the TERRASOFT package in particular specifically mentioned forestry applications. The Forest Research Institute is using TERRASOFT in a range of forestry and harvesting applications.

FIGURE 2: Example of GIS use



Stand data

Cpt 371: 500m^3/ha
Peeler 20%
Sawlog 40%
Pulp 40%

Elevation data

200: 200m elevation

Logging data

Multispan:
Daily production: 200m^3
Daily cost: $4000
Landing costs: $2000

Riparian strips

Wind stability

W: Susceptible to wind damage if thinned

Overlayed result:

Total area = 35ha
Logging area = 30ha
Logging volume = 15000m
Peeler volume = 3000m^3
Sawlog volume = 6000m^3
Pulp volume = 6000m^3
Logging cost = $302000
Days to log = 75

CONCLUSIONS

Computer models will undoubtedly allow planners and loggers to examine many more alternatives in the future than can now be done manually. To finish up I would like to emphasise two words in the title of this paper: MODEL and ASSIST. Firstly, it must be remembered that a model is only someone's attempt to mimic reality – some models are much better at mimicry than others. The accuracy of a model is also dependent on the accuracy and amount of data available to it. Secondly, let me stress that unless logging management has staff trained in the operation of these models and the staff have an understanding of the basic principles underlying the models, frustration rather than assistance may be the end result. Courses such as the New Zealand Forest Engineering Institute will be of tremendous benefit in providing such training and understanding.

REFERENCES

CHUNG, J. 1987: Development of a cable logging system analysis package for micro-computers. Master of Forestry Paper, Oregon State University, 116 pp.

DUGGAN, 1988: COLCO2. LIRA Report, Vol. 13 No. 22, 4 pp.

LEMKNOW, D.Z. 1985: Microcomputer Software for Planning and Engineering. *In* "Improving Mountain Logging Planning, Techniques and Hardware". Proceedings of a Joint Symposium of the IUFRO Mountain Logging Section and the Sixth Pacific Northwest Skyline Logging Symposium. Held at UBC, Vancouver, British Columbia.

McGAUHEY, R.J. and TWITO, R.H. 1988: Large-area timber harvest planning with digital elevation models. *In* Proceedings of the International Logging and Pacific Northwest Skyline Symposium. Held at Portland, Oregon.

RAWLINS, W. and MACARTHUR, I. 1986: Users' manual for RATE-SETTER. CSIRO Division of Forest Research, 52 pp.

REUTEBUCH, S.E. 1987: PC-based analytical stereoplotter for use in Forest Service Field Offices. A paper presented at the 1987 American Society of Photogrammetry and Remote Sensing Fall Convention, Reno, Nevada.

SESSIONS, J. 1986: PACE – Production and Cost Estimator User's Guide. Forest Engineering Department, Oregon State University.

DRAFT COPY ONLY

TWITO, R.H.; REUTEBUCH, S.E.; McGAUHEY, R.J. and MANN, C.N. 1987: Preliminary Logging Analysis System (PLANS): Overview. USDA, Forest Service, PNW Research Station, general Technical Report PNW-GTR-199, 24 pp.

WILBANKS, S.J. and SESSIONS, J. 1985: Modelling running skyline performance based on mechanical capability of the yarder. "Improving Mountain Logging Planning, Techniques and Hardware". Proceedings of a Joint Symposium of the IUFRO Mountain Logging Section and the Sixth Pacific Northwest Skyline Logging Symposium. Held at UBC, Vancouver, British Columbia.