LOGGING SYSTEM ANALYSIS SOFTWARE AVAILABLE AND IN USE IN NEW ZEALAND

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INTRODUCTION

This paper looks at software which is available to assist in selection of logging systems and deciding locations for landings in both ground based and cable logging operations. Planners usually aim to make these selections to minimise the total logging cost (which includes costs for road and landing establishment as well as the logging and transport operations) while meeting requirements of:

- the market (for woodflow and quality)
- environmental constraints (either requirements of the resource consent or self imposed)
- the Health and Safety in Employment Act (1992)
- site fertility for subsequent crop rotations
- the equipment available in the area at the time.

There is a wide variety of ground based and cable logging equipment available which can be used in many different ways. In most situations there will be several systems which will be physically able to extract the logs. Finding an optimal solution is a process of elimination during which the following questions must be asked:

- What logging systems are physically suited to the crop, terrain, soils and climate ?
- Would the daily production of the systems meet market requirements and enable areas to be logged within time constraints ?
- What are the costs associated with each of the systems ?

There are a range of software applications available which can help in this planning process. Many forest owners have developed their own software and spreadsheet templates for these purposes. This paper assesses the capabilities and operating characteristics of applications available "off the shelf".

Applications fall into the following categories:

- terrain analysis (Digi / Planz)
- cable system payload analysis (Logger PC, PLANZ, Softree)
- production modelling for ground based systems (SkidPC, PACE)
- logging cost calculation (PACE, Jobcost, NewCost)

ATTRIBUTES OF GOOD SOFTWARE

When deciding whether to use a particular software application, the following issues must be considered:

- How relevant are the results supplied to the rest of the harvest planning process ?
- How accurate are the results supplied ?
- How easy is the application to learn and use ?
- How easy are the results to understand ?
- How well are the results presented ?
- Does the application fit well with other functions within the organisation ?

Harvest plans must be completed to definite deadlines, and planners like to see evidence that plans are feasible as they develop. Plans must satisfy management, prospective contractors and possibly regional authority staff. A planner will usually be most satisfied with a solution which demonstrates that it is feasible, is easy to understand and is easy to demonstrate to others. People without familiarity of the planning process and the limitations of the models used may be impressed by the appearance of the graphics and tables produced by planning software and may assume that the content of the plan is good because it looks good and was produced by a computer. There is currently a trend toward higher standards of presentation of documents and there may be pressure to use software for these purposes rather than for its functionality or accuracy.

LIMITATIONS OF COMPUTER BASED PLANNING AIDS

It must be remembered that maps and digital terrain models (DTM) are only representations of terrain. They are developed to a particular resolution so it is likely that features are frequently misrepresented and sometimes missed completely. Features such as rock outcrops are not always shown on topographic maps and although they may be only minor topographic features, they may have a significant effect on logging operations. There are also crop factors such as tree lean, maximum tree size, malformation and windthrow which are not represented in MARVL output which can affect logging operations. For these reasons, it is important that the planner walks the block to check that the plan is feasible.

A DTM is an x - y grid with an elevation assigned to each intersection point on the grid. Plotted in a perspective view with the x and y axes in the horizontal plane, and lines linking the elevation points, the DTM approximates the appearance of the ground. When a DTM is produced from a topographic map, straight line interpolation is used to calculate the elevation at each grid intersection point. This means that ground curvature is not accounted for so high points and low points which fall between the contour lines will not be accounted for. In cable logging systems, high points can be critical to the operation of the system as they can limit available deflection. Extraction of a ground profile extracted from a DTM is done by further interpolation which will result in more smoothing of the ground profile. If the suitability of a profile for a particular logging system appears marginal, it should be checked on an accurate contour map or preferably by measuring the profile on site using a clinometer and hip chain or tape.

SUMMARY OF HOW SOFTWARE CAN HELP SOLVE PARTICULAR PLANNING PROBLEMS

Categorising Areas for either Cable or Ground-Based Extraction.
In selecting a logging system, some of the characteristics of the land that need to be quantified are:
- angle, length or aspect of major slopes
- terrain roughness
- height of small ridges or gullies
- soil type and conditions

Software capable of terrain analysis such as Planz or Softree may be used here to help categorise the land into zones suitable for particular types of ground based extraction machines. If this type of software is not used, or a DTM which this software requires is unavailable, zones could be manually identified on a contour map then quantified using Digi.

Selection of Cable Logging Equipment
There is a variety of software available for payload analysis which provides information in minutes that would take days to calculate manually.

In selecting which software to use, the following factors should be considered:
- the size of area to be planned

- whether DTMs are available and their accuracy
- the accuracy of available maps
- the computer skills of the personnel involved
- the existing road network

For small isolated blocks such as farm woodlots, it is unlikely that there will be a DTM or a detailed topographic map available. In such cases LoggerPC would probably be useful as the detailed information that it requires can be gathered by ground measurements, and the whole block can probably be assessed on foot in a reasonably short time.

For larger blocks where it appears that there are many possible combinations of landing locations, using a DTM based model to assess possible landing combinations will help to identify the best options quickly. In such cases it may be worthwhile to digitise a DTM from a contour map if one is not available.

The results from computer models should be interpreted with knowledge of the limitations of the model. Payload analysis provides an estimate only of what will actually happen in a cable logging operation. The calculations model a static situation and do not allow for dynamic loading. Use of tension monitors shows that the highest skyline tensions often occur during breakout - not necessarily when the load is at midspan as a static analysis would suggest. The only way to know exactly what rope tensions are is by using tension monitors.

The accuracy of results of the cable analysis applications reviewed in this paper has not been verified by LIRO.

Selection of Ground - Based Logging Equipment

Most forest owners have their own guidelines for the type of system which is suitable for particular conditions. These guidelines are usually based on safety or environmental requirements. Selection of ground based systems must be done using these guidelines, as there is no software available which predicts payload capability for ground-based logging equipment. The ground-machine-load interaction is very complex with many variable parameters and it would be extremely difficult to develop a meaningful model. Rather than trying to predict payload, it would be easier to develop a method for predicting production (see below).

Forecasting Production and Logging Costs

There are many variables which affect the production of logging operations. Modelling machine performance in relation to terrain and crop variables alone would be very difficult, and this doesn't take into account the ability, alertness or attitude of the operator at a particular time. There is no software available which is able to take into account all of the contributing factors. The best way to predict production for a particular operation is to consult a record of production from similar operations in the past. Such a record should include: date, block area, total volume logged, number of workdays, average stem size, average stocking, average haul distance, labour used, machines used, length of workday, slope, (and deflection for cable operations) soil type, weather, tree form, branching, understorey scrub, number of log sorts, breakage and any other factors affecting production. This information could be stored on a card index system or on a computer database which would allow quicker searching. Allowances may need to be made for differences in the conditions from the blocks logged in the past.

SOFTWARE AVAILABLE FOR TERRAIN AND PAYLOAD ANALYSIS

Digi (DOS environment)
Digi enables features on a topographic map to be analysed using a digitiser. It calculates lengths, areas and average yarding distance between points on a map. It can also be used to digitise profiles of extraction corridors for analysis in LoggerPC. Output data can be printed or saved to a file. Digi is straightforward to set up and use, requiring only a map of known scale for input. Users with no prior computer experience can learn to use Digi in only a few minutes. A digitiser is required.

There is no image of the area or the points entered on the digitiser presented on the screen, so the user is not reassured by a graphical rendition of their work although a beep is emitted with each point entered.

LoggerPC 3.0 (Windows environment)

LoggerPC performs payload analysis for cable logging systems. Hauler types, rope specifications, ground profiles and the type of ground clearance required are entered, and the payload is calculated at each terrain point which corresponds to the maximum allowable rope tensions. Alternatively the user can specify a payload and the corresponding rope tensions will be calculated. Analyses can be performed for standing (fixed), live (able to be raised or lowered during inhaul), and running skylines as well as highlead. Skylines with intermediate supports can also be analysed.

To assess the suitability of a landing location, a series of skyline corridor profiles from the landing are analysed. Data for the profile can be entered by keyboard or imported as an ASCII file produced by Digi or another source such as a GIS. There is also a facility for using a digitiser although this is quite cumbersome to set up and it is easier to use Digi to store the profile data and then import the file into LoggerPC. It can be configured to work in either metric or imperial units and ground slope can be entered in either degrees or percent.

Sideshot data can be entered along with the profile data which enables the lateral deviation of the skyline to be calculated. This is particularly useful when planning for intermediate supports. It also calculates the angle between the skyline and mainline as the carriage approaches the intermediate support jack which indicates whether the skyline needs to be raised for the carriage to pass over the support.

The screen layout follows usual Windows conventions and users familiar with Windows applications and cable systems will find it reasonably easy to learn to use. On-line help is available, and a 48 page manual is provided. There is no on-line tutorial and the manual is a useful for reference on particular functions but is not written in a "how to use" format.
Most haulers now used in New Zealand have 3 or 4 working drums, so the live skyline (where the skyline is able to be raised or lowered during inhaul) analysis will probably be used most frequently. In this mode the length of the log is entered and it is specified whether partial or full suspension is required. For partial suspension, the required height above the ground of the choked end is also specified.

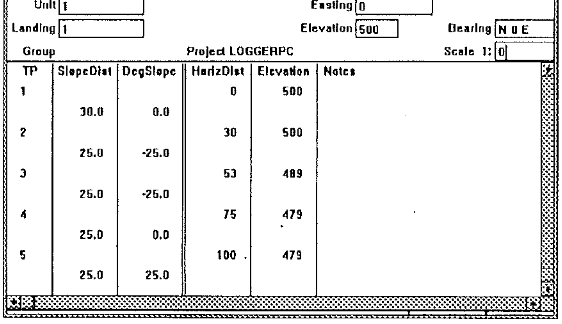

Figure 1 - Profile Data in LoggerPC

The live skyline analysis is based on the slackline system and there is no specific analysis for the North Bend system or any other system using a fallblock although there is a "specified clearance" option which raises or lowers the skyline at each terrain point. The "lifts only" or "drops only" options allow the skyline to be either raised or lowered at up to five terrain points during inhaul. (In practice a hauler operator will probably consider it reasonable to lift or lower the skyline up to two or three times during inhaul.) The actual payload capability of the North Bend system will fall somewhere between the standing skyline and the (live) specified clearance solutions.

The results of the analysis are presented both graphically and in table form, which shows rope tensions, clearance, the maximum payload able to be suspended at that point and the maximum payload able to be taken to the landing. This enables the terrain points or areas along the profile which are limiting the payload to be identified. From the graphical analysis it can be assessed whether these points will be a problem in practice or whether it will result in an acceptable zone of "ground lead" (the whole log dragging along the ground).

If the system needs to be changed from that used in the first analysis the following changes can easily be made:

- the hauler or tailhold can be shifted to any position on the profile
- a tailspar of any height can be used
- the hauler or ropes can be changed
- intermediate supports can be added.

Because the payload at each terrain point is given, it is possible to estimate the average payload for the corridor. What is an "acceptable solution" to a planner depends on many factors, but usually they will have a "target average payload" in mind.

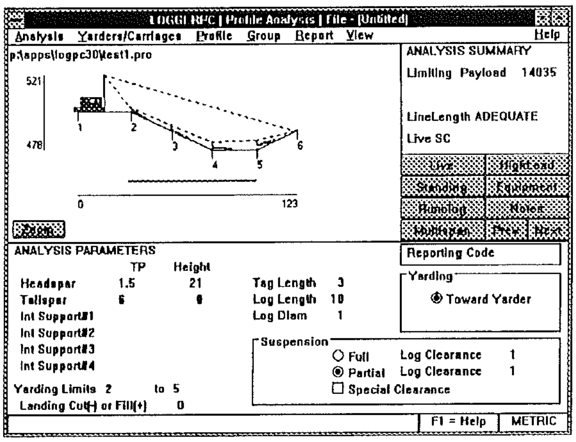

Figure 2 - Live Skyline Analysis

Knowing the average payload for a setting will help when estimating production.

The highlead analysis does not calculate a payload (which would be impossible to estimate accurately) but shows which parts of the setting are within "line of sight" from the top of the tower.

In the running skyline analysis, it is recognised that the allowable tension in the haulback line may be limited by the maximum torque that the interlock clutch is able to exert. (i.e. It may not be possible for the haulback tension to reach safe working load.)

Files of profiles and analyses can be stored within groups, and groups within projects.

The computer used should have a 486 microprocessor and 4 Mb of RAM. (LoggerPC will run on a 386 but there can be problems.) Some files are stored in the Windows directory and there may be problems with saving and retrieving files when using a network.

LoggerPC was developed by Oregon State University and is public domain software, available through LIRO. There is a new version of LoggerPC due for release soon.

Planz (DOS environment)
Planz is an application which assesses the feasibility of cable logging systems at specified landing locations on a DTM. It also provides terrain analysis of slope and aspect, and produces perspective views of the area being planned. Planz is a metricated version of PLANS (Preliminary Logging Analysis System) which was originally developed by the U.S. Department of Agriculture in the 1980s. The metrication was done by the Harvest Planning Group of NZFRI but ceased before all the modules of Planz were metricated.
Planz is suitable for preliminary analysis of areas from 100 ha to 10000 ha. DTMs can either be created by digitising contours on a topographic map or be imported in TerraSoft, ASCII, Surfer, or USGS DEM format. Adjacent DTMs can be combined into one large DTM.

There are three cable analysis modules, Skytower, Skymobil and Highlead.

Skytower simulates the situation where many corridors are yarded without moving the tower. When a landing location is selected on a DTM, Skytower extracts 18 skyline corridor profiles from the DTM and performs payload analysis for each corridor using a specified yarder and ropes. In Skytower, a target payload is specified which must be able to be extracted from all parts of the setting, so the output is in terms of maximum haul distance. When the corridors for each landing are viewed together, a boundary of the area able to be logged from that landing is drawn by linking the tailhold end of each corridor. The feasibility of the landing location can then be assessed according to the area that is able to be logged from the landing.
Limitations of the Skytower method are that the corridors are selected at 18° intervals which may miss some areas with poor deflection, and that areas will not be shown which are feasible to log at lower payloads.

Skymobil performs payload analysis for a corridor defined by digitising on the DTM the ends of the profile then specifying the tower and tailhold locations. Skymobil can solve for either the maximum span over which a specified target payload can be yarded, or the maximum payload which can be yarded over a specified span.

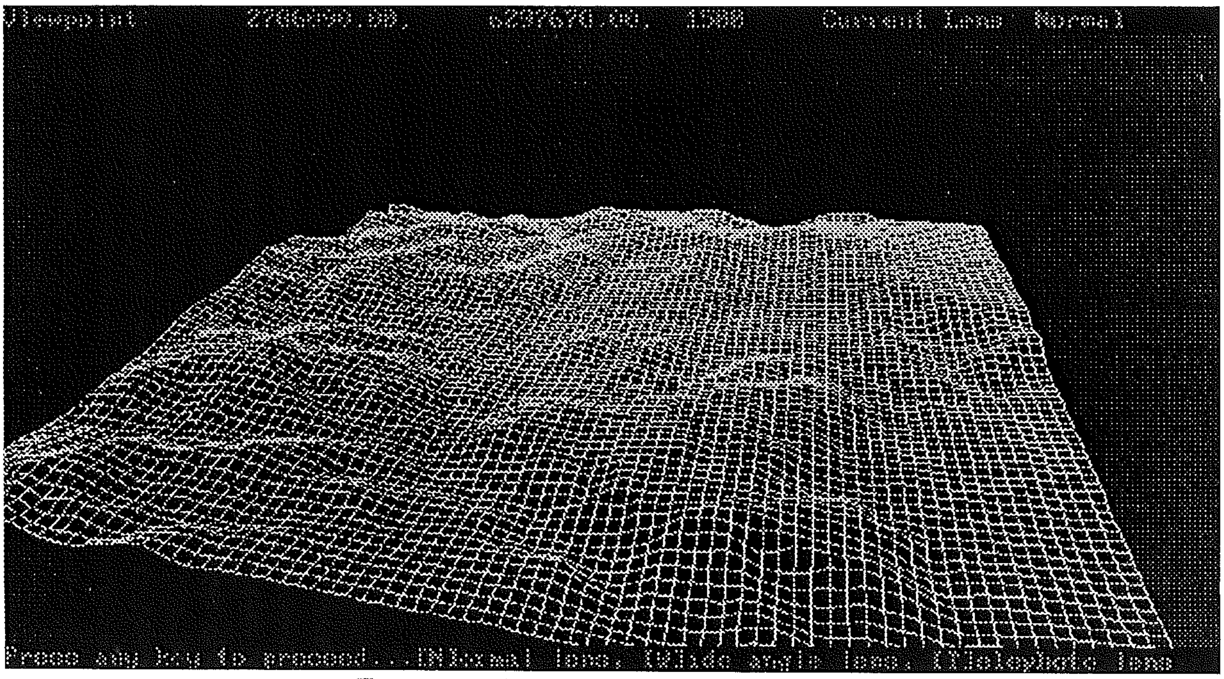
Figure 3 - A Perspective view of a DTM

Both Skytower and Skymobil show the points on the corridor where full suspension is obtained. It is not possible to specify lifts or drops during inhaul, so the system really only models a slackline or gravity system with the skyline length fixed during inhaul.

The Highlead program extracts 18 profiles from around a selected landing location in the same way as Skytower. There is no payload analysis done, but setting boundaries are determined by the either the maximum reach of the yarder or where the zone of blind lead starts, whichever is closer. There is an option of tightlining (applying tension to the tailrope to obtain lift during inhaul) to permit yarding beyond the point of blind lead, if there is a suitable tailhold location.

The Plancad module enables a mosaic of landings and the areas that can be reached from them to be assembled on screen, which can quickly indicate where the most suitable landings are likely to be.

The Visual module produces perspective views of the terrain from user-selected viewpoints. The features of the harvest plan which are developed in other modules can be incorporated into the perspective view.

The Slope module produces overlays that delineate areas into classes of slope, aspect elevation, or combinations of these. It can also provide summaries of the land area in each class.

Softree - Cable Analysis Module
(Windows Environment)
The Softree Cable Analysis software is one module within a set which includes modules for processing survey data to create plans, contour maps and DTMs, and assist in road location design. The software has been designed specifically for forestry use and all of the modules use a similar screen format and method of work.

Another module in the set creates DTMs from survey data or digitised points on a contour map.

Softree performs payload analysis for a corridor defined by digitising on the DTM the ends of the profile then specifying the tower and tailhold locations, as well as the yarder and rope specifications. Several different skyline rigging arrangements are modelled including fallblock systems and clamping carriages. The highlead system is also modelled. A partially suspended load is not modelled so the module is of limited use in planning for most New Zealand operations at present.

Users with some knowledge of skyline systems and familiarity with the Windows environment should find the application easy to learn. There is thorough documentation available in the help menus which describes the procedures to perform an analysis and also discusses the shortcomings of the model. The maximum payload and rope tensions are calculated at each terrain point and this information is presented in a tidy and logical format.

The system is under further development and if future versions include a model for partial suspension there will be advantages in using this system as it is integrated with a road location design module so the same terrain model can be used for both purposes.

PRODUCTION / LOGGING COST ESTIMATING SOFTWARE

JobCost
Job Cost is a template for the Microsoft Excel spreadsheet application which calculates the total cost per workday of a logging operation. In calculating machine

and vehicle costs, consideration is given to depreciation, expected life, cost of tyres, desired return on owner's equity, finance interest rates, repairs, maintenance, fuel, oil and rigging. It also calculates total costs for labour, chainsaws, overheads and operating supplies. The spreadsheet contains cells to be filled in for almost every expense that logging operations are likely to incur. For an accurate estimate of daily cost to be calculated the input values need to be accurate. It has been designed for contractors to evaluate the rate they need to be paid at in order to operate at a satisfactory profit. It can also be useful for estimating logging costs of a particular logging system. Jobcost was developed by LIRO and is supplied with the handbook "Business Management for Logging".

NewCost

NewCost is a template for the Microsoft Excel spreadsheet application which calculates the total cost of operating a log truck.

Log Cost

LogCost is a program that will provide estimates of harvesting production, harvesting costs and transport costs for both production thinning and clearfelling of Pinus Radiata. The program is based on a mixture of industry and standard data and will replace the Harvesting and Production Estimator program (HARPCE) developed in 1985. Log Cost, still under development, will be capable of use as a stand alone program however its major role will be within the NZ FRI stand modelling system STANDPAK. It should be noted that LogCost outputs are for comparative purposes rather than for the evaluation of specific harvesting operations.

SkidPC

SkidPC is a program which calculates cycle time for ground based extraction equipment. Information must be provided on: the characteristics of the machine (weight, power, drawbar pull for tractors, maximum travel speed for skidders, position of centre of gravity, size and type of tracks or tyres), the operating conditions (hook-on and unhook times, delays, whether an arch is used, whether the butts or heads are being pulled, average turn weight, average stem length), and the skid trail conditions (soil coefficient of friction, soil shear strength, slope, average haul distance, soil type - fine or coarse, multiple or single pass).

SkidPC was developed in 1985 and the numerical model is based on studies of machines operating in the USA so is unlikely to be applicable in New Zealand.

Pace

Pace calculates the production rate and costs involved in five aspects of a logging operation (felling, extraction, loading, transport, roading).

It requires costs to be already calculated for each machine and labour unit, and details of the time elements and payload capacity (hence the productivity) for each machine. The calculations that it does are therefore reasonably straightforward and could easily be set up on a spreadsheet; obtaining reliable data for input is the difficult part.

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